Forschungsschiff Sonne cruise SO238

Report on the second OSCAR survey in the Panama Basin: Physical oceanography, seismics, bathymetry and magnetotellurics

06 February 2015 - 06 March 2015

CHIEF SCIENTIST:

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OSCAR - Oceanographic and Seismic Characterisation of heat dissipation and alteration by hydrothermal fluids at an Axial Ridge

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Personnel

Ship's crew

Oliver Meyer	Master
Jens C. Goebel	Ch. Off.
Lars Hoffsommer	2nd Officer
Timm Henning	2nd Officer
Anke Walther	Ship's Doctor
Stefan Meinecke	System Manager
Hermann Josef Pregler	System Manager
Dieter Karl-Heinz Hermesmeyer	Chief Engineer
Steffen Genschow	2nd Engineer
Roman Horsel	2nd Engineer
Hendrik Schmidt	Electrician
Thomas Beyer	Electrician
Helmut Friesenborg	Fitter
Jens Kuderski	MPC/Motorman
Dennis Altendorf	MPC/Motorman
Georg Hoffmann	MPC/Motorman
Frank Tiemann	Chief Cook
André Garnitz	2nd Cook
Andreas Pohl	1st Stwd
Sven Kroeger	2nd Stwd
Alexander Vogt	2nd Stwd
Luis Royo	2nd Stwd
Torsten Bierstedt	Boatswain
Reno Erich Ross	MPC/AB
Guenther Staengl	MPC/AB
Michael Barkow	MPC/AB
Oliver Eidam	MPC/AB
Tobias Erich Georg Siefken	MPC/AB
Rene Papke	MPC/AB
Frank Heibeck	MPC/AB

Science crew

Simona Aracri	Scientist (NOC)
Rafael Eduardo Jaume Catanay	Scientist (NOC)
Luise Paula Hartung	Scientist (GEOMAR)
Miguel Ángel Morales Maqueda	Chief Scientist (NOC)
Gary Gabriel Menéndez Jaramillo	Scientist (INOCAR)
Emyr Martin Tomas Roberts	Scientist (University of Bangor)
José Guillermo Rodríguez Ceballos	Observer (Colombia)
Patrick Philipp Schröder	Technician (GEOMAR)
Klaus-Peter Steffen	Technician (GEOMAR)
Chi Hang Tong	Seismics (University of London)
Daniel Wehner	Technician (GEOMAR)
John Wynar	Technician (NOC)

Summary

The OSCAR (Oceanographic and Seismic Characterisation of heat dissipation and alteration by hydrothermal fluids at an Axial Ridge) research programme in the Panama Basin consisted of three cruises on the RRS JAMES COOK, namely JC112, JC113 and JC114, and a single cruise on the FS SONNE, SO238. This cruise report relates to SO238 but should be read in conjunction with the reports for the other cruises involved in the OSCAR project as a whole.

The cooling of young oceanic crust is the main physical process responsible for removing heat from the solid Earth to the hydrosphere. Close to the mid-ocean ridges, rapid cooling is dominated by hydrothermal circulation of seawater through the porous and fractured basalt crust. This hydrothermal fluid is then discharged into the ocean mainly along the ridges. The cruise SO238 on board FS Sonne is part of an interdisciplinary project (OSCAR) to investigate the effects of this heat loss and hydrothermal circulation in both the solid Earth and the ocean. The data collected during this cruise and its companion cruises on board RRS James Cook, JC112, JC113 and JC114, will allow us to derive an integrated model which will be constrained by geophysical, geological and physical oceanography data that includes pathways in both the solid Earth and the ocean including fluxes through the seabed.

The cruise was divided into three stages. During the first part of the cruise, a 2-ship synthetic aperture multichannel seismic reflection survey over three 270-km transects was carried out to map the evolution of crust structure, properties and morphology along the southern flank of the Costa Rica Ridge. The lead ship for this work was RRS James Cook, with FS Sonne trailing 9 km behind. In the second part of the cruise, we recovered a line of three moorings equipped with current meters, CTD (Conductivity, Temperature, Depth) sensors, bottom pressure recorders (BPRs) and 12 magnetotelluric landers that were deployed in December 2014 from RRS James Cook (cruise JC112). In the final part of the cruise, we deployed an ADCP mooring for 24 hours to monitor flows across the Ecuador Trench, southeast of the Costa Rica Ridge and, subsequently, carried out a series of ~40 CTD casts in the eastern half of the Panama Basin. Swath bathymetry was collected throughout the cruise.

Introduction

The cooling of young oceanic crust is the principal physical process responsible for removing heat from the solid Earth to the hydrosphere. Close to a mid-ocean ridge, rapid cooling is dominated by hydrothermal circulation of seawater through the porous and fractured basalt crust. This hydrothermal fluid is then discharged into the ocean mainly along the ridge through distinct vents called 'black smokers'. The primary objective of this interdisciplinary project is to investigate the effects of this heat loss and hydrothermal circulation on both the solid Earth and the ocean. The data collected as part of the OSCAR project will be used to derive an integrated circulation model, that will be constrained by geophysical, geological and physical oceanography data, which will include fluxes through the seabed.

From a geological viewpoint, understanding of the dynamics of the heat exchange mechanism in the solid Earth requires the resolution of small-scale structural and morphological characteristics of the upper crustal interface between the heat source and ocean. The location of permeability zones and conduits that control the fluid movement is hotly debated, as is the geological nature of seismically imaged layers and their boundaries. Many contradictory models exist, and the majority of these are based on observations made at ridge axes, and do not include the variation in physical properties of the upper crust as it ages and spreads off-axis. OSCAR aims to resolve this debate by acquiring a new geophysical dataset of the upper oceanic crust from ridge axis to ridge flanks, in a location where not only has a spatial variability in heat flux been observed, but also where there is hydrological, geological and geophysical control provided by one of the deepest boreholes drilled to date, into the oceanic crust at site Ocean Drilling Programme (ODP) borehole 504B.

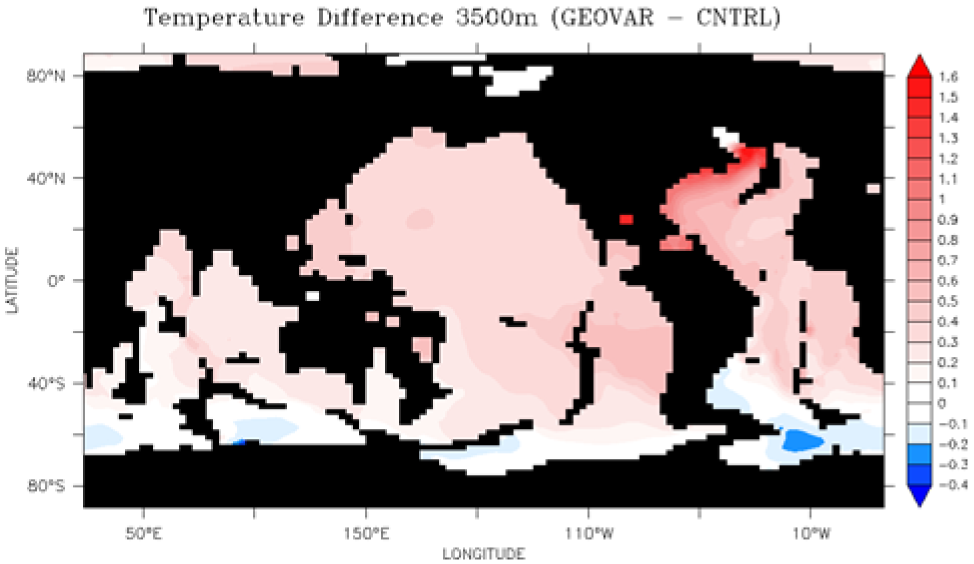


Figure 1. Modelled temperature difference (°C) at 3500 m depth caused by spatially distributed geothermal heating based on the age of ocean crust (Hofmann & Maqueda, 2009).

From an oceanographic viewpoint, it has been generally assumed that geothermal heating only has a small effect on global circulation, but recent modelling has demonstrated that this assumption is wrong and geothermal heating has an influence on mixing in the abyssal ocean and wider effects on the global thermohaline circulation (Fig 1). The modelling is parameterised on a coarse grid and results are based on passive heating above an impermeable seabed and, hence, do not include the dynamic uplift created by the hydrothermal plumes which may, through entrainment, provide a mechanism to lift the cold dense water away from the bottom boundary layer. The coarse resolution of the simulations also means that any large contrasts in the spatial distribution of geothermal and hydrothermal fluxes are not properly represented. In this project, direct measurements of ocean circulation and vertical mixing along a ridge axis and across its flanks have been made, and will be used to build the first high resolution regional ocean-crust model that accounts for both geothermal heat and mass fluxes through the seafloor.

The aims of the OSCAR project require an interdisciplinary dataset which integrates both physical oceanography and geophysical characteristics. Using these data, a new integrated model of the ocean and hydrothermal circulations at active ocean ridges and ridge flanks will be parameterised. This model will provide valuable insight and new constraints on the thermal processes involved, and will set a new benchmark for integrated Earth-system experiments, resulting in both a new representation of the geothermal fluid and heat fluxes at

mid-ocean ridges and a better understanding of what geophysical and oceanographic data can actually resolve in the context of an oceanic axial ridge setting.
The coupling of the ocean and the lithosphere through hydrothermal flow, and the impacts of this flow on both the evolution of the oceanic crust and basin-scale ocean circulation, are the central themes of the OSCAR project.

Study area

A comprehensive investigation of the interaction between geothermal flow and oceanic mixing and circulation requires a combined field and modelling approach in a geothermally active region, with significant tidal and thermohaline circulation, mixing and upwelling. Also, to address the geophysical and geological effects of this hydrothermal flux requires an active spreading ridge with geological constraints provided by a borehole within a distance that can be surveyed within a single geophysical experiment.

The Panama Basin (Fig. 2), which contains the Costa Rica Ridge (CRR) and ODP borehole 504B, is an ideal laboratory for the investigation of these processes. There is a wealth of existing oceanographic, geophysical, geological and geochemical data acquired over many years in independent studies including: numerous heat flow measurements around 504B; detailed down-hole geological and geophysical logging; multichannel seismic (MCS) reflection and ocean-bottom seismograph (OBS) surveys over the CRR and 504B respectively; and physical oceanography (PO) data including part of a World Ocean Circulation Experiment (WOCE) profile.

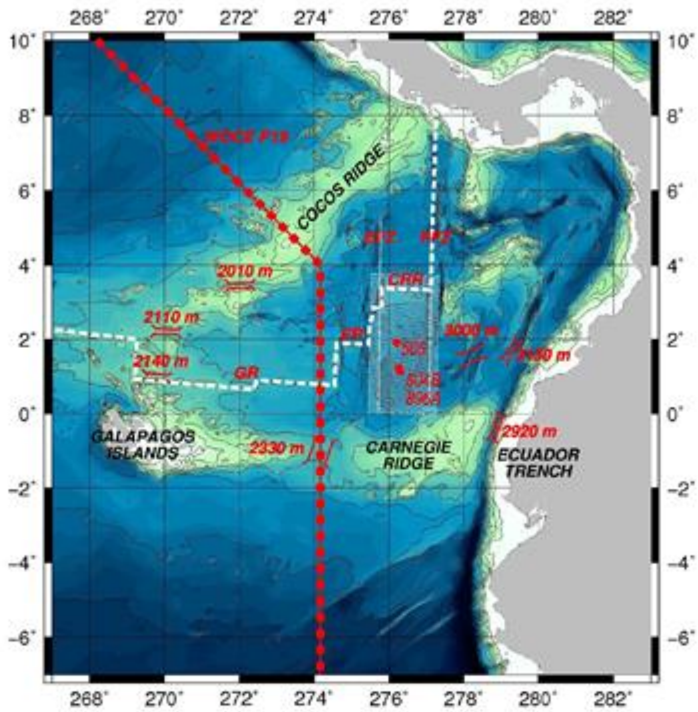


Figure 2. Map of the Panama Basin bounded by the Cocos and Carnegie Ridges. The spreading centre (white dashed line) and the EFZ (Ecuador Fracture Zone) and the PFZ (Panama Fracture Zone) which bound the CRR (Costa Rica Ridge) are marked. WOCE P19 is the track of the World Ocean Circulation Experiment PO profile; ODP drill sites are marked as dots, as are the location of sills and their respective depths (parallel lines). The white shaded box shows the principal research area for SO238.

The Panama Basin itself is a small ocean basin in which the direct effects of geothermal heating on ocean temperature and circulation can be measured and studied in relative isolation from large scale influences. Taking the 2300 m isobath as the basin's natural lateral boundary, then its area is a mere 7 x 105 km2. The lateral communication between the basin and the rest of the Pacific Ocean only occurs through the 2920 m deep Ecuador Trench and the shallow (2330 m) sill of the Carnegie Ridge. It is the isolation of the basin from external influences, except inflow through the Ecuador Trench and downward mixing from above, that makes it an ideal location for the investigation of geothermal and hydrothermal oceanographic impacts.

The inflow through the Ecuador Trench was estimated by Lonsdale (1977) at 0.35 Sv. The average geothermal flux in the basin can be estimated from the digital age map of the ocean floor (Müller et al., 1997) and the Stein & Stein (1992) formula for linking the age of the bedrock to the heat flow through the crust. The basin-averaged geothermal heat flux is 273 mWm-2, which is more than three times the global average. The inflow potential temperature at the Peru Basin end of the Ecuador Trench is 1.75 ^{o}C and, on average, the potential temperature of the outflowing water at 2300 m is 2.1 ^{o}C (Locarnini et al., 2009). Including these values the following interesting results emerge:

• the geothermal heat flux on its own is sufficient to heat up the basin by almost 0.15 ^{o}C, and explains nearly 55% of the water temperature increase as fluid transits through the basin;

• the remaining 45% is the energy necessary to heat the water in the basin to the observed value, and must be provided by downward diffusion, with a vertical diffusivity at 2300 m of around 1 x 10-4 m2s-1, a value which is about 10 times larger that the canonical open ocean background mixing rate (e.g. Polzin et al., 1997).

These simple calculations strongly support the notion that geothermal heat flow plays a central role in the energy balance of the Panama Basin.

Project objectives

The OSCAR project is underpinned by six basic questions about the solid Earth and ocean system that were addressed during cruises JC112, JC113, JC114 and SO238. These questions revolve around a better understanding of shallow oceanic crustal structure and how fluid flows through it and conveys heat to the overlying ocean. A schematic definition of the oceanic crust is shown in Fig. 3, with the possible fluid flow paths marked.

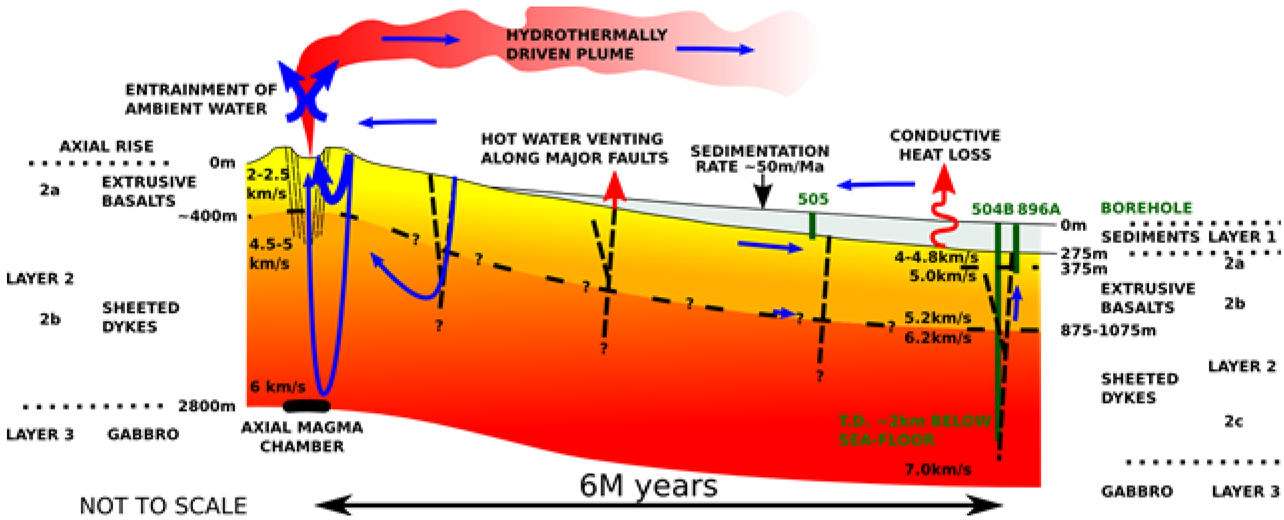


Figure 3. Cartoon showing the structure of the ocean crust from the Costa Rica Ridge to 504B. The blue and red arrows are indicative of the water and heat flow in the crust and ocean.

a) What is the layer 2A/B interface? At the mid-ocean ridge axis this interface is understood to represent the transition from a layer of extrusive flows to the dyke feeder system as defined by changes in the velocity gradient. As the crust ages the velocity gradient gets perturbed by chemical alteration resulting from hydrothermal circulation. The relationship between velocity and geological structure can be calibrated at 504B located some 6 Ma off-axis. The objective here is to geophysically map the transition from axis to borehole.

b) Do dykes play a significant role in fluid flow on- and off-axis? Despite their relatively low porosities, dykes have been shown by micro-earthquake and anisotropy studies to be important for ridge crest and near ridge crest hydrothermal circulation. Electromagnetic studies also show that hydrothermal fluids penetrate to the deeper parts of layer 2 and to a significant distance in the off-axis region, but their role in ridge flank fluid flow is unclear. The objective is to estimate crack density and orientation within a few kilometers of the ridge axis and how this changes on the ridge flanks.

c) How do faults in the upper crust influence the flow of fluids between crust and ocean? Tectonic features are thought to play an important role in fluid flow at upper crustal levels providing pathways through impermeable layers. For example, flow in faults beneath sediment layers on the ridge flanks, in areas without significant basement outcrop, has been proposed to explain the discrepancy between predicted and observed heat flow. The objective is to map heat flow (cruise JC113) variation relative to surface topography using swath bathymetry data, and the relationship to basement structure determined using seismic reflection and sub-bottom profiler data.

d) What is the role of geothermal fluxes in establishing and maintaining the heat budget of an abyssal basin? Theoretical observations and global ocean models indicate that geothermal heating has a strong thermodynamic signature in the abyssal ocean, of the order of 0.3 to 0.5 ^{o}C, and is a key control on the abyssal circulation. However, observational evidence of the impact of geothermal and hydrothermal processes on the ocean circulation of any particular basin is, to the best of our knowledge, non-existent. The objective is to quantify the influence of geothermal heating on the observed temperature in the Panama Basin.

e) How does the basin-scale distribution of diapycnal mixing depend on the distribution and intensity of geothermal heating and hydrothermal venting? We anticipate that all the mixing regimes in which geothermal processes play a role can be characterised by sampling along the axial ridge valley, the ridge flanks and adjacent fracture zones. Current, temperature, salinity, turbidity and 3He/4He concentrations were measured at all depths over a spring-neap tidal cycle during JC112 and JC113. The objective is to constrain detailed basin-scale modelling of the water flow in the Panama Basin.

f) What is the importance of fluid exchange between the crust and the deep ocean? In all ocean modelling studies to date, geothermal forcing is synonymous with heat flux. None of these studies has considered the relative importance of fluid (mass) exchanges between the crust and the ocean. We know that high-temperature hydrothermal fluid is distributed over very long distances by the large-scale circulation and that significant hydrothermal flow occurs at low temperatures. The objective is to build three-dimensional coupled solid Earth ocean models to explore the influence of mass exchange and tidal forcing on geothermal heat flux.

The data from cruise SO238 directly addresses the last three (d, e & f) of these OSCAR objectives.

Cruise Narrative

Miguel A. Morales Maqueda (NOC)

03/02/2015

~1500 GMT. Conversation on the phone with Richard Hobbs. JC114 are ahead of time and will do some seismic work in the rather narrow international water region located in the central area of the basin, south of the Costa Rica Rift. The expectation is still for FS Sonne to rendez vous with RRS James Cook in the vicinity of the International Ocean Drilling Programme 504B and then to start shooting the planned SAP lines (see Fig. 4 below). The plan remains supple in terms of time. If the Sonne can leave Balboa on the 6th February rather than on the 7th, we could start our shooting one day earlier.

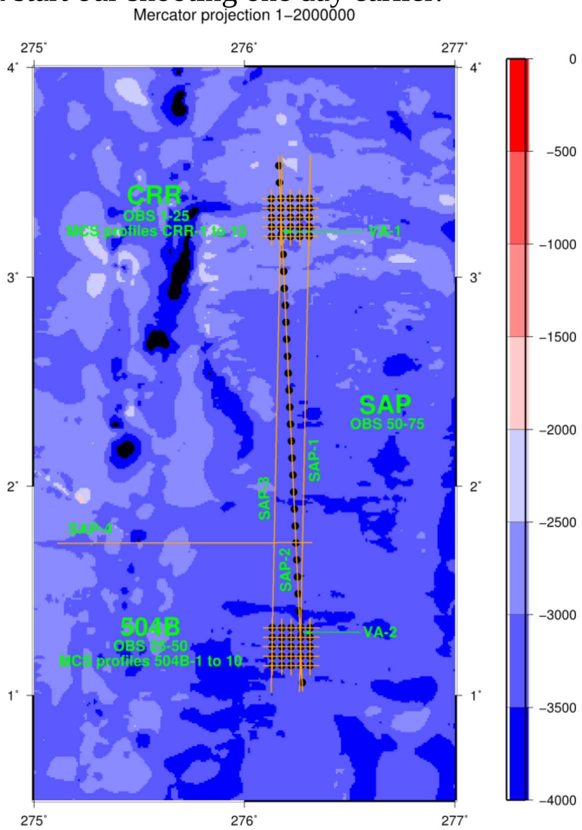


Figure 4. Synthetic Aperture Profile (SAP) lines planned for JC114-SO238. SAP-4 is optional.

04/02/2015

0615 GMT. PSO flying from Manchester to Panama. We had delays departing from Manchester because the Lufthansa aircraft (Airbus 320-200) needed de-icing and the headset of the de-icing engine was not working. Eventually we reached Frankfurt in time. I bought 200 euros (5% commission) at the airport because I forgot to bring any with me and euros are needed for payments in the bonded shop on the Sonne. The flight to Caracas is on a Lufthansa Airbus 330-300. The last leg of the journey, from Caracas to Tocumen International Airport, is with Copa Airlines. Most scientists and technicians are due to arrive in Panama City (Crowne Plaza Hotel) today. Steve Whittle and John Wynar, from NOC, arrived on the 3rd, I understand, while Gary Menéndez (INOCAR) will get into Panama on the 5th February, once he has managed to obtain all the required permits from the Ecuadorian Navy.

05/02/2015

0630-0700 EST (Eastern Standard Time). Informal meeting with some participants in the hotel (Crowne Plaza) during breakfast. The Sonne agent drivers were supposed to pick us up between 0730 and 0830, but they were rather late. Eventually, Jorge, one of the two drivers showed up with Steve Whittle and John Wynar, who had been picked up from their hotel (the Granada). Instead of going immediately to the port, Jorge went somewhere (I do not quite know where) to fix various problems with the documentation of several of us. Rafael Catany, Daniel Wehner and John Wynar had no seafarer visa or permit to enter the harbour, while Simona Aracri was missing a stamp on her visa. Once this paperwork was sorted out, we were all taken to Balboa on a big car and a minibus. At the gate, a second bus took us all to the Sonne.
1200 EST. Lunch on board. Eventually, we wound up at the ship, where we met the Master, Oliver Meyer, and were given a short tour of the ship by the second officer. Then we had lunch and waited for the agent to come and arrange the unloading of 6 containers from the ship (GEOMAR USV and ROV equipment). A crane had to be brought specifically for the task. It was also made clear to the agent by the Master that the ship needed to be bunkering at 0700 on the 7th February. The bunkering will not be done while tied up but away in the bay from a floating barge.
1300 EST. VIPs from the German Embassy in Panama, including the German Ambassador, visited the ship. I gave a short talk about the project, its science, funding and international components. The Ambassador suggested that they would visit the ship again upon our return on the 6th March (this second visit did not take place).
1700 EST. The 6 GEOMAR containers were unloaded by 1900 EST and three containers loaded subsequently. One of these containers contained equipment for the seismic work and the other two containers had been sent from Caldera to Balboa by the James Cook agent in Costa Rica. One of them (white container) was the mooring workshop that had been used during JC112 and the second container (green) was packed with equipment from JC112 to be used in SO238. The scientists and technicians left the ship for the hotel at 1930 EST.

06/02/2015

0700 EST. Unexpectedly, the transporters for the Sonne agent appeared in the Crowne Plaza soon after 0730 EST ready to carry scientists and technicians to the ship for embarkation. Steve Whittle and John Wynar had already been picked up at the Granada Hotel and taken to the ship. Embarkation for the rest of us took place at ~0900 EST. Morning and afternoon was spent in unpacking boxes, deciding in which laboratories to install the different pieces of equipment and setting it up. The Klima Labor I will be used for the Autosal at a constant temperature of 19 C.
0900 EST. The Ecuadorian representative, Cabo Primero Gary Menendez, arrived in Panama the previous night and went to the Crowne Hotel. The agent was instructed to pick him up in the morning from the hotel, but due to various paperwork and visa delays he did not arrive in the ship until ~1530 EST.
1030 EST. Simona Aracri was given the task of cleaning all the Helium samples collected in JC112 and inspecting them for signs of leaks or corrosion. The helium equipment was installed in the Wet Lab II. The workstation pstar that was used during JC112 was installed and networked in the Dry Lab I. It took until late in the afternoon to have it ready. The

computer does not have access to the internet, but it is visible within the ship's network, which is all that matters to us.
1300 EST. A Panama TV crew and local newspaper journalists came to visit the ship alerted by the German Embassy in Panama. The Captain and I talked to them and showed them around the ship.
1430 EST. Back to Trocken Labor I to finalise the installation of the workstation banba.
2030 EST. Patrick, Vicent, Martyn, Paula, Simona, Rafael, Daniel and PSO went to Casco Antiguo in Panama for a few drinks.

07/02/2015

0600 EST. Out into the bay off Panama City for bunkering.
~0800EST. Steve Whittle had to be disembarked due to unexpected family reasons. We are left therefore with just one NMF technician.
1020 EST. Safety meeting in the hangar for all scientists and technicians.
1300 EST. Meeting in the conference room for the scientists to meet with the main officers and doctor.
1400 EST. A problem with the pump to transfer fuel from the bunkering barge to the ship's tank: it is the wrong size. It will take a few hours to bring the proper pump, which means that our departure needs to be delayed until probably midday of tomorrow.

08/02/2015

0600 EST. Refuelling completed and we are on our way.
0900 EST. Meeting with the Captain, First Officer, Doctor, Klaus, Patrick, John, Matthias, Miguel to discuss instruments to be used in the cruise.
1300 EST. Discussion with Matthias and Stefan regarding the acoustic systems. The scientists will be in charge of the EM122 (swath bathymetry) and the swath data processing system (Fledermaus).
1330 EST. Meeting in the conference room with scientists and technicians to discuss watches and other arrangements.
1530 EST. Safety drill. One needs to be dressed in long-leg trousers, overalls or something similar. No shorts!
1600 EST. Met with Simona, Rafael and Martyn in the hydroacoustics room to discuss watches and how to organise ourselves, in combination with the other cruise participants, to deliver the best possible science through the cruise. We are clearly understaffed, though. We will be the focus of activities, but will try to entrain others, such as Paula, Daniel and Gary into the work when appropriate. Patrick and Klaus will assist John in the recovery of moorings.
1800 EST. CTD trial. Bottles were fired and data downloaded, but no samples taken.

09/02/2015

0700 EST. Passed at a few miles away from Malpelo Island, which was well visible in the horizon to port.
0845 EST. Daily bridge meeting.
1100 EST. PSO created a watch program for the science and technical crew.
1300 EST. Simona and Martyn are dealing with the swath bathymetry data. It is stored in disk D of the EM122 PC and shared in disk D of the postprocessing pc in the hydroakustic

raum. PSO explained that, in order to calculate depth from sound time of flight, one needs indeed a profile a sound speed, not just the vertical average. For example:

$$T = \frac{1}{2}\int_{-H}^{0}\frac{dz}{c(z)}\,,$$

where T is the time of flight of the echo sounder signal, H is depth of the water column, and $c(z)$ is the sound speed profile.

1530 EST. Created a work programme for the next two days or so and distribute it around the ship (Wiss. Fahrt Buero, Bridge, Lounge, Hangar, Trocken Lab I). The programme became almost immediately obsolete, as Richard Hobbs provided new information on the plan for the James Cook-Sonne rendez-vous and subsequent shooting starting on the 10th February. The plan considered a starting time of 0700 EST for the Marine Mammal Observations; 0800 EST for the deployment of the airguns; 0900 EST for the soft start; and 1000 EST for the effective.

1700 EST. All is ready for the shooting as far as the GPS antennas, the clock and Vincent's recording device is concerned.

2000 EST. CTD #002 for the training of the Physical Oceanography crew ahead of the commencement of the proper CTD cast series in about one week's time. Richard Hobbs sent an e-mail requesting that we carry out the MMO exercise and the deployment of the airguns simultaneously, which sounds eminently reasonable. After talking to the Captain and Chief Officer, we agreed to approach the rendez-vous point with the Cook as fast as possible after finalising CTD #002 in the early morning of the 10th Feb. The instructions for rendez-vous and subsequent shooting programme from Richard Hobbs are as follows:

"Hi Miguel

Attached are the full waypoint list for the SAP profiles. At current progress we will be at the first of these points by 2200(L) 0400Z on 10th. We tow the MCS gear at 4.9+/-0.2 knts, turn rate is about 1°/min so we carve turns of about 3nm.

Probably the best idea is for the sonne to shadow the cook from ~0400Z staying off to our port side (we always turn to starboard to avoid the hydrophone streamer crossing the airgun lines). The bridge will advise as to what they consider the safe distance. Once we have completed our 3rd turn and heading north ~1200Z then the sonne needs to drop back to be 4.8 nm behind the cook and maintain that position on the north-south profiles to better then +/-0.1 nm, please. I am not so concerned about turns and the short east-west lines.

I suggest communication is primarily through VHF - we need to agree a channel or channels if the bridge wants a separate link from us scientists.

Emma - lead MMO on Cook will be on duty from 1200Z, I suggest you get Simona and Paula lined up ready please as both ship have to do independent MMO duties.

Assuming all clear for 1 hour the Sonne can commence soft start from 1300Z. Unless we have a problem we will continue to fire our guns through the night as they will be recorded on the OBS that we have already deployed. If we have shut down then we will also need to soft start too.

NB the COOK AIM POINT has shifted 3 mile from the first set of points, this is not so important to you as this is when we turn on the multichannel data logger.

1°14.009N, 83°36.351W, TURN
0°50.000N, 83°36.351W, TURN
0°50.000N, 83°42.930W, TURN

SAP_B
0°57.085N, 83°43.292W, COOK AIM POINT

1° 3.730N, 83°43.540W, SAP_35
1°24.274N, 83°44.459W, SAP_29
1°48.603N, 83°45.548W, SAP_24
2°12.933N, 83°46.637W, SAP_19
2°37.263N, 83°47.728W, SAP_14
3° 1.594N, 83°48.818W, SAP_09
3° 6.460N, 83°49.036W, SAP_08
3°31.874N, 83°50.177W, SAP_01

3°40.800N, 83°50.530W, COOK LSP

3°43.840N, 83°50.650W, TURN
3°43.840N, 83°40.900W, TURN

SAP_A
3°36.000N, 83°41.090W, COOK AIM POINT

3°16.819N, 83°41.534W, NG_11

2°53.382'N, 83°41.946'W, HEATFLOW PB02
2°49.578'N, 83°42.048'W,

2°34.266'N, 83°42.444'W, HEATFLOW PB03
2°30.384'N, 83°42.546'W,

2°18.630'N, 83°42.744'W, HEATFLOW PB04
2°14.154'N, 83°42.756'W,

2° 0.228'N, 83°43.122'W, HEATFLOW PB05
1°57.510'N, 83°43.182'W,

SKIP NEXT 2 WAYPOINTS AS THESE ARE NOT ON PROFILE
1°38.718'N, 83°44.454'W, HEATFLOW PB06
1°35.706'N, 83°44.166'W,

1°14.002'N, 83°44.001'W, SG_12

0°52.000'N, 83°44.390'W, COOK LSP

0°49.000'N, 83°44.500'W, TURN
0°49.000'N, 83°52.550'W, TURN

SAP_C
0°56.840'N, 83°52.420'W, COOK AIM POINT

1°13.993'N, 83°52.081'W, SG_15

1°37.828'N, 83°51.586'W
1°58.322'N, 83°51.176'W
2°18.818'N, 83°50.773'W
2°39.313'N, 83°50.376'W
2°59.809'N, 83°49.984'W

3°17.068'N, 83°49.626'W, NG_14

3°40.800'N, 83°49.220'W, COOK LSP"

10/02/2015

0030 EST. End of CTD cast #002. Rosette out of the water. Many squid swarming around the CTD spotlights. Heading to rendez-vous point with James Cook.
0645 EST. Beginning of airgun deployment. First port, then starboard. Simona and Paula ready in the observation room next to the bridge. All went according to plan and the full shooting started at around 0900 EST.
1030 EST. Download of SVP data from Valeport with John Wynar. A message indicating that there is a timer error or inconsistency of some sort appeared several times on the screen. Also, none of the dates of the data files in the Valeport Midas memory card correspond to a file created yesterday or today. Most strange. Must investigate, but will have to leave until tomorrow as I need to sort out GEBCO bathymetry data for the Panama Basin for Simona and Martyn.
1300 EST. Using the gebco_08.nc data set to extract a subdomain spanning the entire Panama Basin. Since all laptops on board lack the memory to load and manipulate the 1-minute-arc GEBCO data, I have loaded the dataset on the BANBA workstation and downloaded from the web a matlab program that allows us to read the GEBCO dataset and extract a window of predetermined lat-lon size. The program is called gebconetcdf.
1600 EST. Conversation with Richard Hobbs and Vincent on the VHF system for an update on seismic shooting. All seems to be running smoothly. Richard confirmed that some spares for the Cook are being carried on the Sonne and will have to be exchanged at the end of the joint seismic program. We also mentioned the fact that there is only one NMF technician on board the Sonne. NMF are considering transferring one technician from the Cook to the Sonne after the seismic shooting is finished, although John Wynar seems confident that he should be able to handle all the mooring work with the help of Patrick.
1800 EST. Richard Hobbs has sent a plot of preliminary data from today's shooting. I have printed it for Vincent, who is going to add some comments and show it to the other scientists and officers on board.
2000 EST. Richard on the VHF again. The back end of the Cook's hydrophone streamer has developed a problem and is no longer working. As a result, the Cook plan to drop to the east of the shooting line and recover the streamer for repairs and/or replacement of the faulty system. This will take the best part of the night. In the meantime, FS Sonne to carry on shooting along the agreed shooting line for about 5 hours (until ~0100 on the 11th Feb.) and then turn back along the said line to rendez-vous with the Cook by early daylight on the 11th Feb. to resume shooting at 0800 EST. Richard has promised detailed instruction in an e-mail.
2100 EST. It turns out that 4 of our own airguns are out of order, and so Klaus is recommending recovering the whole system for inspection.
2330 EST. End of recovery of the Sonne airgun array. The problem was quickly identified and solved by about 0130 on the 11th Feb. It seems that some of the tubes connecting a section of the compressed air conduit to the airguns was damaged, which caused a significant fall in pressure. Typical airgun pressure is 210 psi.

11/02/2015

0930 EST. Meeting in Trockenlabor I with the Physical Oceanography group to discuss work (e.g. who is going to deal with the underway data, etc.). We then went to Trockenlabor III, where John has installed a Guildline salinometer. The laboratory is maintained at a temperature of 18^{o} C. Unfortunately, the autosal is giving very erratic readings and will have to be replaced by a second autosal. John spent part of the morning and afternoon replacing and testing this second salinometer.

1030 EST. I downloaded all the data contained in the SVP that is being deployed clamped to the CTD rosette. Some of the data in the SVP (a Valeport Midas with CTD) goes back to the first test deployment of the CTD in 2014, but I downloaded that too. Interestingly, the clock of the SVP seems to have developed a problem during the last download, as the data recorded is dated 24/01/2061!. The date and time of the instrument must be reset before the next CTD cast, which will be the first properly scientific cast of the cruise.
1330 EST. Helping John Wynar to install the replacement autosal in Dry Laboratory III.
1600 EST. Radio conversation with Richard Hobbs regarding progress of the seismic shooting. No news. All is running smoothly.

12/02/2015

0845 EST. Meeting with Captain and officers in the bridge. Need to collect information about travelling arrangements for all science participants as it is need by the Sonne agent by this coming week end. Container arrangements for our arrival in Balboa need to be sorted out by next week in liaison with the Cook agent. The captain asked to clarify with Richard Hobbs whether the airguns were going to be stopped during the turning into line SAP 1 from SAP 2 (the latter being the line we are doing first).
0930 EST. Meeting in Trockenlabor III with John and the Physical Oceanographers to receive training on the use of the salinometer. The replacement salinometer behaves better than the first one but is still somewhat erratic. John Wynar will empty it, clean it and refill it with MiliQ water.
1330 EST. Discussed with Rafael about the variables logged through the DSHIP system and that need to be downloaded and stored by us. The documentation for many of these variables is very poor. We need to come up with a strategy in the next couple of days.
1600 EST. Speaking to Richard Hobbs again on the radio. All running smoothly on both ships. The expectation is to finish line SAP 1 at around 1700 of 13/02/2015 and then move onto SAP 3.

13/02/2015

0600 EST. Richard Hobbs sent a message about a small seamount the James Cook has detected with their swath system (coordinates 3 42.3N, 83 48.3W). Since the feature is not present in the GEBCO dataset, Richard suspects that it must have formed recently and that it might still be relatively hot and worthwhile exploring with the CTD. A taller seamount to the north is probably one we saw during JC112 while scouting for a suitable area where to do our tow-yos.
0730 EST. Got information about the Parasound system, which sounds very promising for water column exploration.
0800 EST. Reset the date and time in the Valeport SVP to reflect present time (as opposed to some strange time and date in 2061!).
0900 EST. I arranged with Matthias to meet at 1300 to turn on and setup the Atlas Parasound system.
1300 EST. Discussion with Matthias about Parasound system. He set up the system for water column monitoring and explained the rudiments of the system to me. I also downloaded information on the tween system that is used on the Maria S. Merian.
1330 EST. Discussed with Rafael about the downloading of Met Station data and TSG data from the DSHIP system. Subsequently I started to look at downloading all the navigation data by myself.

1600 EST. Talked to Richard and Vincent on the VHF radio in the bridge. They still expect to finish the seismic work by around midday on the Cook (there is one hour difference between time on the Cook and time on the Sonne, as they use Costa Rican time, while we use Panama time). Once the seismic work is completed, we will exchange the spare parts for the Cook and the salinometer for the Sonne via boat transfer. The Cook expect to be ready to enter Balboa on the 6th March together with the Sonne. That would make the transfer of containers from the Sonne to the Cook easier. All that will remain to be done on the Cook after the joint seismic work is finished on Sunday is to recover the OBS along SAP2 and then shoot the 5 by 5 seismic grid around 504B, finishing by recovering the 2 seismic moorings deployed in the Sandra Ridge area.

14/02/2015

0600 EST. Established a template order to download all navigation and WAMOS data from the ship. One hour of full navigation data (3 GPS, 2 gyroscopes, NACOS, Seapath, and some other minor data sets) amount to no more than 3 Mbytes.
0900 EST. Helium training session with Simona, Paula, Rafael, Martyn and Guillermo. It turns out that the compressed air tube that I borrowed from the James Cook does not fit in the compressed air sources installed in the laboratories on the Sonne. I suspect a problem of Imperial versus metric sizes. I have spoken to the chief engineer about this. He is confident that a solution will be found prepared.
1030 EST. Discussion with Simona, Rafael and Martyn about DSHIP data download and storage.
1520 EST. Guided visit to the engine room. Arranged with Roman Horsel, 2nd engineer, to sort out the compressed air connection for the foot pump that actuates the crimping tool (helium sampling equipment).

15/02/2015

0900 EST. Continue shooting seismic line until around 1400.
1100 EST. Conversation on the VHF with R. Hobbs and V. Tong. The Cook are having problems with their airguns and are going to stop shooting one hour ahead of time. They requested that the Sonne continues shooting all the way to the end of the line so that the shoots are recorded by the OBSs.
1400 EST. Recovery of the airguns.
1530 EST. CTD over "new" seamount discovered by the James Cook during their seismic work.
2130 EST. CTD in the vicinity of M1.

16/02/2015

0130EST. Swath survey around M1.
0600EST. Preparing recovery of M 1. EM122 and Parasound had to be turned off to avoid interference with the over side transducer used to communicate with the IXSEA releases. When turning off the EM122, I realised that the CTD station completed the previous night was not in the right place. I wanted a CTD station located about 2.5 miles to the east of the M1 mooring in the axial ridge, but ended up with a station located about 2 miles to the northwest and outside the axial ridge.

0630EST. Mooring released and coming up to the surface. The mooring was grappled by the central buoyancy pack, as shown below and got entangled in the rudder as it was dragged for recovery astern. Eventually, a boat had to be put in the water in order to loosen the entangled polyester rope. Recovery was completed successfully, finishing at about 1130.
1400EST. Boat transfer to the Cook. Geodetic equipment, some spares for the Cook, four boxes of Becks bier were sent across. The Colombian observer sent coffee and an external hard drive to the Colombian observer on the Cook. Vincent Tong went across to the Cook to discuss with the seismic team a number of problems regarding the recording of seismic data on board the Sonne. These problems will be discussed in their contribution to the cruise report.
1600EST. Beginning of MT recoveries, starting at MT 12 and continuing uninterruptedly to MT 6. These landers are equipped with Novatec radio and light beacons. Only the light beacon of one of the MT landers failed. The lander had to be found using the ship's search light, as it was still dark, but it was eventually found and recovered.

17/02/2015

0830EST. M2 mooring released. The mooring was recovered by positioning the ship downwind of the mooring packages, avoiding in this manner the problems experienced the previous day when the mooring was recovered from the starboard side. Mooring on board without major problems at 1100.
1300EST. Release of RAPID lander. Communicating with the equipment was easy and it released quite rapidly. Initial ascent speed of about 50 m/min. It took a long time to see the lander once it reached the surface, the reason being that the radio beacon antenna remained under water. This feature of the lander design is particularly bad. It would be better for the lander to remain vertical as it reaches the surface, maybe by putting some foam inside the top sphere, thus giving it more buoyancy than the bottom one.
1530EST. CTD station at M2 site.
1930EST. Continue with the recovery of MT3 to MT1, followed by recovery of M1 in the morning.

18/02/2015

0630EST. Release of M3. Although initial estimates seemed to suggest an ascent speed of over 1 m/sec, the mooring took almost one hour to reach the surface. The boat was put on the water to ensure that the top of the mooring could be recovered first using the aft A-frame. As in the other two mooring recovery cases, the mooring line was seriously entangled. It seems that the bottom buoyancy package (7 spheres) is so buoyant that it catches up with the one above it during the ascent. Also, the recovery line is next to useless: it comes always completely wrapped around the top buoyancy package.
1030EST. Steaming to CTD station number 6. I have reduced the number of CTD stations between M3 and ADCP-West to 3 from the original 4 in order to ensure that all mooring recoveries can be made by daylight.
1430EST. CTD 6. Three small pyrosomes where recovered from the top of the CTD. Similar to those encountered around the Galapagos in JC112, but smaller. Note: maybe this CTD should have been carried out at the location of M3, in the same way as there was a CTD at M1 and M2. Anyway, it is too late for regrets now.

19/02/2015

0200EST. End of CTD cast. Heading towards mooring site ADCP-West.
0930EST. Mooring site ADCP-West. Recovery mooring without complications.
1400EST. Likewise for ADCP-East. We next go back towards the northwest to complete CTD 8.
2030EST. CTD on deck. We head to the southern end of the Ecuador Trench. It will take about 18 hours to get there.

20/02/2015

1700EST. CTD at Ecuador Trench South. Readjusted CTD location compared to initial choice.

21/02/2015

0000EST. CTD at 0050. Ecuador trench middle. We had to move the CTD cast slightly to the east compared to the original position. Spent most of the 8 hours before the deployment of mooring ADCP-Ecuador Trench trying to figure out why the Fledermaus software that we use on the Sonne does not provide realistic values for the vertical coordinate or scalar field. It was easy to display these values on the James Cook. Must investigate further. Without the capability for performing this simple task, the use of the Fledermaus in combination with the GEBCO bathymetry to guide the location of CTD and mooring sites is significantly compromised. The chosen place for deployment of the ADCP (the northern sill of the trench) was eventually located about 8 miles north of the initially specified site according to GEBCO.
0800EST. Deployment of ADCP mooring in the Ecuador Trench. This is identical to the earlier mooring ADCP-EAST. Jens Goebel, the first mate, pointed out to me that in the diplomatic clearance application, I had indicated that no activity in Ecuadorian waters, other than CTDs, was going to take place inside the 50 mile limit. As it turns out, the ADCP mooring in the Ecuador Trench is abour 38 miles from the nearest land (Cabo Pasado). Jens was concerned about the "legality" of deploying the mooring. However, the diplomatic clearance, which was approved, clearly gives the coordinates of the point and so the Captain and I agreed that it was all right to proceed.
0900EST. CTD cast in the vicinity of the ADCP mooring, with Helium sampling.
1215EST. The RS-232 communication between the CTD cable and the instruments or the computer was interrupted while the CTD was on its way up and at about 700 m depth. The CTD was brought to the surface and Matthias Grossman is investigating.
1630EST. CTD Equipment repaired. Station 11-00 to be repeated.
1930EST. CTD 11-00. Equipment on deck ready for helium sampling.

22/02/2015

0000EST. CTDs all night. PSO creating station plan for the remainder of the cruise.
1000EST. Recovery of ADCP mooring. All recovered by 1100.
1100EST. Sailing to ECDR 1 (CTD station 012). The ECDR line was not included in the initial SO238 plan but, given that we have sufficient time, it makes sense to complete it for the benefit of our Ecuadorian colleagues (and ours).

23/02/2015

0100EST. First Ecuador line CTD. We plan to do 9 CTDs along this line with salinity sampling only at odd numbered stations.

24/02/2015

0000EST. CTD cast at ECDR 6.
0500EST. CTD cast at ECDR 7. Forgot to split the CTD data file into two parts (downcast and upcast) as we usually do.
0700EST. Created a "plan" for the calibration dip which will take place at ECDR 9 (CTD station 020). This is very similar to the plan for the calibration dip during JC112. SBE37s: 10 second sampling period; SBE53s: 60 second sampling period. The CTD should be stopped at 3000 m, 2700 m, 2350 m, 2000 m and 1500 m for a period of 20 minutes at each of these depths
0845EST. Meeting on the bridge. The Captain has asked that the two NOC containers be ready for unloading on the 6th as early as possible. The bosun and John Wynar should discuss the details of packing.

25/02/2015

0130EST. Last CTD of the Ecuador Line. This CTD is also a calibration dip for all microCaTs that have been recovered during the cruise as well as the two SBE53s. These instruments were clamped to ratchet straps from the CTD (SBE37s) or tied up to the vertical bars of the rosette (SBE35s). We have also taken helium and salinity samples in this station. We were late starting the CTD cast because clamping the SBE37s to the CTD took much longer than initially expected. In the future, allow for at least one hour to arrange 20 microCaTs to the rosette.
1100EST. A small Ecuadorian boat approached us near CTD station CTD12. They wanted some food, to sell us some fresh fish (mahi-mahi) and to tell us that they had a fishing line (maybe a few hundred meters long) located to starboard of us. From the bridge, it was possible to see fish (maybe tuna) jumping around the black flag located at the end of their fishing line. The Captain bought two mahi-mahi from the fishermen at a price of $40 (bargain!). We have moved the CTD station about half a mile to the west to avoid overrunning the fishermen's line.

26/02/2015

26 Had to change coordinates of CTD 16 (station 025). The original position was on the western flank of the subduction zone, rather than at the centre. In retrospect, the station's nominal position corresponded to the Ryan 7 position and should have been retained. Too late now for corrections.

27/02/2015

0200EST. Looking for depths larger than 5000 m for CTD 19 (Station 026). None found. Suspect that GEBCO 1minute is too inaccurate in this area and that the >5000 m depths reported in the software do not actually exist.
0900EST. Meeting in bridge. Captain asked to mention Klima Labor problems (too much condensation) in cruise report.

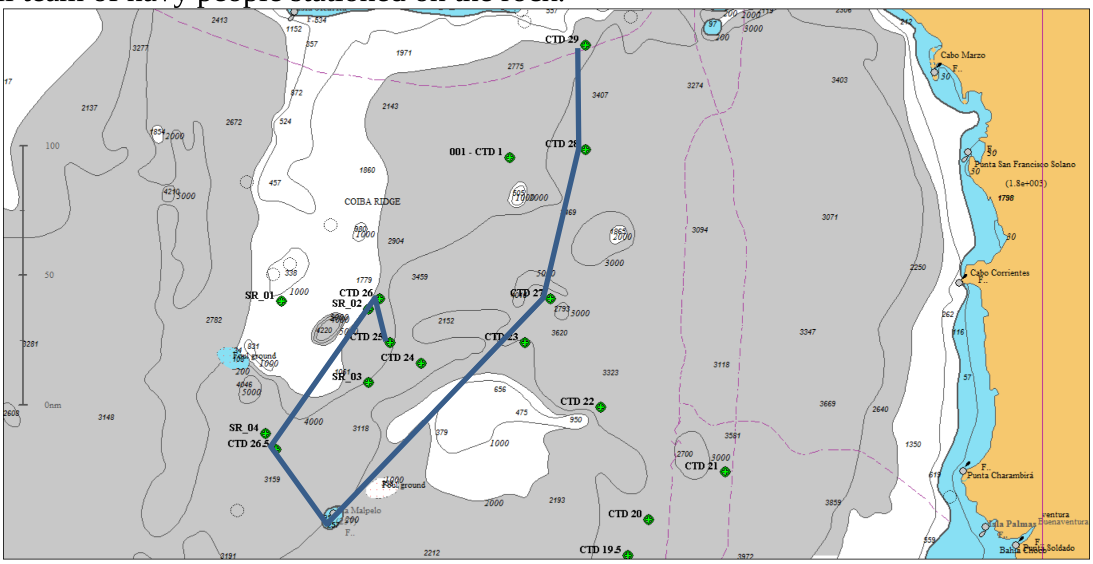
0900EST. Did last 9 samples of Helium at CTD19 (Station 026) (2 leaked).
1300EST. Turned on barometer in wet lab for calibration of RAPID lander.

01/02/2015

1300EST. Finally started recording the barometric data in the aft wet laboratory. I am using a Latitude Laptop borrowed from John Wynar to do the recording via hyper terminal. The RS232 serial connection is the one that Jon Seddon fabricated for me on the James Cook.
2000. Created a new plan for the last two days of science that involves going around Malpelo Island on Monday morning or early afternoon. See diagram below.

02/03/2015

0600EST. Discovered that SVP has run out of batteries. It did so quite a few CTDs back. Need to determine missed data stations. Must find out when the discovery was made. I think it was on the 01/01/2015 and that Matthias changed the batteries accordingly on the morning of the second, while the crew were cleaning the winch wire (too much blue grease seems to have caused the wire to repeatedly slip during the previous cast).
0900EST. The Captain advised that the weather was going to deteriorate, with force 4-5 winds and gusts of 6-7.
1200EST. Going to Malpelo in our way to the last three stations. Too windy and rough to approach the island. We entered the marine protected area but keep about 4 miles away from the coast. When we got there at ~1500, the Colombian observer talked on the radio with the small team of navy people stationed on the rock.



03/03/2015

0900EST. Completed a draft of the cruise de-briefing document during the early hours of the midnight to midday watch and sent it to the Captain before the 0845 meeting in the Bridge.
1100EST. Downloaded data from the RAPID lander RL14. All the data seems good.
1530EST. De-briefing meeting with the Captain, the head of IT and the chief engineer. The debriefing document should be included as appendix to the cruise report.

04/03/2015

1930EST. Karaoke Abend to celebrate the end of the cruise and Luis Royo's birthday.

FS Sonne track during SO238.

Seismic data acquisition

Vincent Tong (Birkbeck College, University of London)

1. Overview

SO238 formed part of the two-ship seismic data acquisition programme in the OSCAR consortium. The acquisition involved both the Sonne and the James Cook (JC114). The principal objective of the two-ship acquisition was to obtain long-offset seismic reflection data for imaging the crustal structures along three north-south profiles in the Panama Basin between the Costa Rica Rift and the borehole 504B. The two-ship data acquisition was performed from 10 February to 15 February. Whilst airgun shots were fired from the Sonne and the James Cook alternately, the Sonne was not involved in any recording of seismic data. For activities related to seismic data recording by streamer and the ocean-bottom seismometers, please refer to the cruise report of JC114.

2. Airgun array

A total of 12 G Guns (Geomar) in six pairs were deployed from the Sonne and used in the seismic data acquisition. Fig. 5 shows the configuration with airgun numbers and capacity

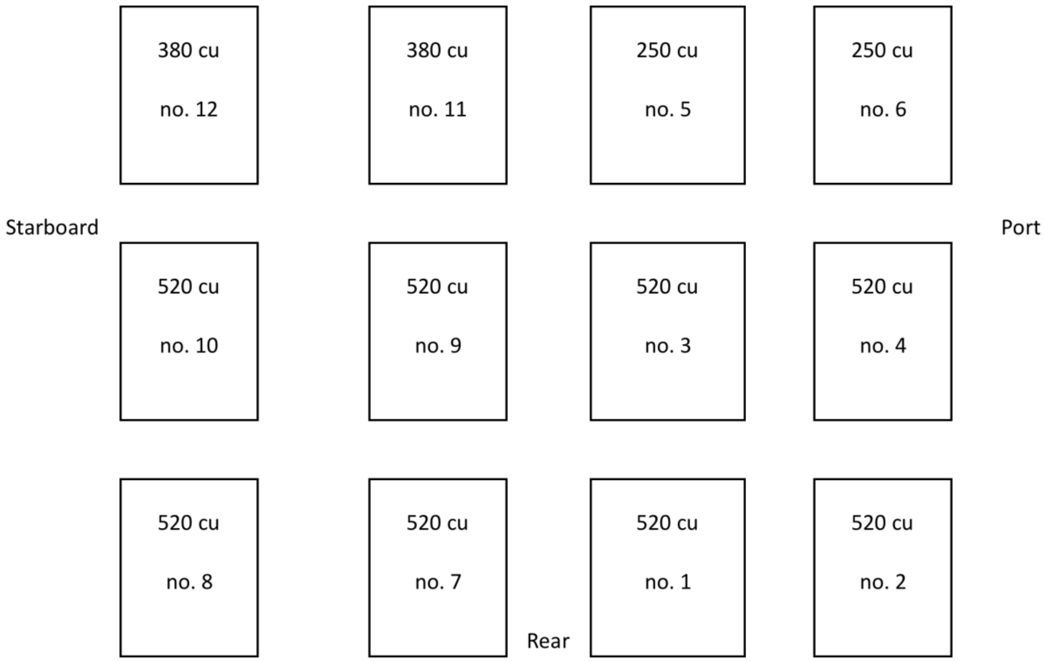


Figure 5. Airgun array deployed from the Sonne with airgun number and capacity (cubic inches or cu)

The deployment of the airguns commenced at 9:00 am on 10 February (local time, GMT-5). The airgun array was in operation until 3:30 pm on 15 February (local time, GMT-5), the end of the two-ship seismic data acquisition. Fig. 6 shows the deployment of the G Guns on the Sonne.

Several airguns experienced technical problems during the course of the data acquisition. Other stand-by airguns were switched on to replace the failed airguns. Table 1 summarises the performance of the individual airguns with key events linked to the seismic data acquisition.

Date	**Time**	**Event**	**Airguns capacity (cu)**
10.02.2015	09:00	Deployment	4280 cu
	12:20	Gun no. 10 (520 cu) failed and Gun no. 3 (520 cu) was turned on	
	15:20	Gun no. 4 (520 cu) failed and Gun no. 12 (380 cu) was turned on	
	21:05	Gun no. 1+3 failed	
	22:00	Profile ends and all brought back on the deck	
11.02.2015			4280 cu
	07:30	Soft start	
	08:30	Profile start	
12.02.2015	13:30	Gun no. 9 (520 cu) failed and G Gun no. 3 (520 cu) was turned on	
13.02.2015	02:50	G Gun no. 4 (520 cu) failed and G Gun no. 12 (380 cu) was turned on	
13.02.2015	11:05	G Gun no. 2 (520 cu) failed and G Gun no. 5 (250 cu) was turned on	
13.02.2015	18:15	G Gun no. 7 (520 cu) failed until the end of the profile	
		Array set (first port side then starboard side)	
13.02.2015	23:30	all clear	
13.02.2015			4280 cu
	23:30	Profile 3 start	
14.02.2015	08:10	Starboard parked and the fender was used	
	08:20	Starboard back in water and all clear	
14.02.2015	22:00	G Gun no. 8 (520 cu) failed and G Gun no. 3 (520 cu) was turned on	
15.02.2015	07:45	G Gun no. 3 (520 cu) failed and G Gun no. 5 (250 cu) was turned on	
	15:30	End of two-ship experiment	

Table 1. Performance of individual airguns with key events linked to the two-ship seismic data acquisition. Local times (GMT-5) are shown.

Figure 6. Deployment of the G Guns (Photo credits: SO238 Captain Oliver Meyer).

3. GPS clocks and navigation data

Two GPS clocks with separate antennae (OBIC, Durham University) were set up to record the locations and time of the airgun shots fired from the Sonne. The location and time data were logged on two laptops running scripts developed by Ben Pitcairn (Durham). The ship location was also recorded by the Seapath GPS system on the research vessel, and the location information has been found to be consistent with that recorded by the GPS clocks.

One of the original aims of logging the GPS time was to provide the record the shot firing at the aim point (i.e. airguns rather than shot trigger time). However, such information was not available as the trigger times were logged instead. With the use of on-screen record from the shot triggering system and modelling of seismic data from ocean-bottom seismometers, a latency time between the trigger time and actual aim point of 80 ms was determined (please see JC114 cruise report for details).

4. Two-ship data acquisition

The two-ship operation was performed along three north-south seismic profiles, known as the SAP lines or synthetic aperture profile lines, linking the ridge axis area of the Costa Rica Rift and the area near borehole 504B. The three profiles connect the two seismic grids in these two areas (Fig. 3).

Airguns on the Sonne were fired on 30 second past each minute at one-minute interval, whilst the Bolt airguns on the James Cook were fired on the second at one-minute interval. This alternating firing effectively resulted in 30-second shot interval during the two-ship operation.

The firing of airgun shots was continuous, including the periods when the research vessel was turning from the end of one profile to the next. The reason for firing shots during the turns was that ocean-bottom seismometers deployed by the James Cook continued to record data corresponding the shots fired between the three seismic profiles.

The Sonne followed the James Cook with a roughly constant distance of 9 km. The end points and turning points of the three SAP lines (SAP A, SAP B and SAP C) are:

SAP B line

0°57.085N, 83°43.292W, James Cook Aim point
3°40.800N, 83°50.530W, James Cook Last shot point
3°43.840N, 83°50.650W, TURN
3°43.840N, 83°40.900W, TURN

SAP A line

3°36.000N, 83°41.090W, James Cook Aim point
0°52.000'N, 83°44.390'W, James Cook Last shot point
0°49.000'N, 83°44.500'W, TURN
0°49.000'N, 83°52.550'W, TURN

SAP C line

0°56.840'N, 83°52.420'W, James Cook Aim point
3°40.800'N, 83°49.220'W, James Cook Last shot point

5. Outreach

Vincent Tong, the lead on seismic work on the Sonne, gave a presentation entitled "Why did we stalk and shoot at the James Cook?" on 19 February. The theme of his informal talk was on the two-ship seismic work and the scientific rationale underpinning the geological investigations in OSCAR. The talk held in the bar was well attended by both the crew and scientists, and it has generated some good scientific discussions.

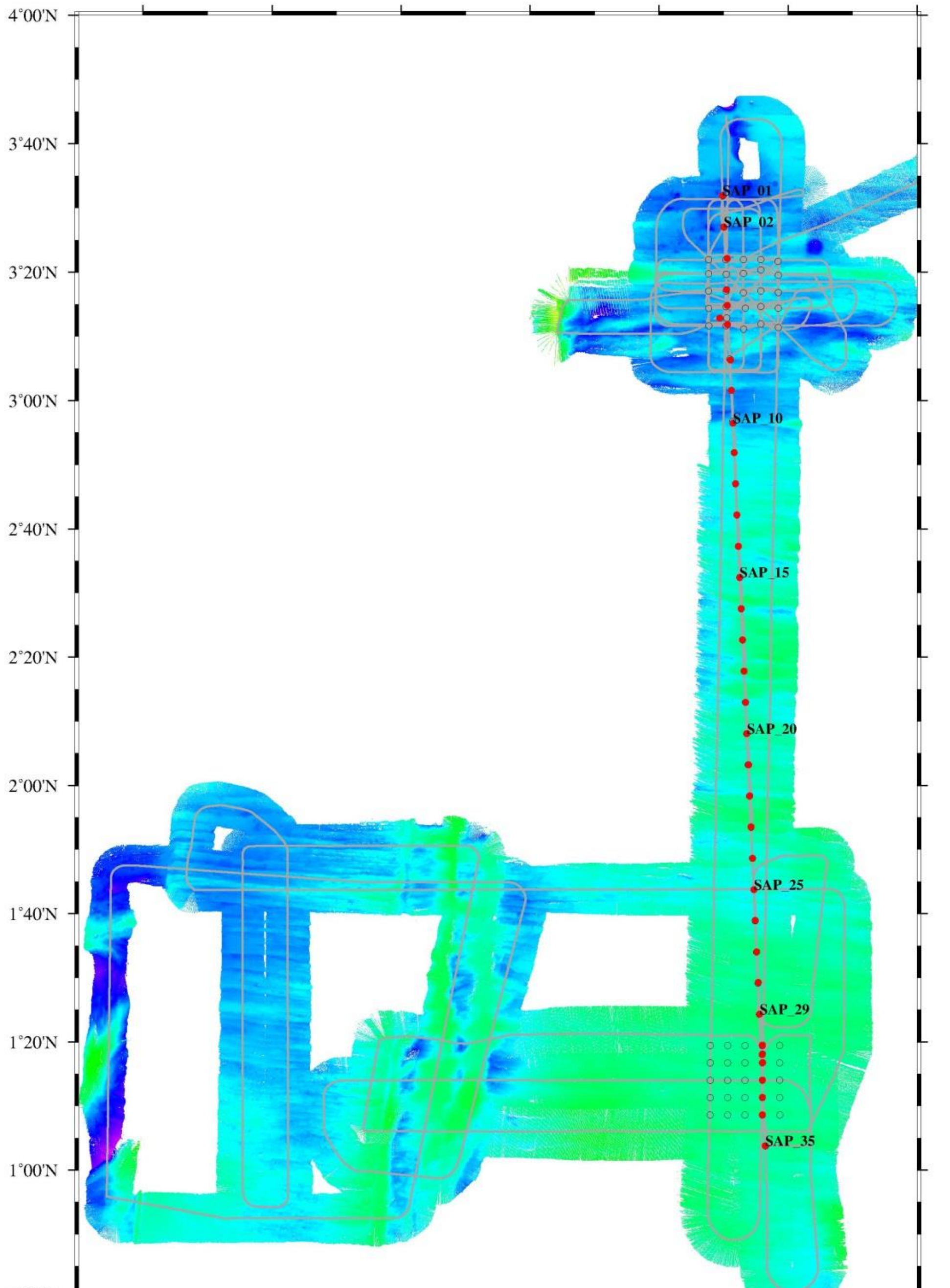


Figure 7. The north-south SAP (Synthetic Aperture Profile) lines linking the northern and southern seismic grids are shown. Circles indicate the locations of ocean-bottom seismometers (OBSs), whereas the OBSs on the main SAP line are shown in red circles. For details about OBSs, please refer to the James Cook JC114 cruise report. (Credits: Christine Peirce)

Swath Bathymetry

Emyr Martyn Tomas Roberts (Bangor University) and Simona Aracri (NOC)

Introduction

During the SO238 cruise, led on board of the German RV Sonne, bathymetry data have been collected through the Eco-Marine sounder EM122, Fig. 8. The data were visualised with the fledermaus software and used to select sites for CTD casts and mooring deployment. The recorded EM122 bathymetry was overlaid on the GEBCO bathymetry, Fig. 9, of the Panama Basin in order to determine its reliability.
EM122 serial numbers:

• transceiver unit 1: 101
• transceiver unit 2: 101
• Pre-amplifier (type EM1-213285): 201

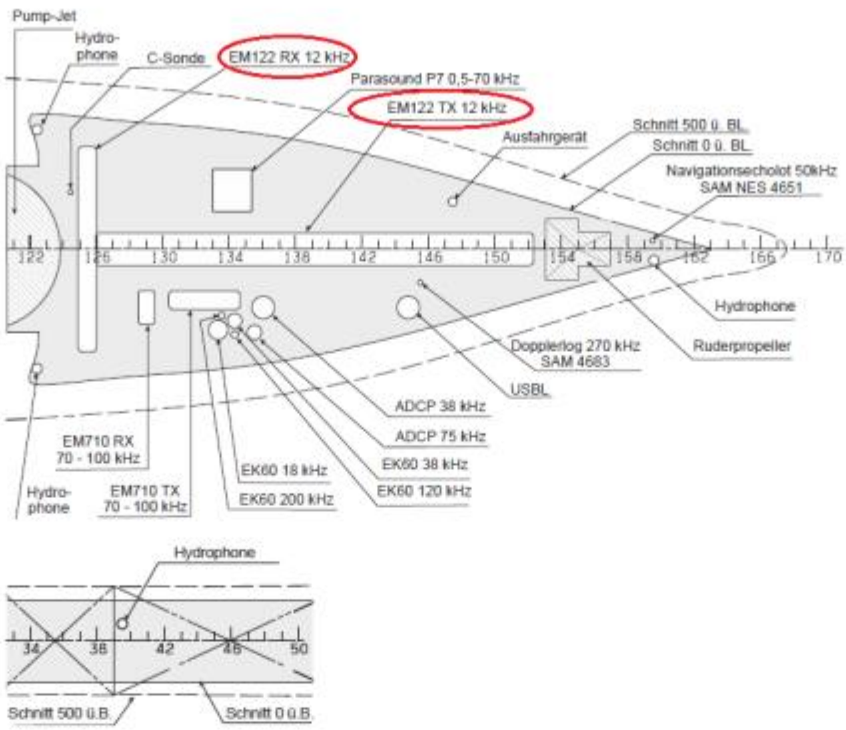


Figure 8. The EM122 device in the red circles.

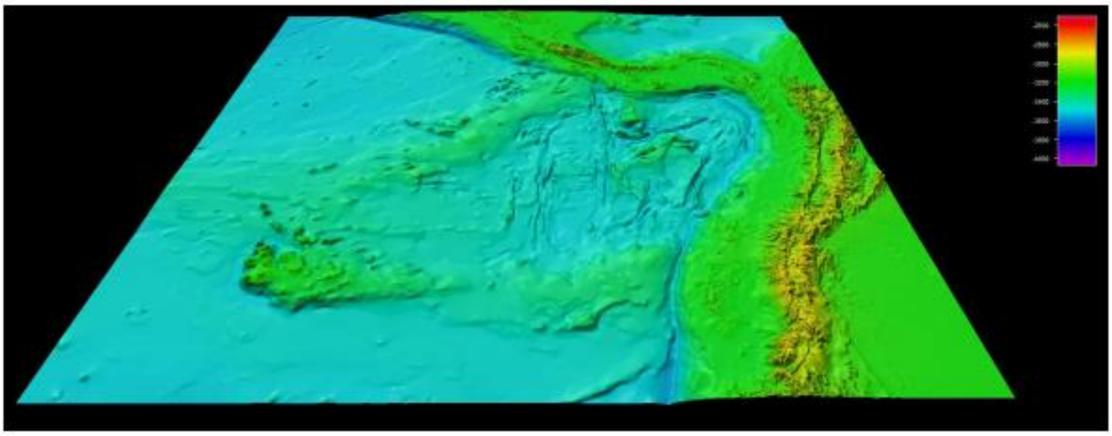


Figure 9. Bathymetry plot from one minute GEBCO gridded data.

Protocol

The data were downloaded daily from the local drive to the shared drive: scientists. Files were generated approximately every half an hour.

The files were automatically named as follow:
sequentialnumber yyyymmdd hhmmss Sonne EM122 (e.g. so the zero file created on 9th February 2015 at 1:25:54 am on board of the Sonne from the EM122 eco-sounder will be named: 0000 20150209 012554 Sonne EM122). Two kind of files are produced by the system, in the folder have been copied also the sound velocity profiles:

- .all: ungridded data
- .wcd
- .asvp: sound velocity profile extracted from the CTD cast.
- .temp: temperature profile extracted from the CTD cast.

During the CTD cast the logging was switched off, because of the tendency to generate spikey data when on station. The pinging and the logging were switched off during on board operations that involved acoustic communication, e.g. mooring recovery, in order to avoid interference. Spikey data were also generated during ship turning but it was not possible to shut the logging down every time.

When coping data from the local driver to the scientist shared driver the user must pay attention to the logging active line on the top right of the EM122 pc screen. The active line represents the file that is being written by the system at a given moment, better said it is the last file where the data are being logged, so don’t copy/move the logging file.

Preliminary results

A visual check of the data was carried out with fladermaus software , Fig. 10. The Swath Bathymetry data start 9th February 2015 at 1:25:54 am and stop on 4th March 2015 at 13:03:24.

Improvements

The visualizing software is not user friendly. The manual doesn't correspond to the software version installed.

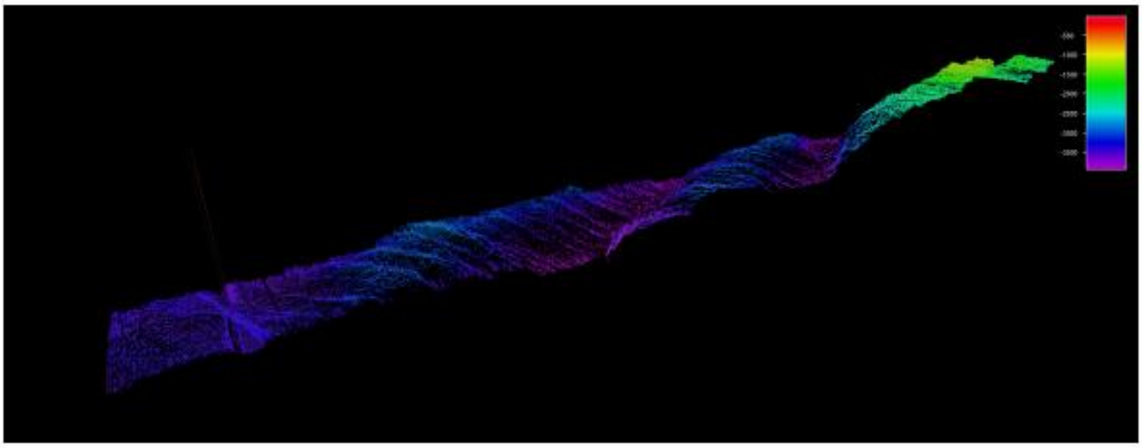


Figure 10. Example of fladermaus output for data collected 9th February.

Navigation data

Simona Aracri (NOC)

Introduction

During the SO238 cruise, led on board of the German RV Sonne, as part of the Oscar project, a new internal data distribution system was installed. The new system, named DAVIS-SHIP, systematically collects nautical and scientific parameters. The DAVIS-SHIP manual can be found in the dedicated intranet DAVIS-SHIP section: 'System Documentation'. The navigation data was collected by several GPS and positioning devices. The principal system for scientific purposes is the SeaPath, all the other devices (GPS1,GPS1,Nacos,Leica) are used for navigation records, since they have different certifications. The GPS1 and GPS2 antenna, in Fig. 11, are located at the bow. The serial numbers of the various systems are listed below:

- GPS1
  - antenna: 1228-160681-0079
  - NAV sensor: 23247-0025 (situated on deck 6)
  - display: 100170-B1
- GPS2
  - antenna: 1218-160347-0014
  - NAV sensor: 23247-0015
  - display: 100216-B1
- Leica
  - antenna: type AR10
  - Rx: 2540667 Equipment 5339151 (type CS15)
  - display: 1534472 Equipment 5339151 (type GS10 Professional)
- SeaPath
  - antenna 1: NHE12190046
  - antenna 2: NHE121900431

Protocol

The data were downloaded daily through the DAVIS-SHIP system. Each file contains the data recorded from 00.00 to 23.59.59 of a given day, every second. The files were named as follow: (*d*)*dth NavigationS* (e.g. the file containing data collected during 14th February will be 14*th NavigationS*). Only the file contains 2 days: 7th 8th Navigation. No month identifier number was inserted since all the data were collected from 7th February to 4th March, therefore there are no doubles for the day number.

Four kind of files are produced by the system:

- .txt: description of submitted order and list of the selected variables
- .dat: the actual data
- .sys
- .log

Appendix A and B represent an example of the data extraction definition displays

Figure 11. GPS1 and GPS2 antennas in the red circles.

Figure 12. GPS1 and GPS2 displays on bridge.

Figure 13. : Leica display on bridge.

Preliminary results

A visual check of the data was carried out producing for each day plots such as the one in Fig. 14. The plot was produced after importing the data through the matlab routine present in the data folder, Navigationtest.m. The script is commented in order to be useful for potential future users. The plots are named after the day they refer to, for instance 16th February plot representing the comparison among all the different GPSs systems will be named Coor16.png. No month identifier number was inserted in the plot name since all the data were collected from 7th February to 4th March, therefore there are no doubles for the day number.

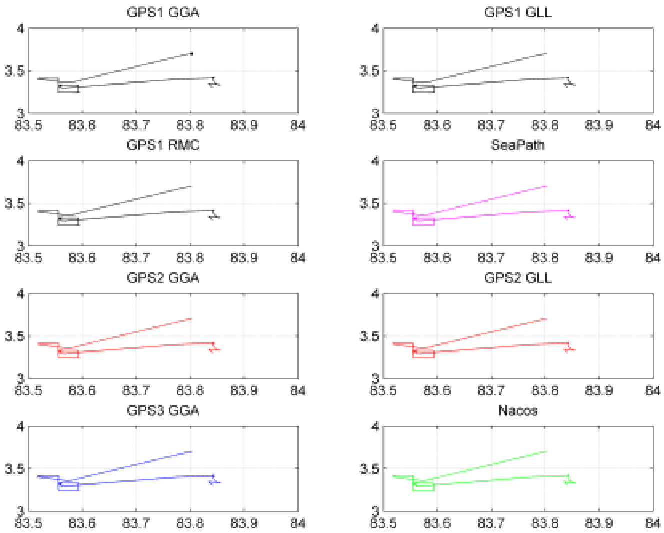


Figure 14. Comparison among all the different GPSs systems. The dot in the first plot at the top left of the figure indicates the starting point.

Appendix A

Selection of parameters. Note that it is important to select the right precision and field dimensions. The total number of figures specified in the ’Field width’ space needs to be big enough to contain both the number of decimal figures required in the ’precision’ space and the integers, otherwise the system will give no number as an output.

List of DAVIS-Ship sensors http://dship_admin/cgi-bin/WebEx

DAVIS SHIP

List of DAVIS-Ship sensors

Export V4.0

Selected sensors

GPS1(SAAB-R5)

☑ **Age of differential** Output format Real Field width 8 Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Altidude re** Output format Real Field width 8 Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Course over grond RMC** [deg] Output format Real Field width 7 Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Course over ground mag** [deg] Output format Real Field width 7 Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Course over ground true** [deg] Output format Real Field width 7 Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Date** Output format Text Field width 12
☐ Samples ☑ Spot ☐ Value validity

☑ **Date RMC** Output format Integer Field width 6 Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Day** Output format Integer Field width 2 Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Differential reference** Output format Integer Field width 4 Precision 0

1 von 12 05.03.2015 13:58

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **GPS quality indicator** Output format Integer Field width 1 Precision 0

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Geodial separation** Output format Real Field width 8 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Horizontal dilution of precision** Output format Real Field width 8 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Latitude GGA** Output format Position Lat Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Latitude GLL** Output format Position Lat Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Latitude RMC** Output format Position Lat Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Local zone hours** Output format Integer Field width 2 Precision 0

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Local zone minutes** Output format Integer Field width 2 Precision 0

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Longitude GGA** Output format Position Lon Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Longitude GLL** Output format Position Lon Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Longitude RMC** Output format Position Lon Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Magnetic variation EW RMC**	Output format Text	Field width 1	
☐ Samples ☑ Spot		☐ Value validity	
☑ **Magnetic variation RMC** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Mode indicator GLL**	Output format Text	Field width 1	
☐ Samples ☑ Spot		☐ Value validity	
☑ **Mode indicator VTG**	Output format Text	Field width 1	
☐ Samples ☑ Spot		☐ Value validity	
☑ **Month**	Output format Integer	Field width 2	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Number of satellites**	Output format Integer	Field width 2	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Speed over ground RMC** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Speed over ground km/h** [km/h]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Speed over ground kn** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Status RMC**	Output format Text	Field width 1	
☐ Samples ☑ Spot		☐ Value validity	
☑ **Time**	Output format Text	Field width 8	
☐ Samples ☑ Spot		☐ Value validity	

☑ **UTC**	Output format Real	Field width 8	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **UTC** [s]	Output format Integer	Field width 12	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **UTC RMC**	Output format Real	Field width 12	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **UTC of position**	Output format Real	Field width 8	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **UTC_raw**	Output format Real	Field width 11	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Year**	Output format Integer	Field width 4	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	

GPS2(SAAB-R5)

☑ **Age of differential**	Output format Real	Field width 8	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Altitude re**	Output format Real	Field width 8	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Course over ground mag.** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Course over ground true** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Day**	Output format Integer	Field width 2	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Differential reference**	Output format Integer	Field width 4	Precision 0

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **GPS quality indicator** Output format Integer Field width 1 Precision 0

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Geodial separation** Output format Real Field width 8 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Horizontal dilution of precision** Output format Real Field width 8 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Latitude GGA** Output format Position Lat Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Latitude GLL** Output format Position Lat Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Local zone hours** Output format Integer Field width 2 Precision 0

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Local zone minutes** Output format Integer Field width 2 Precision 0

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Longitude GGA** Output format Position Lon Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Longitude GLL** Output format Position Lon Field width 12 Precision 2

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Mode indicator** Output format Text Field width 1

☐ Samples ☑ Spot ☐ Value validity

☑ **Mode indicator VTG** Output format Text Field width 1

☐ Samples ☑ Spot ☐ Value validity

☑ **Month**	Output format Integer	Field width 2	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Numbers of satellites**	Output format Integer	Field width 2	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Speed over ground km/h** [km/h]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Speed over ground kn** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **UTC**	Output format Real	Field width 8	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **UTC of position**	Output format Real	Field width 8	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **UTC_raw**	Output format Real	Field width 9	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Year**	Output format Integer	Field width 4	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	

GPS3(Leica)

☑ **Age of differential**	Output format Real	Field width 8	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Altitude re**	Output format Real	Field width 8	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Differential reference**	Output format Integer	Field width 4	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	

☑ **GPS quality indicator** Output format Integer Field width 1 Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Geodial separation** Output format Real Field width 8 Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Horizontal dilution of precision** Output format Real Field width 8 Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Latitude GGA** Output format Position Lat Field width 12 Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Longitude GGA** Output format Position Lon Field width 12 Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Numbers of satellites** Output format Integer Field width 2 Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **UTC** Output format Real Field width 8 Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

Gyro1

☑ **Heading** [deg] Output format Real Field width 7 Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Rate of turn** [°/min] Output format Real Field width 8 Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

Gyro2

☑ **Heading** [deg] Output format Real Field width 7 Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Rate of turn** [°/min] Output format Real Field width 8 Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

NACOS

☑ **Course** [deg] Output format Real Field width 7 Precision 1

☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Course reference**	Output format Text	Field width 1	
☐ Samples ☑ Spot		☐ Value validity	
☑ **Heading** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Latitude**	Output format Position Lat	Field width 12	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Longitude**	Output format Position Lon	Field width 12	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Next Waypoint Long**	Output format Position Lon	Field width 12	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Next waypoint Lat**	Output format Position Lat	Field width 12	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Speed** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Speed reference**	Output format Text	Field width 1	
☐ Samples ☑ Spot		☐ Value validity	
☑ **UTC of position**	Output format Real	Field width 8	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Vessel drift** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Vessel set** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	

☑ **Waypoint Name**	Output format Text	Field width 1	
☐ Samples ☑ Spot		☐ Value validity	
	Nav-Lot		
☑ **Depth** [m]	Output format Real	Field width 8	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Maximum range scale in use**	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Offset from transducer** [m]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
	Sat-Log		
☑ **Longitudinal ground speed** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Longitudinal water speed** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Transverse ground speed** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Transverse water speed** [kn]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
	Seapath		
☑ **Age of differential**	Output format Real	Field width 8	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Altitude re**	Output format Real	Field width 8	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Course over ground mag** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	

☑ **Course over ground true** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Differentail reference**	Output format Integer	Field width 4	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **GPS quality indicator**	Output format Integer	Field width 1	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Geoidal separation**	Output format Real	Field width 8	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Heading** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Heave** [m]	Output format Real	Field width 6	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Horizontal dilution**	Output format Real	Field width 8	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Latitude GGA**	Output format Position Lat	Field width 12	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Longitude GGA**	Output format Position Lon	Field width 12	Precision 2
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Number of satellites**	Output format Integer	Field width 2	Precision 0
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Pitch** [deg]	Output format Real	Field width 7	Precision 1
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Roll** [deg]	Output format Real	Field width 7	Precision 1

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Speed over ground km/h** [km/h] Output format Real Field width 7 Precision 1

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Speed over ground kn** [kn] Output format Real Field width 6 Precision 1

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **UTC** Output format Real Field width 8 Precision 0

☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

Submit Request Reset Request

How to fill in the form ?

Output format
Select the sensors you want to export by clicking the check box in front of the sensor name. The **output format** specifies the format of the generated data. You may chose between:

Text	ASCII character
Real	Number with decimal digits
Integer	Number without decimal digits
PosLon	Longitude position with Deg Min, decimalMin E/W
PosLat	Latitude position with Deg Min, decimalMin N/S
PosDeg	Position with +/-Deg, decimalDeg (- for south and west)

The default output format has been configured by the administrator. Please note that not all combinations of sensor, output format and field width make sense. 'Field width' specifies the length of the whole output column including both, decimal symbol and precision. With the precision input field you enter the number of decimal digits.

Samples
The second line of each sensor item carries check boxes for **statistical** information about the data. Each of them will generate an additional column in the output file.

Samples	Number of valid samples within the interval
Spot	First sample (valid) of the interval
Min	Minimum value (valid) of the interval
Max	Maximum value (valid) of the interval
Mean	Average over all valid samples
Variance	Variance of all valid samples
Std dev	Standard deviation of all valid samples
Value valid	Validity of the calculated values (V-Valid / I-Invalid)
Mean valid	Validity of the calculated average (V-Valid / I-Invalid)

Appendix B

Order confirmation. Here extracted data interval, columns separator, output file name etc. are defined.

DAVIS SHIP

List of DAVIS-Ship parameters

Export V4.0

Inputted information about the extraction file:

Time/date of export

Start date/time	04.03.2015 00:00:00	
End date/time	04.03.2015 23:59:59	
Duration [s]	86399	
Interval	1	[s]
Selected extraction takes (approx.)	5 h	

Result

File name	4th_Navigation
User name	
Mail address	
Get mail	☐

File format

Separator	,
End of record marker	New line
Date / time format	YYYY/MM/DD*HH:mm:ss * = Separator
Decimal symbol	.
Header row	☑
Max. data file size	0 MByte ☑ unlimited

Error/invalid value pattern

Error value numeric	#
Error value alphanumeric	#
Error value position	#
Include invalid values	☑
Skip invalid lines	☐
Fit to format	☑

Save order ☐ as SaveSaveSO238_Navig

Start Extraction Reset Request

How to fill in the form ?

The following lines briefly explain the meaning of the input-fields.

Separator
The 'separator' is inserted between the individual values extracted for one point of time.

End of record marker
The 'end of record marker' separates the single export steps representing one point of time.

Error values
The 'error values' are used to indicate missing or invalid data. It is possible to define different values for figures, positions and text.

Include invalid values
If 'show invalid values' is selected, Export will use these invalid values instead of error values.

Skip invalid lines
If 'skip invalid lines' is selected, Export will not store lines into the resulting data file which contains only invalid values.

Fit to format
If 'fit to format' is selected, Export fills up the output format with leading blanks.

Start date/time
'Start date/time' is the start date and time of the request. The string must have the format "DD.MM.YYYY HH:mm:ss".

End date/time
'End date/time' is the end date and time of the request. The string must have the format "DD.MM.YYYY HH:mm:ss".

Duration
As an alternative to the 'end date/time' you may specify the 'duration'. The duration calculates the end date/time of the request in seconds from the start data/time. If end date/time is specified, it will be adopted.

Interval
'Interval' is the gap in time between two data lines. You may specify this gap in hours ('[h]'), minutes ('[min]'), seconds ('[s]') and milliseconds ('[ms]'). If you choose [ms], only 50, 100, 200 or any value divisible by 1000 are permissible values.
For extraction of 10MinRecords, the interval is fixed to 10 minutes as a matter of course.

File name
'File name' is the prefix of the output files. The generated files will have names appended by the following extensions:

.dat	Extracted data
.log	Extracted log-entries (only for full data sets)
.sys	Notifications resp. errors from the extraction process
.txt	Generic description of the processed order

Decimal Symbol
You can choose between the German and the English decimal-symols, ',' and '.'.

Header row
If 'Header row' is selected, Export produces lines at the top of the data file containing the sensor and device names.

Max. data file size
The 'max. data file size' is the maximum size (in Mega Bytes) a data file may have. The system generates new files, if necessary. The files will then be numbered. The minimum is 1 and only integers are allowed. Entering 0 is equal to checking 'unlimited'. In this case, no limit for the file size is taken into account.

Get mail
If 'Get mail' is selected, an e-mail is sent on completion of the export.

User name
The 'user name' has to be your full name.

Mail address
The 'mail address' has to be your complete e-mail address.

Date / time format
You may choose the 'date / time format' from the following defaults. Please note that the asterisk (*) represents the separator.

YYYY*MM*DD*HH*mm*ss	year*month*day*hour*minute*second
YYYY*ddd*HH*mm*ss	year*julian days*hour*minute*second
YYYY/MM/DD*HH:mm:ss	year/month/day*hour:minute:second
DD.MM.YYYY*HH:mm:ss	day.month.year*hour:minute:second
YYYY*MM*DD	year*month*day
YYYY*ddd	year*julian days
YYYY/MM/DD	year/month/day
DD.MM.YYYY	day.month.year
HH*mm*ss	hour*minute*second
HH:mm:ss	hour:minute:second
Seconds since 1970	Time in seconds since 01.01.1970 00:00:00
None	No time / date column in the output file

Appendix C

List of Navigation folder contents.

```
totale 2023395
-rwxrwxrwx 1 simona simona  76122294 feb 15 15:13 09th_Navigation.dat
-rwxrwxrwx 1 simona simona    937989 feb 15 15:13 09th_Navigation.log
-rwxrwxrwx 1 simona simona       344 feb 15 15:13 09th_Navigation.sys
-rwxrwxrwx 1 simona simona     24694 feb 15 15:12 09th_Navigation.txt
-rwxrwxrwx 1 simona simona  56536724 feb 27 19:19 09th_Navigation.xlsx
-rwxrwxrwx 1 simona simona  76122294 feb 15 15:14 10th_Navigation.dat
-rwxrwxrwx 1 simona simona        42 feb 15 15:14 10th_Navigation.log
-rwxrwxrwx 1 simona simona       341 feb 15 15:14 10th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 15 15:13 10th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 15 15:15 11th_Navigation.dat
-rwxrwxrwx 1 simona simona        42 feb 15 15:15 11th_Navigation.log
-rwxrwxrwx 1 simona simona       341 feb 15 15:15 11th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 15 15:14 11th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 15 15:15 12th_Navigation.dat
-rwxrwxrwx 1 simona simona    309797 feb 15 15:15 12th_Navigation.log
-rwxrwxrwx 1 simona simona       344 feb 15 15:15 12th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 15 15:15 12th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 15 15:16 13th_Navigation.dat
-rwxrwxrwx 1 simona simona      3773 feb 15 15:16 13th_Navigation.log
-rwxrwxrwx 1 simona simona       342 feb 15 15:16 13th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 15 15:15 13th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 15 15:16 14th_Navigation.dat
-rwxrwxrwx 1 simona simona       390 feb 15 15:16 14th_Navigation.log
-rwxrwxrwx 1 simona simona       341 feb 15 15:16 14th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 15 15:15 14th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 17 14:01 15th_Navigation.dat
-rwxrwxrwx 1 simona simona       535 feb 17 14:01 15th_Navigation.log
-rwxrwxrwx 1 simona simona       341 feb 17 14:01 15th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 17 14:00 15th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 17 14:19 16th_Navigation.dat
-rwxrwxrwx 1 simona simona      5443 feb 17 14:19 16th_Navigation.log
-rwxrwxrwx 1 simona simona       342 feb 17 14:20 16th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 17 14:18 16th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 19 16:26 17th_Navigation.dat
-rwxrwxrwx 1 simona simona       304 feb 19 16:26 17th_Navigation.log
-rwxrwxrwx 1 simona simona       341 feb 19 16:26 17th_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 feb 19 16:26 17th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 20 18:49 18th_Navigation.dat
-rwxrwxrwx 1 simona simona     20510 feb 20 18:49 18th_Navigation.log
-rwxrwxrwx 1 simona simona       343 feb 20 18:49 18th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 20 18:48 18th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 21 15:56 19th_Navigation.dat
-rwxrwxrwx 1 simona simona     34520 feb 21 15:56 19th_Navigation.log
-rwxrwxrwx 1 simona simona       343 feb 21 15:56 19th_Navigation.sys
-rwxrwxrwx 1 simona simona     24695 feb 21 15:55 19th_Navigation.txt
```

```
-rwxrwxrwx 1 simona simona  27564544 feb 27 16:47 19th_Navigation.xls
-rwxrwxrwx 1 simona simona  76122294 mar  5 18:33 1st_Navigation.dat
-rwxrwxrwx 1 simona simona      3978 mar  5 18:33 1st_Navigation.log
-rwxrwxrwx 1 simona simona       342 mar  5 18:33 1st_Navigation.sys
-rwxrwxrwx 1 simona simona     24665 mar  5 18:32 1st_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 22 10:03 20th_Navigation.dat
-rwxrwxrwx 1 simona simona      6188 feb 22 10:03 20th_Navigation.log
-rwxrwxrwx 1 simona simona       342 feb 22 10:03 20th_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 feb 22 10:03 20th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 feb 22 13:09 21st_Navigation.dat
-rwxrwxrwx 1 simona simona       461 feb 22 13:09 21st_Navigation.log
-rwxrwxrwx 1 simona simona       341 feb 22 13:09 21st_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 feb 22 13:08 221st_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  1 19:45 22nd_Navigation.dat
-rwxrwxrwx 1 simona simona       304 feb 24 11:03 22nd_Navigation.log
-rwxrwxrwx 1 simona simona       341 feb 24 11:03 22nd_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 feb 24 11:03 22nd_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  1 19:46 23rd_Navigation.dat
-rwxrwxrwx 1 simona simona        42 mar  1 19:47 23rd_Navigation.log
-rwxrwxrwx 1 simona simona       341 mar  1 19:47 23rd_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 mar  1 19:46 23rd_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  1 19:47 24th_Navigation.dat
-rwxrwxrwx 1 simona simona        42 mar  1 19:47 24th_Navigation.log
-rwxrwxrwx 1 simona simona       341 mar  1 19:47 24th_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 mar  1 19:47 24th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  2 14:18 25th_Navigation.dat
-rwxrwxrwx 1 simona simona        42 mar  2 14:19 25th_Navigation.log
-rwxrwxrwx 1 simona simona       341 mar  2 14:19 25th_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 mar  2 14:18 25th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  1 19:48 26th_Navigation.dat
-rwxrwxrwx 1 simona simona     37136 mar  1 19:48 26th_Navigation.log
-rwxrwxrwx 1 simona simona       343 mar  1 19:48 26th_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 mar  1 19:48 26th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  1 19:48 27th_Navigation.dat
-rwxrwxrwx 1 simona simona    464472 mar  1 19:48 27th_Navigation.log
-rwxrwxrwx 1 simona simona       344 mar  1 19:48 27th_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 mar  1 19:48 27th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  1 19:48 28th_Navigation.dat
-rwxrwxrwx 1 simona simona       195 mar  1 19:48 28th_Navigation.log
-rwxrwxrwx 1 simona simona       341 mar  1 19:48 28th_Navigation.sys
-rwxrwxrwx 1 simona simona     24663 mar  1 19:48 28th_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  5 17:36 32nd_Navigation.dat
-rwxrwxrwx 1 simona simona      7106 mar  5 17:37 2nd_Navigation.log
-rwxrwxrwx 1 simona simona       342 mar  5 17:37 2nd_Navigation.sys
-rwxrwxrwx 1 simona simona     24665 mar  5 17:37 2nd_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  4 22:58 3rd_Navigation.dat
-rwxrwxrwx 1 simona simona        42 mar  4 22:59 3rd_Navigation.log
-rwxrwxrwx 1 simona simona       341 mar  4 22:59 3rd_Navigation.sys
-rwxrwxrwx 1 simona simona     24662 mar  4 22:58 3rd_Navigation.txt
-rwxrwxrwx 1 simona simona  76122294 mar  5 16:01 4th_Navigation.dat
```

```
-rwxrwxrwx 1 simona simona       195 mar  5 16:01 4th_Navigation.log
-rwxrwxrwx 1 simona simona       341 mar  5 16:01 4th_Navigation.sys
-rwxrwxrwx 1 simona simona     24662 mar  5 16:00 4th_Navigation.txt
-rwxrwxrwx 1 simona simona 152240694 feb 15 15:16 7th_8th_Navigation.dat
-rwxrwxrwx 1 simona simona    843229 feb 15 15:16 7th_8th_Navigation.log
-rwxrwxrwx 1 simona simona       345 feb 15 15:16 7th_8th_Navigation.sys
-rwxrwxrwx 1 simona simona     24666 feb 15 15:14 7th_8th_Navigation.txt
-rwxrwxrwx 1 simona simona    121121 mar  2 10:22 Coor10.png
-rwxrwxrwx 1 simona simona    124126 mar  2 10:29 Coor11.png
-rwxrwxrwx 1 simona simona    135307 mar  2 10:36 Coor12.png
-rwxrwxrwx 1 simona simona    129842 mar  2 10:41 Coor13.png
-rwxrwxrwx 1 simona simona    125072 mar  2 10:54 Coor14.png
-rwxrwxrwx 1 simona simona    138924 mar  2 11:00 Coor15.png
-rwxrwxrwx 1 simona simona    135796 mar  2 11:07 Coor16.png
-rwxrwxrwx 1 simona simona    127990 mar  2 11:13 Coor17.png
-rwxrwxrwx 1 simona simona    122961 mar  2 11:21 Coor18.png
-rwxrwxrwx 1 simona simona    119432 mar  2 11:29 Coor19.png
-rwxrwxrwx 1 simona simona    121882 mar  5 18:50 Coor1.png
-rwxrwxrwx 1 simona simona    121743 mar  2 11:34 Coor20.png
-rwxrwxrwx 1 simona simona    130820 mar  2 11:52 Coor21.png
-rwxrwxrwx 1 simona simona    125106 mar  2 11:58 Coor22.png
-rwxrwxrwx 1 simona simona    131263 mar  2 14:19 Coor23.png
-rwxrwxrwx 1 simona simona    114741 mar  2 14:26 Coor24.png
-rwxrwxrwx 1 simona simona    116485 mar  2 15:14 Coor25.png
-rwxrwxrwx 1 simona simona    117676 mar  2 15:45 Coor26.png
-rwxrwxrwx 1 simona simona    107985 mar  2 15:55 Coor27.png
-rwxrwxrwx 1 simona simona    114946 mar  2 16:01 Coor28.png
-rwxrwxrwx 1 simona simona    125497 mar  5 17:46 Coor2.png
-rwxrwxrwx 1 simona simona    115802 mar  5 17:03 Coor3.png
-rwxrwxrwx 1 simona simona    116226 mar  5 18:58 Coor4.png
-rwxrwxrwx 1 simona simona    115093 mar  2 10:16 Coor9.png
-rwxrwxrwx 1 simona simona         0 mar  5 20:31 list.txt
-rwxrwxrwx 1 simona simona      6124 mar  5 18:43 Navigationtest.asv
-rwxrwxrwx 1 simona simona      6124 mar  5 18:52 Navigationtest.m
-rwxrwxrwx 1 simona simona   1840881 mar  5 15:12 order_d.pdf
-rwxrwxrwx 1 simona simona    357594 mar  5 15:11 order.pdf
-rwxrwxrwx 1 simona simona      2613 set 23 18:52 process.m
-rwxrwxrwx 1 simona simona    168448 mar  5 18:51 Thumbs.db
```

Vessel-Mounted ADCPs

Emyr Martyn Tomas Roberts (Bangor University)

Introduction

The FS Sonne is fitted with two vessel-mounted ADCPs, one operating at a frequency of 38 kHz (S/N 41140) and the other at 75 kHz (S/N 27512). Both instruments are located on the starboard side of the hull (depth 6.4 m), near the bow (Fig. 15), and they were used throughout the cruise to measure the horizontal velocity field. Since the data files generated were not very large, it was decided that the ADCPs would record velocities continuously over the cruise (from 11/02/15 to 04/03/15). Each instrument has a dedicated computer for data acquisition and monitoring, and these are located in the Data Centre (Datenzentrale).

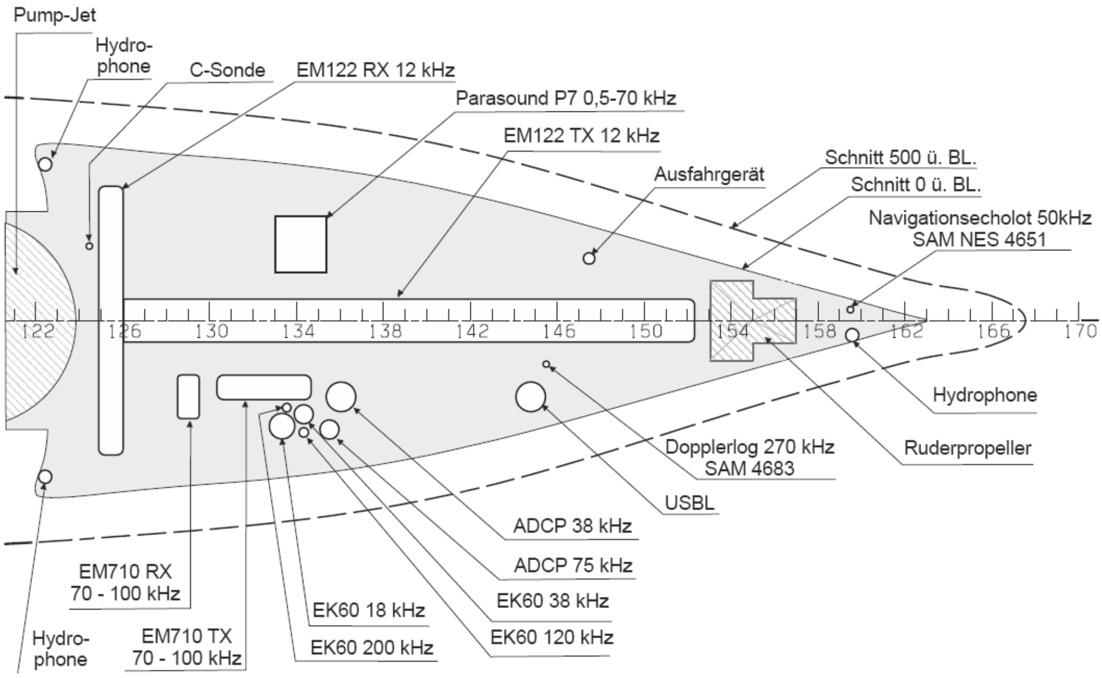


Figure 15. Schematic of the hull of the FS Sonne, showing the positions of hydroacoustic instrumentation. Reproduced from the FS Sonne Handbook.

Instruments, Software and Settings

The vessel-mounted ADCPs were of the type Ocean Surveyor (OS), manufactured by Teledyne RD Instruments (Poway, California, USA). The depth ranges and resolutions of the instruments are determined by their operating frequencies: the lower frequency ADCP (38 kHz) has poorer vertical resolution (45 bins with 20 m bin depth) but can penetrate to greater depths (approx. 900 m); the higher frequency ADCP (75 kHz) has better vertical resolution (80 bins with 10 m bin depth) but can only penetrate to approx. 750 m. Settings can be found in the files with the extension .VMO. The screen captures shown in Figures 16 and 17 contain some important settings for reference. The software used for acquisition and monitoring was the Teledyne RDI VmDas software (Version 1.46.5).

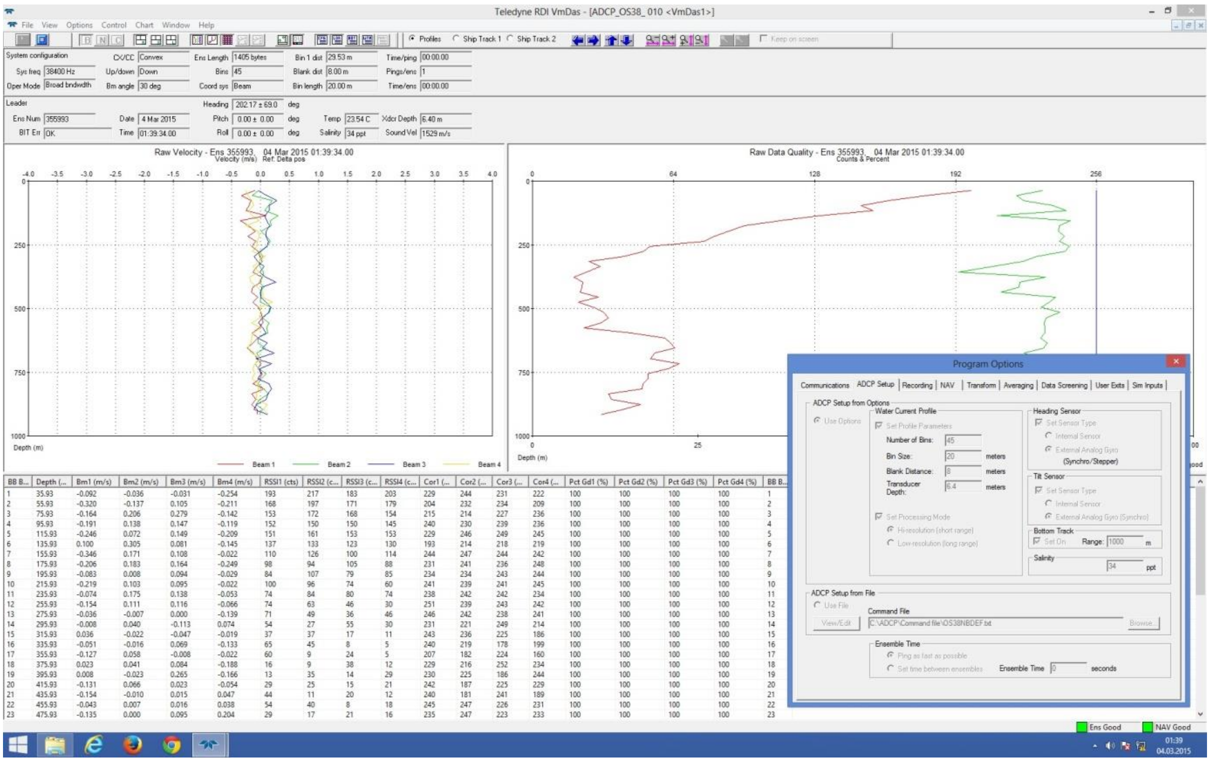


Figure 16. Screen capture of VmDas Software (being used to acquire data from the 38 kHz ADCP). On close inspection important configuration settings can be seen.

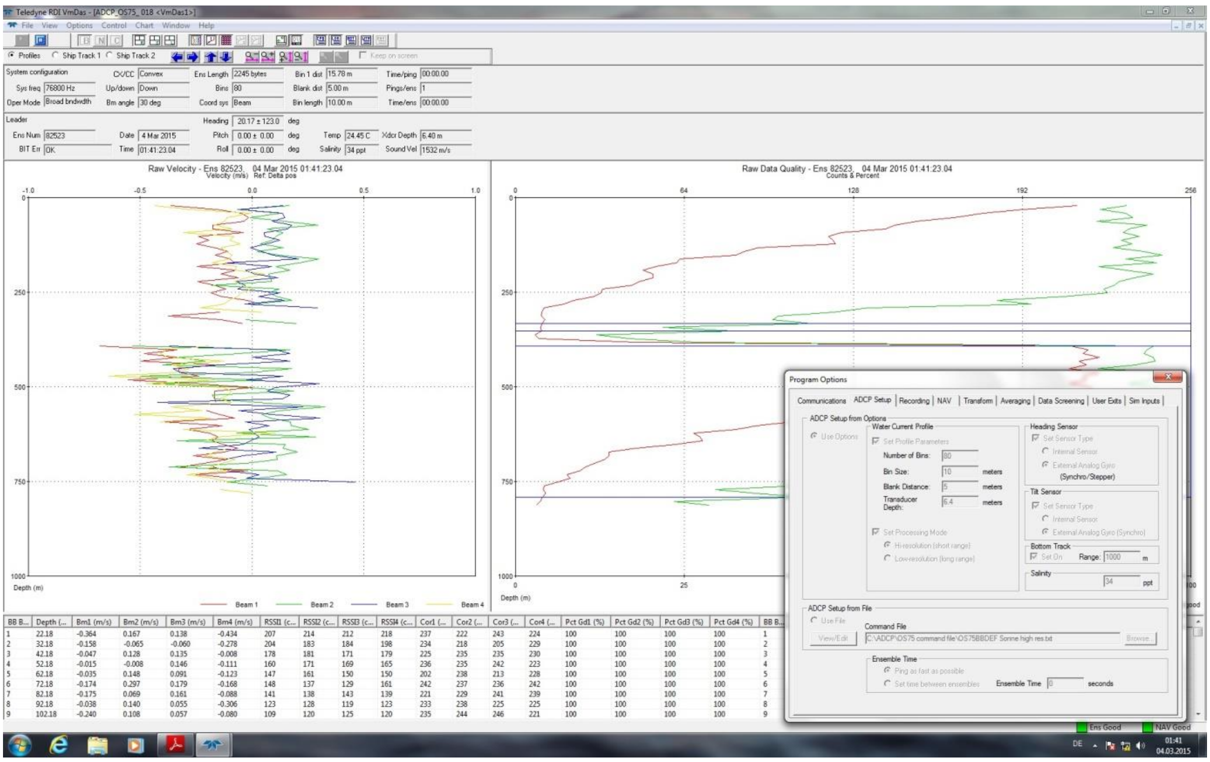


Figure 17. Screen capture of VmDas Software (being used to acquire data from the 75 kHz ADCP). On close inspection important configuration settings can be seen.

Data Acquisition and Data Files Produced

The protocol for collecting data with VmDas is as follows:

1. Open VmDas from the Start Menu.
2. File > Collect Data.
3. Options > Edit Data Options – then proceed to set configurable parameters.
4. To begin recording, click the blue 'start' button at the top left hand side of the screen.
5. To stop recording, click the blue 'stop' button at the top left hand side of the screen.

Data files generated were named according to the following format:
ADCP_OS<Inst>_<SeqNo>_<FileNo>.<Ext>,
where <Inst> is the instrument number (38 or 75), <SeqNo> is the sequence number (unfortunately, we did not specify this at the beginning and so our sequence numbers are, in terms of this project, arbitrary – the sequence begins and ends on 10 for the 38 kHz files (continuous recording throughout cruise), and in begins on 16 and ends on 18 for the 75 kHz files (crashed three times, restarted twice – see Table 3), <FileNo> is the file number (this increases by one every time a new file, of a particular type, is created after the former reaches its user-defined size limit of 25 Mb), and <Ext> is the extension.
File types generated by VmDas are summarized in Table 2 below.

Table 2 File types generated by the VmDas software, and their extensions.

Extension	File Type Description
.ENR	Binary raw data files.
.ENS	Binary ADCP data after being screened for RSSI and correlation and with navigation data included.
.ENX	ADCP single ping data and navigation data after having been bin-mapped, transformed to Earth coordinates and screened for error velocity and false targets.
.STA	Binary files of short-term average ADCP data (10s, user-specified in VmDas).
.LTA	Binary files of long-term average ADCP data (60s, user---specified in VmDas).
.N1R	ASCII text files of raw NMEA navigation data from the NMEA1 stream.
.N2R	ASCII text files of raw NMEA navigation data from the NMEA2 stream.
.N3R	ASCII text files of raw NMEA navigation data from the NMEA3 stream.
.NMS	Binary files of navigation data after screening.
.VMO	ASCII text files specifying the option settings used for the data collection.
.LOG	ASCII text files logging all output and error messages.

Data Monitoring and Archiving Protocols

Data monitoring was qualitative only and involved regularly checking that data was still being acquired by examining the various displays offered by VmDas (e.g., raw, short-term avg., and long-term avg. displays in the Chart Menu).
Files were initially stored in folders (on local drives) with the following paths:
D:\ADCP-Data\SO238\ (38 kHz);
C:\ADCP\SO238\ (75 kHz).

The archiving protocol was to copy files from these locations to the network 'Scientists' drive (usually z:) on a daily basis. The paths for these copied files were as follows:

Z:\SO238\ADCP\38kHz\<ddmmyy>;
Z:\SO238\ADCP\75kHz\<ddmmyy>,

where <ddmmyy> represents the date, and all files placed into these folders were closed by VmDas on the date in question.

Problems Encountered

Problems encountered are listed below:

- The 75 kHz instrument's data acquisition software had a tendency to crash and did so on three separate occasions during the cruise (Table 3);
    - *(n.b., The warning read 'Real-time vessel-mounted data acquisition software > funktioniert nicht mehr (no longer working)'. Action required was to close the VmDas program, restart, go to Control > Go (or click the start collecting data button). New data files are automatically generated following a restart. The problem seemed to stem from the Windows operating system of the 75 kHz instrument's PC (the 38 kHz instrument's computer was running Linux and there were no similar problems).)*
- There were no ADCP specialists onboard, and therefore activities were limited to qualitative monitoring of the data stream and data archiving (no post-processing was attempted);
- The VmDas software writes data files up to a maximum size limit (user defined – 25 Mb in our case), before creating new ones, and yet archiving was performed on a daily basis – the result is that ADCP data folders for most days will contain files of data that actually span 2 days;
- The ADCP computers occupied a position in the Data Centre that would have been better suited to the CTD control computers, given its view of the CTD launch area/equipment.

Table 3 Dates, times and durations of software crashes/data loss, and the instruments that were affected.

Instrument	Date	Time of Crash (UTC)	Approx. Time Restarted (UTC)	Duration (Hrs)
OS75 (75 kHz)	15/02/15	11:56	17:59	6:03
OS75 (75 kHz)	25/02/15	05:32	18:00	12:28
OS75 (75 kHz)	04/03/15	10:20	Not restarted (end of cruise)	-

Recommendations for Future Cruises and for Development of the FS Sonne

Recommendations are as follows:

- Check data stream on an hourly basis, in order to detect software crashes as early as possible;
- (FS Sonne) Switch positions of ADCP and CTD computers in Datenzentrale (see last point in section above).

Radiometers

Emyr Martyn Tomas Roberts (Bangor University)

Introduction

Radiation was recorded continuously during the SO238 cruise using the ship's onboard radiometers, which feed data to the database where underway measurements are stored (DSHIP). Measurements of broadband irradiance (in a number of different wavelength ranges) will be invaluable when estimating heat fluxes at the air-water interface. Such estimates are required if it is desirable to quantify the contribution of hydrothermal venting to the energetics of the water column in thermodynamic terms.

Instruments

With limited onboard documentation (in English), it was necessary to visit the radiometers in order to determine their exact type and location. The instruments were located in an elevated position on the Forecastle Deck, and they are pitch/roll compensated (tilting table) (Fig. 18 and 19).

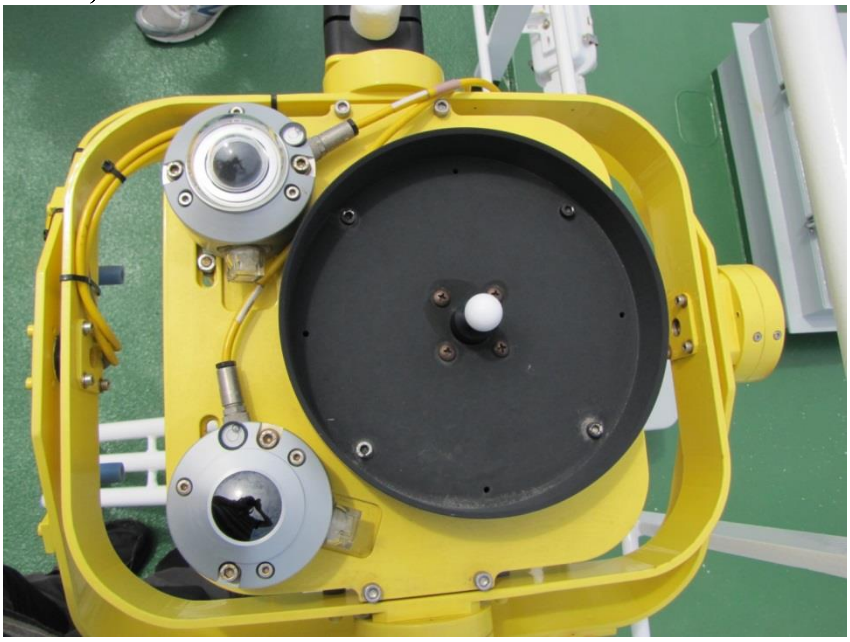


Figure 18. On-board radiometers on the Forecastle Deck of FS Sonne. Note the pitch/roll compensation (tilting table).

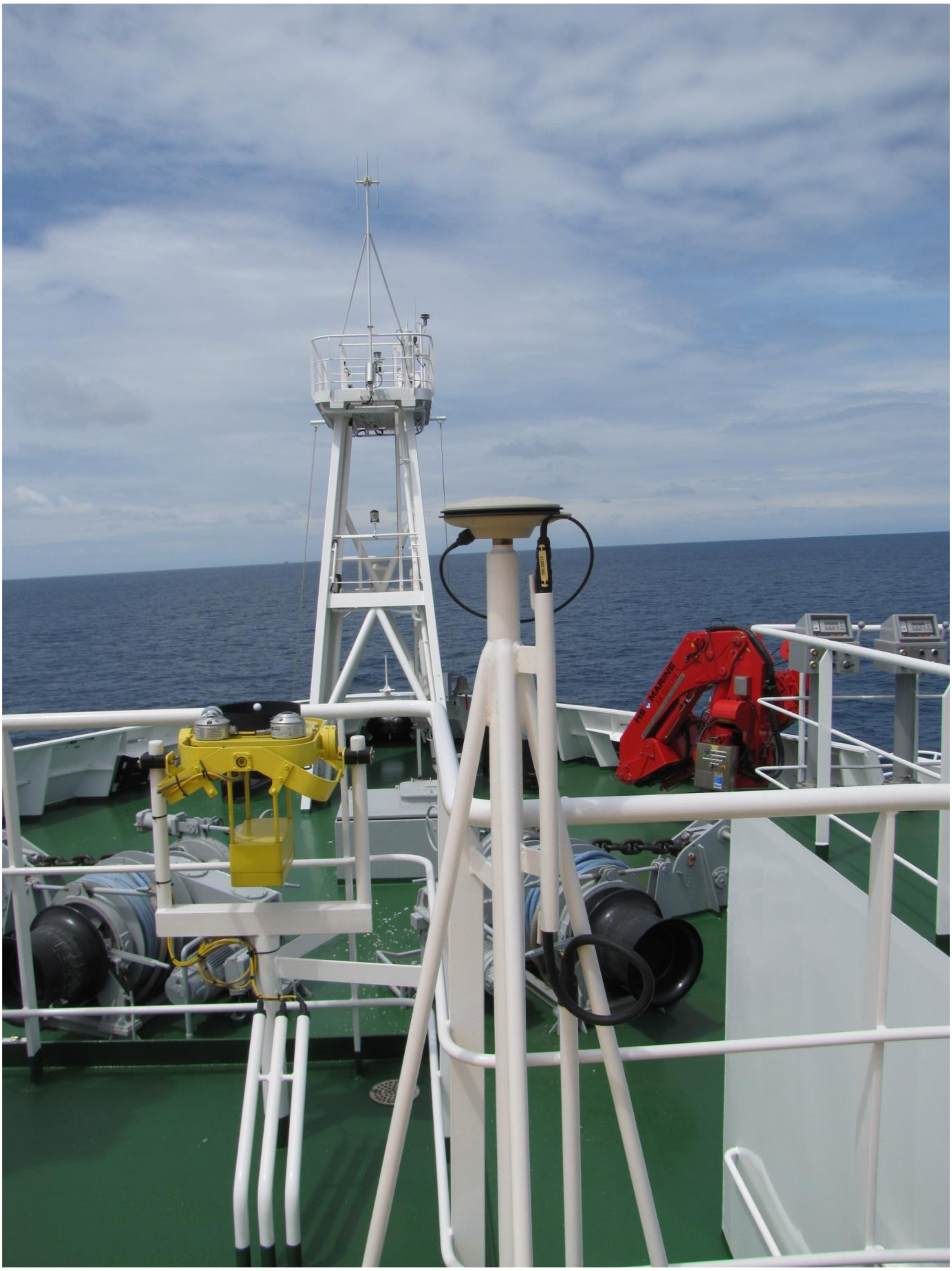


Figure 19. Location of radiometers on the Forecastle Deck (looking towards the bow).

Information on the sensors installed is presented in Table 4. The sampling interval was set to 1 min for all 3 sensors.

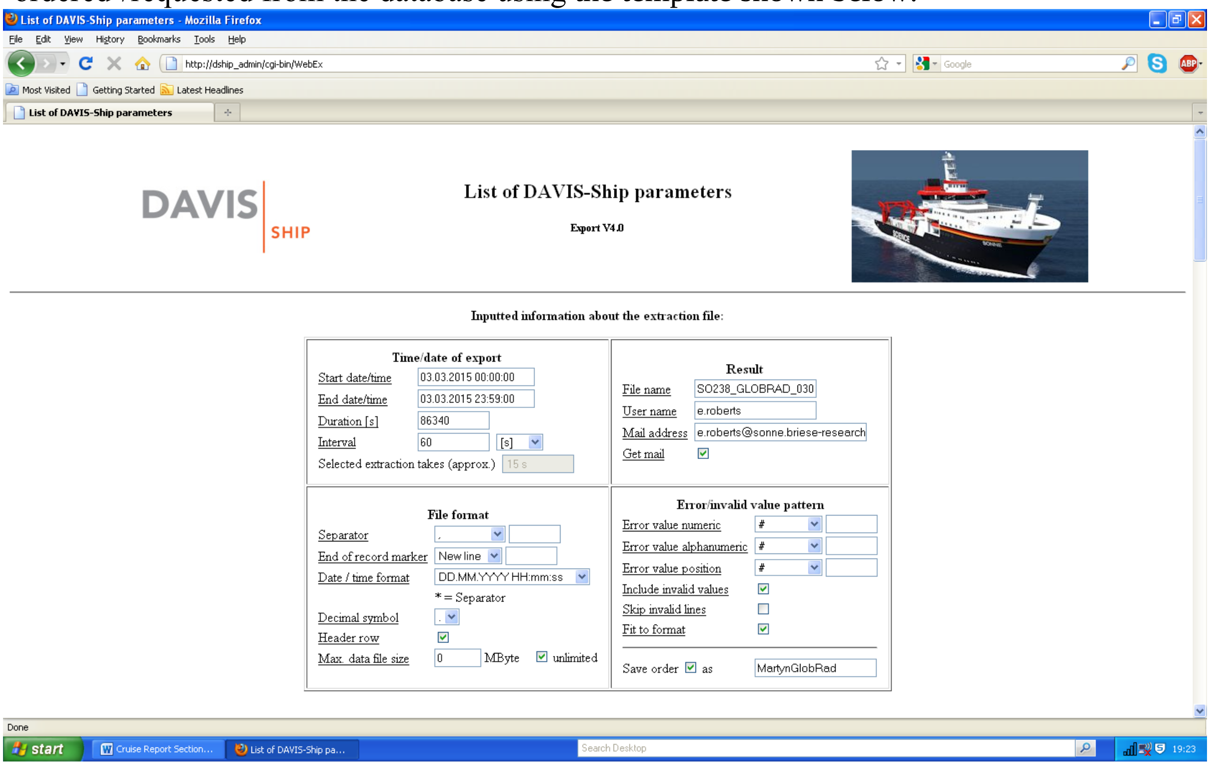
Table 4 Key information on the FS Sonne's onboard radiometers (as read from the instruments themselves).

Instrument	Wavelength Range (nm)	Type	Manufacturer	Serial No.	Calibration Date
PAR Sensor	400-700	QSR2200	Biospherical Inst.	20441	-
Pyranometer	285-2800	CMP21	Kipp and Zonen	122950	4/12/2012
Pyrgeometer	4500-42000	CGR4	Kipp and Zonen	120542	16/11/2012

Note that the CMP21 and CGR4 are temperature(and cosine)-compensated instruments; recorded temperatures were also collected during data acquisition (see next section).

Data Acquisition and Data Files Produced

As for many other types of underway and meteorological data, the radiation data were accessible via FS Sonne's DSHIP Interface. Data were downloaded on a daily basis, and immediately archived on the 'scientists' drive (see next section). Data were 'ordered'/requested from the database using the template shown below.



The FS Sonne's DSHIP interface for requesting data from the database. Here, the template used for ordering radiation data on a daily basis is shown.

Each time radiation data were ordered four files were generated. The file types are shown in Table 5 All files were named according to the following format:

SO238_GLOBRAD_<ddmmyy>,

where <ddmmyy> is the date on which the data were recorded.

Table 5. File types generated by DSHIP when fulfilling orders for the extraction of radiation data from the database.

File Type	Description
DAT	The data file with header lines. Radiation and Temperature are included.
LOG	Extracted log entries.
SYS	A log of events/errors relating to the extraction process and export of data from the database.
TXT	Text file containing a description of the data order placed.

Data Monitoring and Archiving Protocols

Data extracted using DSHIP were automatically stored in http://192.168.40.10/results/e.roberts/ (sonneweb2 > DSHIP), and from there they were copied on a daily basis to the appropriately dated folder in 'GlobalRadiation' (scientists drive – path: Z:\SO238\GlobalRadiation). The total period for which data was extracted was from 7/2/15 to 3/3/15.

For the purpose of visualizing extracted radiation data and quality control a MatLab script, GLOBRAD.m, was written, which plotted the daily variation in the three radiation parameters measured (and also the instrument temperatures of the CMP21 and CGR4). GLOBRAD.m was stored in the folder 'GlobalRadiation'. A jpeg file (containing a plot) was generated for every day of the cruise and saved in the appropriately dated folders, as with the data files above. An example of such a plot is shown in Figure 20.

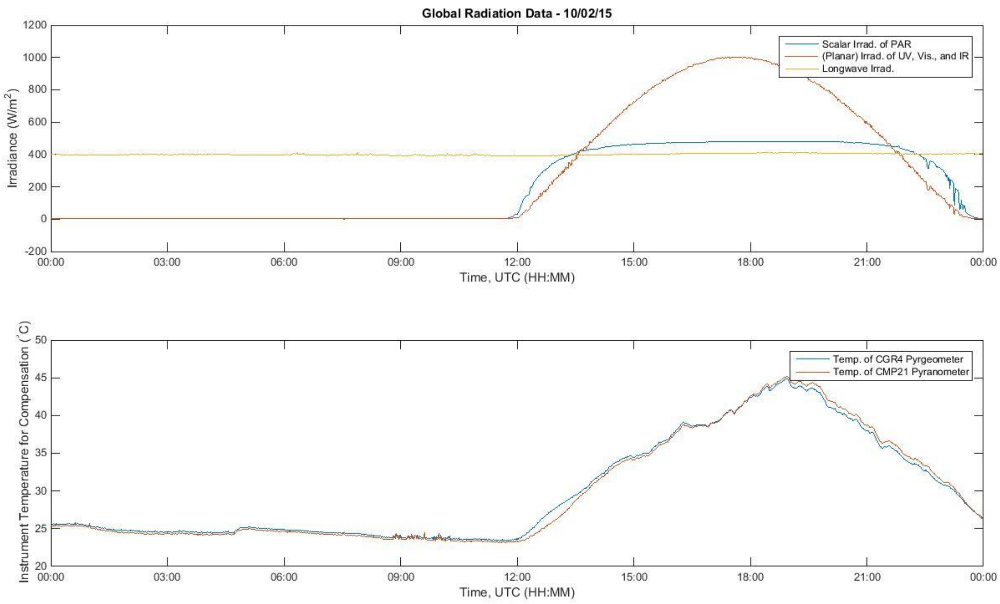


Figure 20. (Upper Panel) Diurnal variation in the three radiation parameters measured by the radiometers on-board FS Sonne. (Lower Panel) Corresponding diurnal variation in the temperature of the instruments CMP21 and CGR4, which we understand to be automatically temperature-compensated instruments (using this temperature data).

Problems Encountered and Recommendations for Future Cruises

There were no problems encountered. These instruments, and this data stream, were very reliable. It is advisable, however, to determine a format for the extracted data that is easy to work with in MatLab, for example, as early as possible in the cruise. Create a template for that particular extraction, and do not vary from this template (or alter it except where absolutely necessary) in future extractions. Complications arise if extractions generate files that are difficult to work with and if the format of the extractions is varied or inconsistent.

Wave sensor (WAMOS)

Simona Aracri (NOC)

Introduction

During the SO238 cruise, led on board of the German RV Sonne, as part of the Oscar project, a newinternal data distribution system was installed. The new system, named DAVIS-SHIP, systematically collects nautical and scientific parameters. The DAVIS-SHIP manual can be found in the dedicated intranet DAVIS-SHIP section: 'System Documentation'.

Wamos (Waves and Surface Monitoring System) represents the dedicated system to collect radar data concerning significant wave height, wave period, wave length, wave peak direction. For accurate wave and surface current measurements the wind speed needs to be at least 3 m/s, the wave height larger than 0.5-0.75 m. The data are processed and available through the DAVIS- SHIP system The radar antennas, in Fig. 21, are located at the bow.

The specifications of the radar (Fig. 22) antenna are:

- name: PLATINUM X-BAND SCANNER UNIT
- serial number: 305/30416
- brand: SAM Electronics

More details can be found in the WaMoS II Operating Manual, present in the data folder: 'WaMoS Manual f¨ur TF Sonne.pdf'.

Figure 21. The acquisition device antenna, at the Sonne bow.

Figure 22. Radar antenna specifications.

Protocol

The data were downloaded daily through the DAVIS-SHIP system. Each file contains the data recorded from 00.00 to 23.59.59 of a given day, every 60 seconds. The files were named as follow: (d) d m W AMOS (e.g. the file containing data collected during 14th February will be 14 2 W AMOS). Four kind of files are produced by the system:

- .txt: description of submitted order and list of the selected variables
- .dat: the actual data
- .sys
- .log

Appendix A and B represent an example of the data extraction definition displays.

Preliminary results

A visual check of the data was carried out producing for each day plots such as the one in Fig. 23. The plot was produced after importing the data through the matlab routine present in the data folder, wamos2.m. The script is commented in order to be useful for potential future users. The plots are named after the day they refer to, for instance 16th February plot representing peak period (Tp) and significant wave height (Hs) will be named TpHs16.png. No month identifier number was inserted for the plots since all the data were collected from 11th February to 4th March, therefore there are no doubles for the day number. The WaMoS data starts from 11th February at 14:26 UTC and ends the 4th March at 24.00.

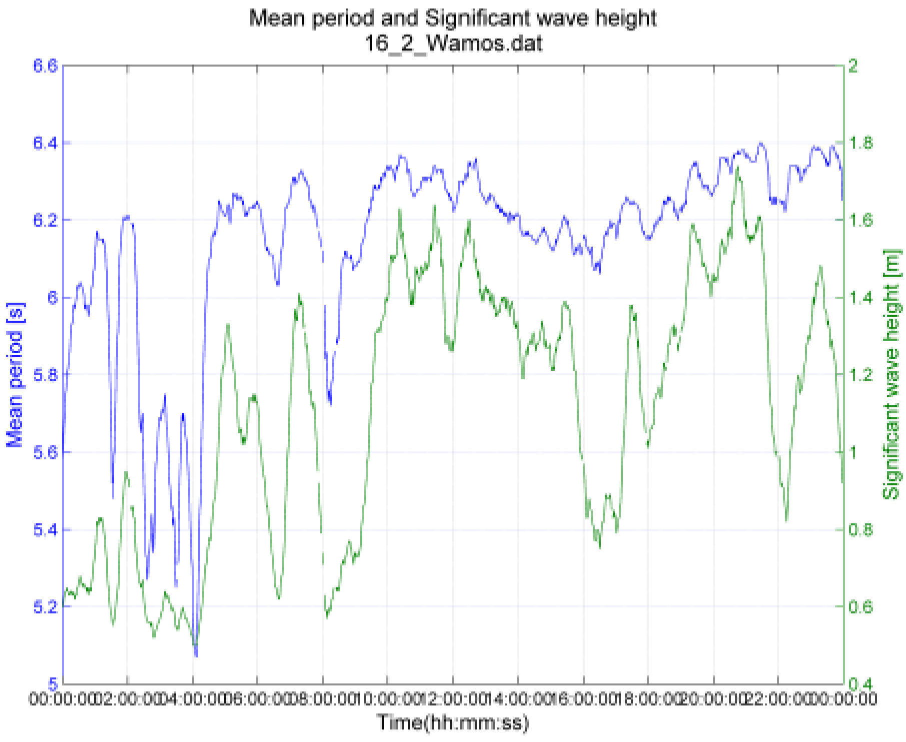


Figure 23. Peak period (Tp) and significant wave height (Hs). Day: 16th February 2015.

Appendix A

Selection of parameters. Note that it is important to select the right precision and field dimensions. The total number of figures specified in the 'Field width' space needs to be big enough to contain both the number of decimal figures required in the 'precision' space and the integers, otherwise the system will give no number as an output.

List of DAVIS-Ship sensors http://dship_admin/cgi-bin/WebEx

DAVIS SHIP

List of DAVIS-Ship sensors

Export V4.0

Selected sensors

Wamos

☑ **Current direction** [deg] — Output format: Real — Field width: 8 — Precision: 3
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Current speed** [m/s] — Output format: Real — Field width: 8 — Precision: 3
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Mean period** [s] — Output format: Real — Field width: 8 — Precision: 3
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Peak direction second system** [deg] — Output format: Real — Field width: 8 — Precision: 3
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Peak wave direction** [deg] — Output format: Real — Field width: 8 — Precision: 3
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Peak wave direction first system** [deg] — Output format: Real — Field width: 8 — Precision: 3
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

☑ **Peak wave length** [m] — Output format: Real — Field width: 8 — Precision: 3
☐ Samples ☑ Spot ☐ Min ☐ Max ☐ Value validity

1 von 3 05.03.2015 13:59

☑ **Peak wave length first system** [m]	Output format Real	Field width 8	Precision 3
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Peak wave length second system** [m]	Output format Real	Field width 8	Precision 3
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Peak wave period** [s]	Output format Real	Field width 8	Precision 3
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Peak wave period first system** [s]	Output format Real	Field width 8	Precision 3
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Peak wave period second system** [s]	Output format Real	Field width 8	Precision 3
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	
☑ **Significant wave height** [m]	Output format Real	Field width 8	Precision 3
☐ Samples ☑ Spot ☐ Min ☐ Max		☐ Value validity	

Submit Request Reset Request

How to fill in the form ?

Output format
Select the sensors you want to export by clicking the check box in front of the sensor name. The **output format** specifies the format of the generated data. You may chose between:

Text	ASCII character
Real	Number with decimal digits
Integer	Number without decimal digits
PosLon	Longitude position with Deg Min, decimalMin E/W
PosLat	Latitude position with Deg Min, decimalMin N/S
PosDeg	Position with +/-Deg, decimalDeg (- for south and west)

The default output format has been configured by the administrator. Please note that not all combinations of sensor, output format and field width make sense. 'Field width' specifies the length of the whole output column including both, decimal symbol and precision. With the precision input field you enter the number of decimal digits.

Samples
The second line of each sensor item carries check boxes for **statistical** information about the data. Each of them will generate an additional column in the output file.

Samples	Number of valid samples within the interval
Spot	First sample (valid) of the interval
Min	Minimum value (valid) of the interval
Max	Maximum value (valid) of the interval
Mean	Average over all valid samples
Variance	Variance of all valid samples
Std dev	Standard deviation of all valid samples
Value valid	Validity of the calculated values (V-Valid / I-Invalid)
Mean valid	Validity of the calculated average (V-Valid / I-Invalid)

Appendix B

Order confirmation. Here extracted data interval, columns separator, output file name etc. are defined.

DAVIS SHIP

List of DAVIS-Ship parameters

Export V4.0

Inputted information about the extraction file:

Time/date of export

Start date/time	04.03.2015 00:00:00	
End date/time	04.03.2015 23:59:59	
Duration [s]	86399	
Interval	60	[s]
Selected extraction takes (approx.)	15 s	

Result

File name	04_3_WAMOS
User name	
Mail address	
Get mail	☐

File format

Separator	,
End of record marker	New line
Date / time format	YYYY/MM/DD*HH:mm:ss
	* = Separator
Decimal symbol	.
Header row	☑
Max. data file size	0 MByte ☑ unlimited

Error/invalid value pattern

Error value numeric	#
Error value alphanumeric	#
Error value position	#
Include invalid values	☑
Skip invalid lines	☐
Fit to format	☑

Save order ☐ as SaveHighSO238_WAM(

Start Extraction Reset Request

How to fill in the form ?

The following lines briefly explain the meaning of the input-fields.

Separator
The 'separator' is inserted between the individual values extracted for one point of time.

End of record marker
The 'end of record marker' separates the single export steps representing one point of time.

Error values
The 'error values' are used to indicate missing or invalid data. It is possible to define different values for figures, positions and text.

Include invalid values
If 'show invalid values' is selected, Export will use these invalid values instead of error values.

Skip invalid lines
If 'skip invalid lines' is selected, Export will not store lines into the resulting data file which contains only invalid values.

Fit to format
If 'fit to format' is selected, Export fills up the output format with leading blanks.

Start date/time
'Start date/time' is the start date and time of the request. The string must have the format "DD.MM.YYYY HH:mm:ss".

End date/time
'End date/time' is the end date and time of the request. The string must have the format "DD.MM.YYYY HH:mm:ss".

Duration
As an alternative to the 'end date/time' you may specify the 'duration'. The duration calculates the end date/time of the request in seconds from the start data/time. If end date/time is specified, it will be adopted.

Interval
'Interval' is the gap in time between two data lines. You may specify this gap in hours ('[h]'), minutes ('[min]'), seconds ('[s]') and milliseconds ('[ms]'). If you choose [ms], only 50, 100, 200 or any value divisible by 1000 are permissible values.
For extraction of 10MinRecords, the interval is fixed to 10 minutes as a matter of course.

File name
'File name' is the prefix of the output files. The generated files will have names appended by the following extensions:

.dat	Extracted data
.log	Extracted log-entries (only for full data sets)
.sys	Notifications resp. errors from the extraction process
.txt	Generic description of the processed order

Decimal Symbol
You can choose between the German and the English decimal-symols, ',' and '.'.

Header row
If 'Header row' is selected, Export produces lines at the top of the data file containing the sensor and device names.

Max. data file size
The 'max. data file size' is the maximum size (in Mega Bytes) a data file may have. The system generates new files, if necessary. The files will then be numbered. The minimum is 1 and only integers are allowed. Entering 0 is equal to checking 'unlimited'. In this case, no limit for the file size is taken into account.

Get mail
If 'Get mail' is selected, an e-mail is sent on completion of the export.

User name
The 'user name' has to be your full name.

Mail address
The 'mail address' has to be your complete e-mail address.

Date / time format
You may choose the 'date / time format' from the following defaults. Please note that the asterisk (*) represents the separator.

YYYY*MM*DD*HH*mm*ss	year*month*day*hour*minute*second
YYYY*ddd*HH*mm*ss	year*julian days*hour*minute*second
YYYY/MM/DD*HH:mm:ss	year/month/day*hour:minute:second
DD.MM.YYYY*HH:mm:ss	day.month.year*hour:minute:second
YYYY*MM*DD	year*month*day
YYYY*ddd	year*julian days
YYYY/MM/DD	year/month/day
DD.MM.YYYY	day.month.year
HH*mm*ss	hour*minute*second
HH:mm:ss	hour:minute:second
Seconds since 1970	Time in seconds since 01.01.1970 00:00:00
None	No time / date column in the output file

Appendix C

List of Wamos folder contents.

```
totale 13500
-rwxrwxrwx 1 simona simona  179185 feb 26 13:23 11_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 13:23 11_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 13:23 11_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 13:22 11_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 13:32 12_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 13:32 12_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 13:32 12_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 13:32 12_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 14:56 13_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 14:56 13_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 14:56 13_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 14:56 13_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 mar  4 22:55 1_3_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 mar  3 18:50 1_3_WAMOS.log
-rwxrwxrwx 1 simona simona     339 mar  3 18:50 1_3_WAMOS.sys
-rwxrwxrwx 1 simona simona    3338 mar  3 18:50 1_3_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 14:56 14_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 14:57 14_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 14:57 14_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 14:56 14_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 14:57 15_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 14:57 15_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 14:57 15_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 14:57 15_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 14:59 16_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 14:59 16_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 14:59 16_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 14:59 16_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:04 17_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 15:04 17_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:04 17_21_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:04 17_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:44 18_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 15:44 18_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:44 18_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:44 18_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:44 19_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 15:44 19_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:44 19_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:44 19_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:44 20_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 15:44 20_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:45 20_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:44 20_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:45 21_2_WAMOS.dat
```

```
-rwxrwxrwx 1 simona simona      42 feb 26 15:45 21_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:45 21_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:45 21_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:45 22_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 15:45 22_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:45 22_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:45 22_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:45 23_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 15:45 23_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:45 23_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:45 23_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 mar  3 18:50 2_3_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 mar  3 18:50 2_3_WAMOS.log
-rwxrwxrwx 1 simona simona     339 mar  3 18:50 2_3_WAMOS.sys
-rwxrwxrwx 1 simona simona    3338 mar  3 18:50 2_3_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:45 24_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 15:45 24_22_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:45 24_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:45 24_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 feb 26 15:46 25_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 feb 26 15:46 25_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 feb 26 15:46 25_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 feb 26 15:46 25_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 mar  1 13:04 26_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 mar  1 13:04 26_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 mar  1 13:04 26_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 mar  1 13:04 26_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 mar  1 13:04 27_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 mar  1 13:04 27_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 mar  1 13:04 27_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 mar  1 13:04 27_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 mar  1 13:05 28_2_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 mar  1 13:05 28_2_WAMOS.log
-rwxrwxrwx 1 simona simona     339 mar  1 13:05 28_2_WAMOS.sys
-rwxrwxrwx 1 simona simona    3339 mar  1 13:04 28_2_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 mar  5 16:06 3_3_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 mar  5 16:06 3_3_WAMOS.log
-rwxrwxrwx 1 simona simona     339 mar  5 16:06 3_3_WAMOS.sys
-rwxrwxrwx 1 simona simona    3340 mar  5 16:05 3_3_WAMOS.txt
-rwxrwxrwx 1 simona simona  197918 mar  5 15:19 4_3_WAMOS.dat
-rwxrwxrwx 1 simona simona      42 mar  5 15:20 4_3_WAMOS.log
-rwxrwxrwx 1 simona simona     339 mar  5 15:20 4_3_WAMOS.sys
-rwxrwxrwx 1 simona simona    3338 mar  5 15:19 4_3_WAMOS.txt
-rwxrwxrwx 1 simona simona  120706 feb 27 10:12 Hs11.png
-rwxrwxrwx 1 simona simona       0 mar  5 20:17 list
-rwxrwxrwx 1 simona simona       6 mar  5 20:13 list.txt
-rwxrwxrwx 1 simona simona  118326 feb 27 10:24 Peaks11.png
-rwxrwxrwx 1 simona simona  128989 feb 27 10:31 Peaks12.png
-rwxrwxrwx 1 simona simona  119552 feb 27 10:30 Peaks13.png
-rwxrwxrwx 1 simona simona  123005 feb 27 10:34 Peaks14.png
```

```
-rwxrwxrwx 1 simona simona  123577 feb 27 10:34 Peaks15.png
-rwxrwxrwx 1 simona simona  125068 feb 27 10:35 Peaks16.png
-rwxrwxrwx 1 simona simona  124736 feb 27 10:35 Peaks17.png
-rwxrwxrwx 1 simona simona  130351 feb 27 10:36 Peaks18.png
-rwxrwxrwx 1 simona simona  127530 feb 27 10:37 Peaks19.png
-rwxrwxrwx 1 simona simona  130043 mar  5 15:25 Peaks1.png
3-rwxrwxrwx 1 simona simona  124093 feb 27 10:37 Peaks20.png
-rwxrwxrwx 1 simona simona  121503 feb 27 10:38 Peaks21.png
-rwxrwxrwx 1 simona simona  124772 feb 27 10:38 Peaks22.png
-rwxrwxrwx 1 simona simona  127413 feb 27 10:39 Peaks23.png
-rwxrwxrwx 1 simona simona  127236 feb 27 10:39 Peaks24.png
-rwxrwxrwx 1 simona simona  127993 feb 27 10:39 Peaks25.png
-rwxrwxrwx 1 simona simona  130538 mar  5 16:50 Peaks26.png
-rwxrwxrwx 1 simona simona  127052 mar  4 22:37 Peaks27.png
-rwxrwxrwx 1 simona simona  128616 mar  4 22:38 Peaks28.png
-rwxrwxrwx 1 simona simona  128978 mar  5 15:26 Peaks2.png
-rwxrwxrwx 1 simona simona  120450 mar  5 16:08 Peaks3.png
-rwxrwxrwx 1 simona simona  125461 mar  5 15:27 Peaks4.png
-rwxrwxrwx 1 simona simona  115659 feb 27 10:00 Tm11.png
-rwxrwxrwx 1 simona simona  151961 feb 27 10:31 TpHs12.png
-rwxrwxrwx 1 simona simona  139575 feb 27 10:28 TpHs13.png
-rwxrwxrwx 1 simona simona  153717 feb 27 10:33 TpHs14.png
-rwxrwxrwx 1 simona simona  146330 feb 27 10:34 TpHs15.png
-rwxrwxrwx 1 simona simona  167558 feb 27 10:35 TpHs16.png
-rwxrwxrwx 1 simona simona  159265 feb 27 10:35 TpHs17.png
-rwxrwxrwx 1 simona simona  160092 feb 27 10:36 TpHs18.png
-rwxrwxrwx 1 simona simona  158187 feb 27 10:37 TpHs19.png
-rwxrwxrwx 1 simona simona  153370 mar  5 15:25 TpHs1.png
-rwxrwxrwx 1 simona simona  146982 feb 27 10:37 TpHs20.png
-rwxrwxrwx 1 simona simona  136434 feb 27 10:38 TpHs21.png
-rwxrwxrwx 1 simona simona  158995 feb 27 10:38 TpHs22.png
-rwxrwxrwx 1 simona simona  143121 feb 27 10:39 TpHs23.png
-rwxrwxrwx 1 simona simona  142945 feb 27 10:39 TpHs24.png
-rwxrwxrwx 1 simona simona  145082 feb 27 10:39 TpHs25.png
-rwxrwxrwx 1 simona simona  150936 mar  5 16:50 TpHs26.png
-rwxrwxrwx 1 simona simona  148812 mar  4 22:37 TpHs27.png
-rwxrwxrwx 1 simona simona  155585 mar  4 22:38 TpHs28.png
-rwxrwxrwx 1 simona simona  162422 mar  5 15:26 TpHs2.png
-rwxrwxrwx 1 simona simona  159637 mar  5 16:08 TpHs3.png
-rwxrwxrwx 1 simona simona  141620 mar  5 15:27 TpHs4.png
-rwxrwxrwx 1 simona simona    6769 feb 27 10:30 wamos2.asv
-rwxrwxrwx 1 simona simona    6838 mar  5 16:50 wamos2.m
-rwxrwxrwx 1 simona simona 3172160 gen  7 20:07 WaMoS  Manual_für TF Sonne.pdf
```

Surface Meteorological Sampling System (Surfmet)

R. Catany, S. Aracri and E. Roberts

The surface meteorological conditions were measured throughout the cruise using the Surfmet package. A brief discussion of the performance of the meteorological sensors is give in this section.

Instrumentation

The Sonne is instrumented with a variety of meteorological sensors to measure air temperature, humidity, atmospheric pressure, shortwave radiation and wind speed and direction. **Table 6** gathers accuracy and calibration information for each sensor, as well as information about instrument location around the ship for each sensor.
Data was logged and plotted in daily basis as described in *Downloading data* section. Data quality was assessed visually only and then it was stored in a big matrix, which contained the whole cruise Surfmet data in a unified format. Reader can refer to the readme file to learn more about the data structure and about how to treat possible missing data.

Underway Temperature and Salinity
Near surface oceanographic parameters were measured by sensors located in the non-toxic supply. The sea surface temperature (SST) was measured at a depth of 2.5 m bellow the sea surface.

Variable	Instrument	Serial number	Sensor position	Accuracy
Thermosalinograph- housing temperature (temperature_internal)	SBE45 MicroTSG	-	Water sampling room	
Thermosalinograph – conductivity	SBE45 Micro TSG	-	Water sampling room	
Sea surface temperature (temperature_external)	SBE38 Digital thermometer	-	Near water intake in the sampling room	
Fluorescence	-	-	-	-
Transmittance	-	-	-	-

Table 6: Underway SST, Conductivity, fluorescence and transmittance instruments details

The Underway surface temperature and salinity was plotted for the whole cruise (**Fig. 24 'salt_SO238v2_tsg_all.tif' and Fig. 25 'temp_SO238v2_tsg_all.tif**). It is possible to see that instruments were recording properly both variables. It is possible to see that there two gaps in the graphs. The gap between 16:00 and 20:00 hours on the 2nd of March it is due to pass of Sonne close to the Mal Pelo Island. This is a protected natural park in Colombian waters and it was advise to stop all the scientific instruments. There is another gap (24h on the 27th February), which is not clear why instruments stop recording but most probable is due to some change undertaken in the logging system of the ship.

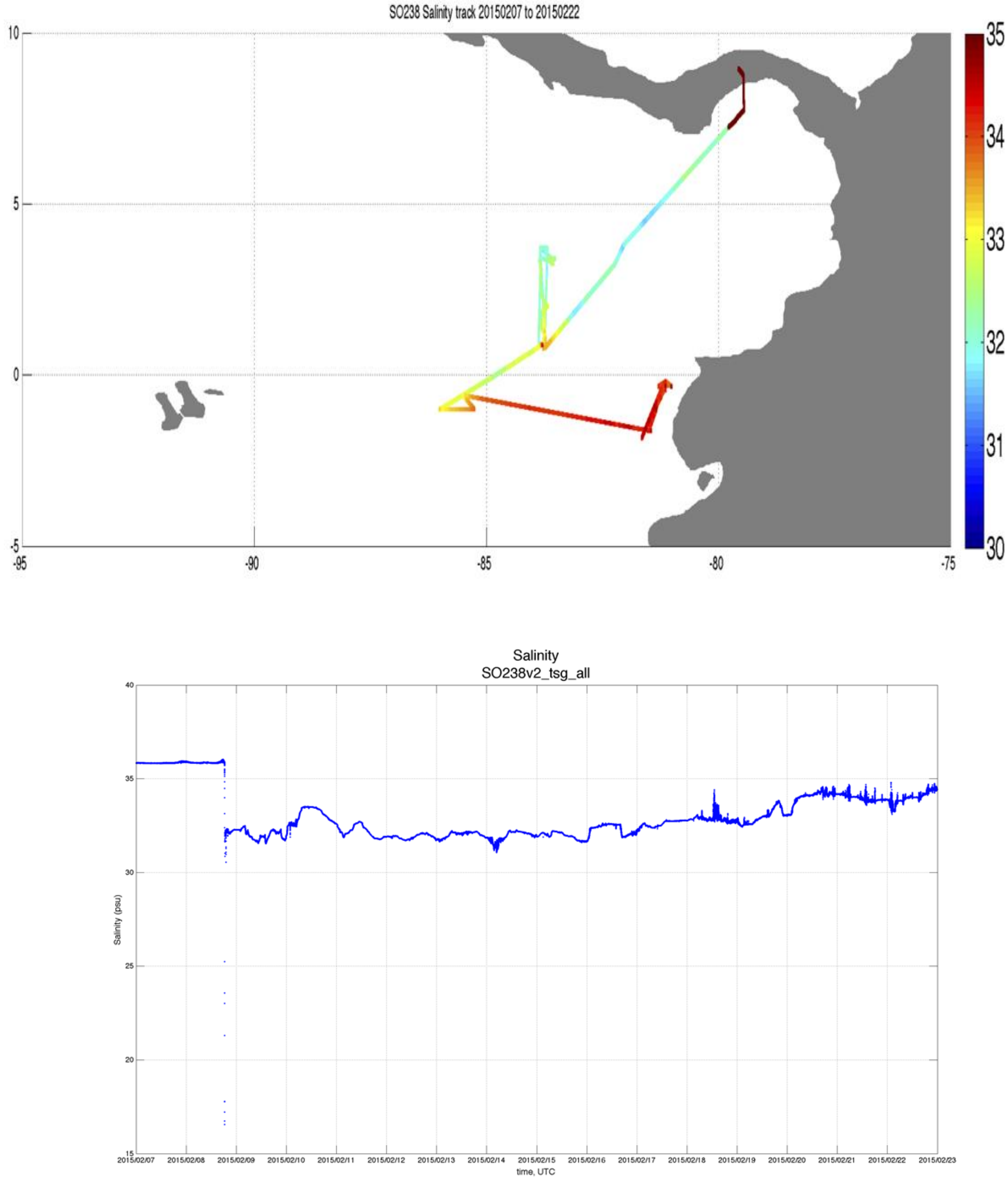


Figure 24. Surface salinity. Top: chart. Bottom: time series.

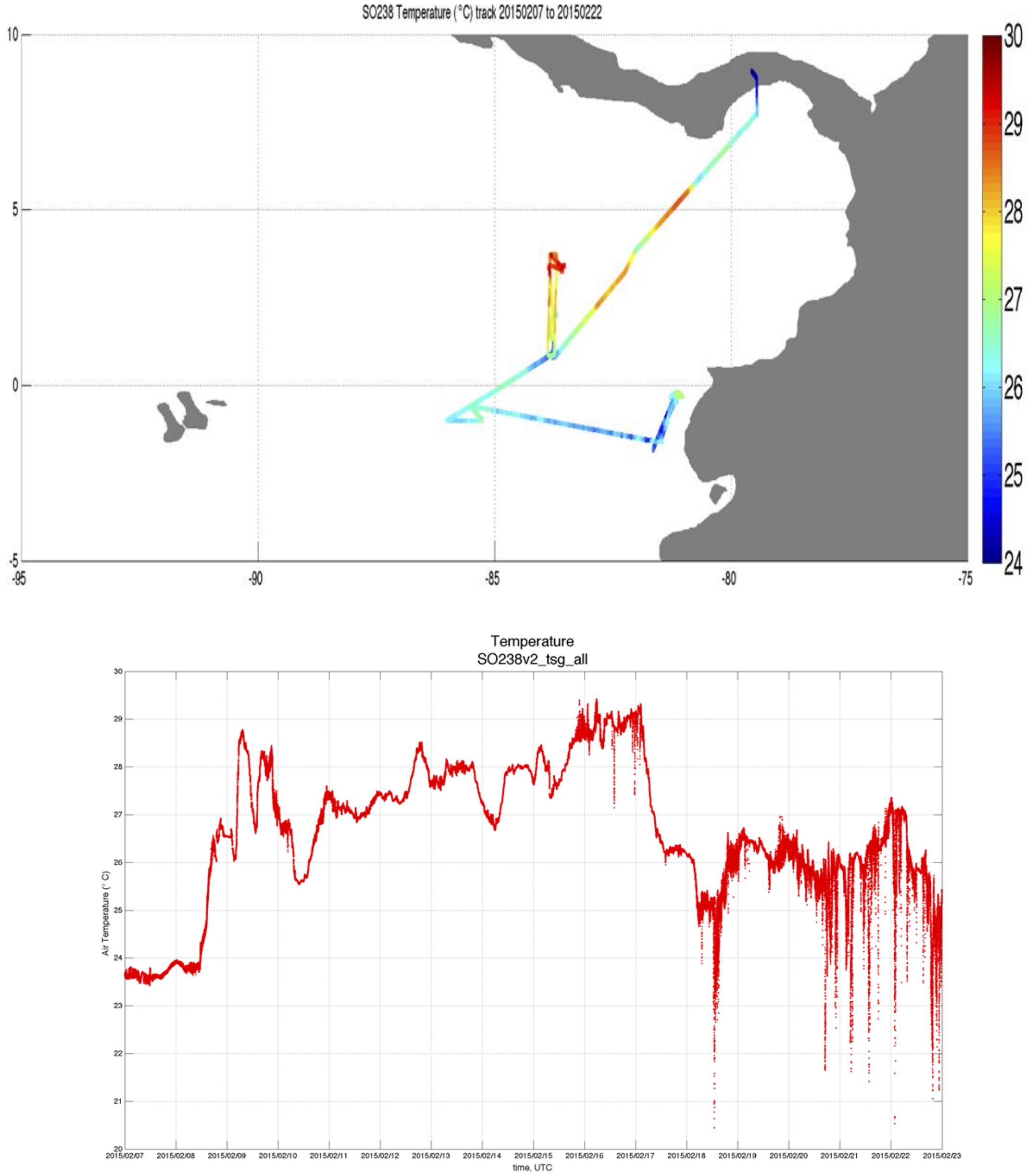


Figure 25. Surface temperature. Top: chart. Bottom: time series.

Mooring Operations

John Wynar (Sensors and Moorings Group, National Marine Facilities Sea Systems, National Oceanography Centre), Peter Schröder (GEOMAR), Miguel A. Morales Maqueda (NOC)

Main objectives

1. To recover a line of 12 magnetotelluric (MT) landers deployed during the cruise JC112 on RRS James Cook.
2. To recover the moorings M1,M2, M3, Mooring ADCP West and Mooring ADCP East deployed during JC112 from the James Cook.
3. To re-deploy the 75kHz ADCP mooring in the Ecuador trench.
4. To recover the mooring deployed in (b) above.

MT landers

Eleven out of the twelve landers were recovered in good state. The non-recovered lander (MT07) was eventually found adrift by a commercial vessel sometime later. See accompanying chart for lander deployments (Fig. 26).

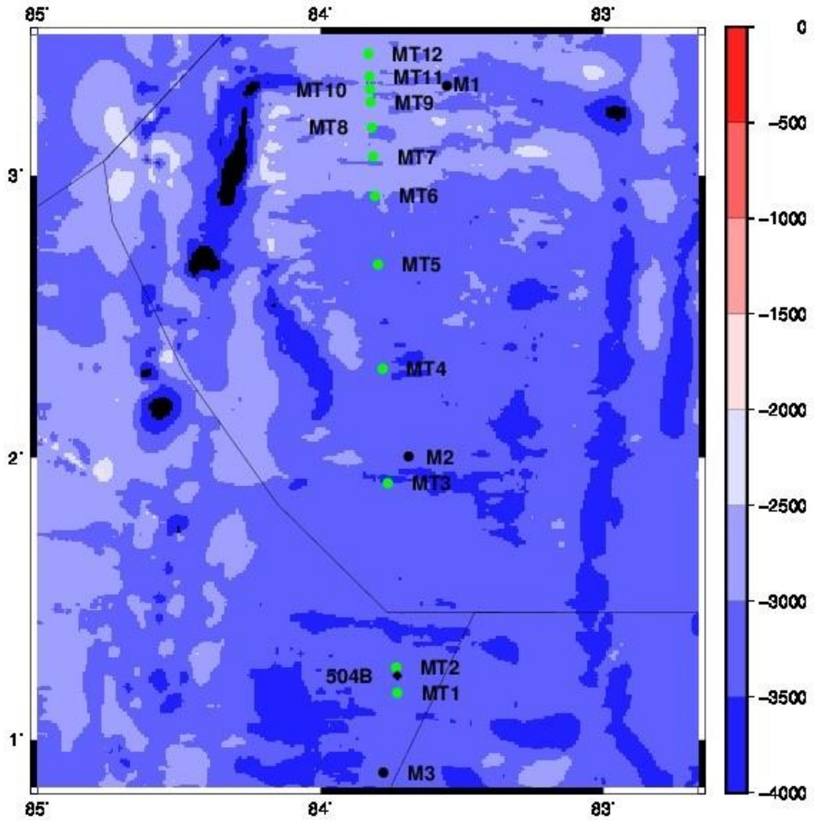


Figure 26. Location of MT landers (green dots). Also shown are the locations of the three taut moorings M1, M2 and M3 (black dots) and the bore hole 504B (black dot). The thin, black lines delineate the 200 mile boundaries of the EEZ of Costa Rica, Colombia and Ecuador.

Mooring recoveries and deployments

All echo sounders were switched off or put in passive mode during acoustic interrogation to avoid interference.

The deck unit used throughout was Ixsea TT801, s/n: 013 and respective transducer; and acoustic module AM661, s/n: 048.

All moorings had been deployed with releases “doubled-up”. The codes for the second, generally unused release are given in parenthesis.

The vessel’s own dedicated mooring winch was used for recoveries (except those done over the stb’d side) and deployment.

All times given below are in UTC unless stated otherwise.

1a) Recovery of M1 (16th February 2015)

Acoustic release, AR861; s/n: 1498 (1134)
Arm: 09D9 (0822)
Diagnostic: Arm & 0949 (0849)

Release:	Arm & 09D9 (0822)

11:30	Arm and diagnostic command sent: Received range: 3360m & vertical
11:35	Release command sent: Received release OK; range: 3365m, 3172m
11:37	3172m
11:38	3098m
11:39	2999m
11:40	2879m

Consistent ranges were received over the next few minutes enough to ascertain an ascent rate of over 100m/min.

The mooring was sighted on the surface at 12:15 and the vessel began its approach when the bridge officer was satisfied all the buoyancy was visible. Initially the ship attempted a conventional recovery, grappling the upper buoyancy from the starboard side deck. Unfortunately the OOW (officer on watch) erroneously approached the centre, five-sphere buoyancy pack and not the Billings float, perhaps mistaking it for top-most six-sphere pack. As the line was passed down the deck to aft, one line went under the stern and became entangled round the rudder post.
Various attempts were made to free the line culminating in cutting one side of the line but the remaining line was still stuck fast. The ship's work-boat was launched to obtain a view from the water-line and also to allow the rope to be worked from a more direct angle. After some further judicious cutting and pulling of the line the remaining rope was pulled free with no loss or damage to equipment. Eventually everything was recovered by 17:20.

1b) Recovery of M2 (17th February 2015)

Acoustic release, AR861; s/n: 1613 (474)

Arm:	0A6a (1525)
Diagnostic:	Arm & 0A49 (1549)
Release:	Arm & 0A55 (1555)

Water depth: 3320m

13:39	Arm and diagnostic command sent: Received range: 3357m & vertical
13:40	Release command sent: Received release OK; range: 3357m, 3357m
13:42	3196m
13:43	3102m

An ascent rate of approximately 100m/min was estimated.

On this occasion the vessel approached the mooring stern first to avoid any recurrence of the previous incident. Although this took longer it was entirely feasible given the prevailing sea conditions (calm) and capabilities of the ship.

Unfortunately the recovery line, Billings float and top buoyancy pack were all wrapped round each other. This made recovery difficult and hazardous due to the potential for a sudden drop of the tangled buoyancy spheres. Later on the lower section of the mooring from the four-sphere pack down were similarly found to be tangled on recovery.

14:48	Upper mooring section grappled
14:52	Upper mooring section on board
15:13	SBE37 s/n: 9390 on board
15:25	Aquadopp s/n: 8485 & SBE37 s/n: 9391 on board
15:50	SBE37 s/n: 9392 on board
16:01	Remaining lower section recovered

1c) Recovery of M3 (18th February 2015)

Acoustic release, AR861; s/n: 1496 (1271)

Arm:	09D7 (08CC)
Diagnostic:	Arm &0949 (0849)
Release:	Arm &0955 (0855)

11:30	Arm and diagnostic command sent:
	Received range: 3520m & vertical; 3517m & vertical
11:35	Release command sent:
	Received release OK; range: 3513m
11:36	3430m
11:37	3322m

Subsequent ranges received were consistent and gave an ascent rate of around 100m/min.

In an attempt to reduce package tangling, the ship's work-boat was launched to stream out the mooring. This approach did have some effect with the top two thirds of the mooring recovered successfully without further problems. However, the lower section once again became entangled and required careful handling during recovery.

13:35	Six-sphere pack on deck
13:43	Billings float recovered
14:00	Aquadopp s/n: 9905 & SBE37 s/n: 9395 on board
14:19	SBE37 s/n: 9397 recovered
14:31	Aquadopp s/n: 9909 & SBE37 s/n: 9398 on board
14:59	SBE37 s/n: 11110 recovered
15:10	Remaining lower section recovered

1d) Recovery of ADCP 300kHz West (19th February 2015)

Acoustic release, AR861; s/n: 1749 (321)

Arm:	1A04 (14D1)
Diagnostic:	Arm &1A49 (1449)
Release:	Arm &1A55 (1455)

14:33	Arm and diagnostic command sent: Received range: 2431m & vertical; 2434m & vertical
14:36	Release command sent: Received release OK; range: 2442m
14:37	2394m
14:38	2317m
14:39	2228m
15:19	Mooring recovered

After release, subsequent ranging gave an ascent rate of approximately 80m/min.

The entire package was grappled from the starboard side and recovered as one unit using the stb'd side crane.

1e) Recovery of ADCP 75kHz East (19th February 2015)

Acoustic release, AR861; s/n: 1750 (1614)

Arm:	1A05 (0A6B)
Diagnostic:	Arm &1A49 (0A49)
Release:	Arm &1A55 (0A55)

19:15	Arm and diagnostic command sent: Received range: 3385m & vertical;3389m & vertical
19:16	Release command sent: Received release OK; range: 3393m
19:17	3351m
19:18	3316m
19:19	3283m
19:55	Buoy on deck
20:00	Releases recovered

Shortly after release, ranging gave an approximate ascent rate of 70m/min.

Unfortunately the recovery line was again tangled up around the syntactic float requiring extra care during the process.

2) Deployment of ADCP 75kHz (21st February 2015)

On this occasion no large release link was available. Hence the deployment was done with a single release only. In an attempt to mitigate the tangling of the recovery line round the buoy, a 17inch glass sphere was used.

Acoustic release, AR861; s/n: 1614

Arm:	0A6B
Diagnostic:	Arm & 0A49
Release:	Arm & 0A55

13:13	Mooring deployed at position: 0°19.451'S, 81° 08.178'W Water depth: 2921m

13:20	Range: 1512m
13:21	Range: 1657m
13:34	Range: 3023m, 3024m, 3024m – on the sea floor

An average descent rate of 140m/min was estimated.

3) Recovery of ADCP 75kHz (22nd February 2015)

15:10	Arm and diagnostic command sent: Received range: 3321m & vertical; 3320m & vertical
15:12	Release command sent: Received release OK; range: 3317m
15:13	3199m
15:14	3099m
15:37	Sighted at the surface
16:00	Mooring recovered

Note: At the surface the recovery line had streamed out and was not wrapped around the buoy.

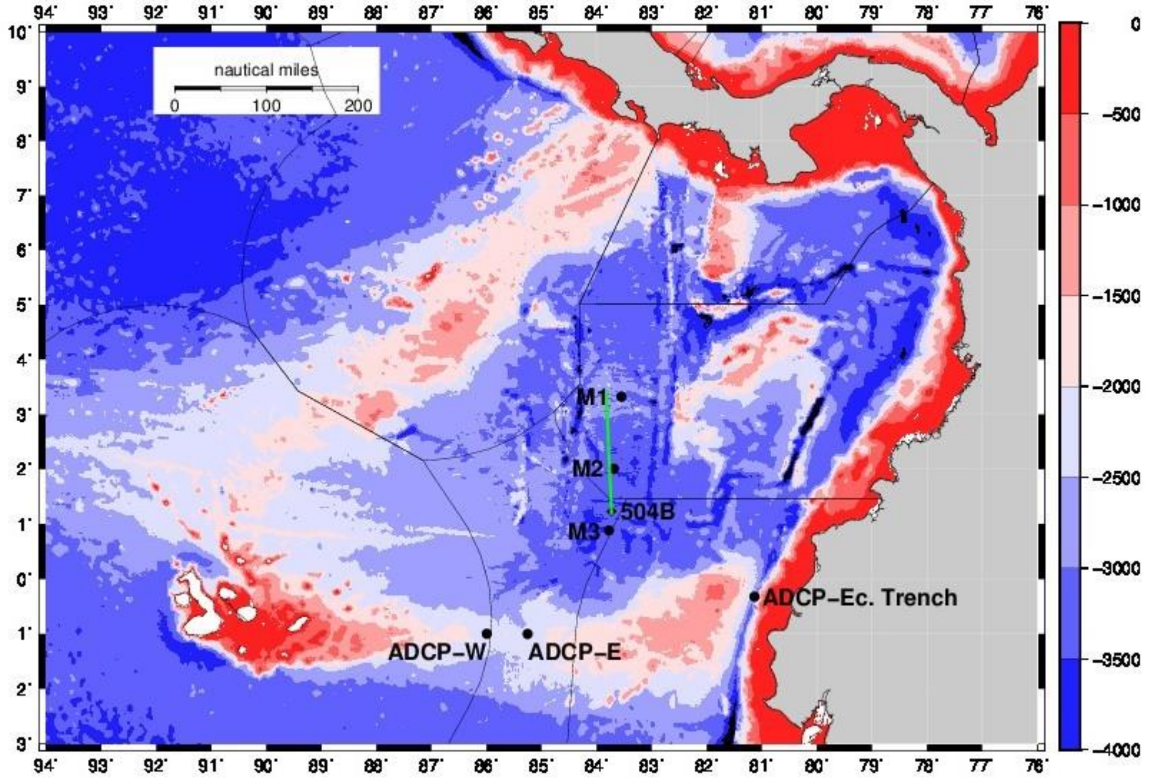


Figure 27 . Location of all mooring recoveries and deployments (black dots). Also shown is the line along which the MT landers were deployed (in green) and the location of the bore hole 504B (black dot). The thin, black lines delineate the 200 mile boundaries of the EEZ of Costa Rica, Panama, Colombia and Ecuador.

Instrumentation Summary

TRDI

- **75kHz ADCP** s/n: 20676 stopped data logging at 21:34 on 19/02/15.

- **300kHz ADCP** s/n: 21028 stopped data logging at 13:51 on 23/02/15.

- **75kHz ADCP** s/n: 20676 started data logging at 10:15:30 on 21/02/15 for Ecuador trench deployment.
  All parameters remained the same except for the following:
  Pings per ensemble: 50
  Number of bins: 40
  Cell size: 10m
  Deployment depth: 2700m
  Temperature: 3°C

- **75kHz ADCP** s/n: 20676 stopped data logging at 14:02 on 22/02/15.

Nortek

Aquadopp current meters all stopped on 24/02/15
s/n: AQD 9905 stopped at 13:49:00
s/n: AQD 9912 stopped at 14:25:00
s/n: AQD 8493 stopped at 14:53:00
s/n: AQD 8485 FLOODED
s/n: AQD 8468 stopped at 15:30:00
s/n: AQD 9909 stopped at 16:02:00
s/n: AQD 8450 stopped at 16:30:00
s/n: AQD 8463 stopped at 17:50:00
s/n: AQD 8460 stopped at 18:25:00

SBE

SBE37 s/n: 9396 stopped at 01:33:00 on 20/02/15
SBE37 s/n: 9396 started logging at 12:06:00 on 21/02/15 for Ecuador trench deployment.
SBE37 s/n: 9396 stopped at 19:44:00 on 22/02/15
SBE37 s/n: 9390 stopped at 14:17:30 on 21/02/15
SBE37 s/n: 9382 stopped at 14:52:00 on 21/02/15
SBE37 s/n: 9399 stopped at 15:38:00 on 21/02/15
SBE37 s/n: 9386 stopped at 15:48:00 on 21/02/15
SBE37 s/n: 9380 stopped at 16:01:00 on 21/02/15
SBE37 s/n: 9388 stopped at 16:09:00 on 21/02/15

SBE37 s/n: 9389 stopped at 16:16:00 on 21/02/15
SBE37 s/n: 9391 stopped at 16:51:00 on 21/02/15
SBE37 s/n: 9387 stopped at 17:59:00 on 21/02/15
SBE37 s/n: 9392 stopped at 18:19:00 on 21/02/15
SBE37 s/n: 11111 stopped at 18:51:00 on 21/02/15
SBE37 s/n: 9393 stopped at 19:04:00 on 21/02/15
SBE37 s/n: 9395 stopped at 19:31:00 on 21/02/15
SBE37 s/n: 9397 stopped at 19:37:00 on 21/02/15
SBE37 s/n: 11108 stopped at 20:02:00 on 21/02/15
SBE37 s/n: 11110 stopped at 20:56:00 on 21/02/15
SBE37 s/n: 11109 stopped at 20:59:00 on 21/02/15
SBE37 s/n: 9398 stopped at 21:28:00 on 21/02/15
SBE37 s/n: 11107 stopped at 21:32:00 on 21/02/15

Instrument calibration

All the SBE37's and SBE53's were calibrated against the CTD SBE9plus on a cast of depth greater than 3000m. The same sampling regime was kept for the SBE53's but for the SBE37's the sampling average was changed to 15 seconds. Four stops were made for approximately 20 minutes each.

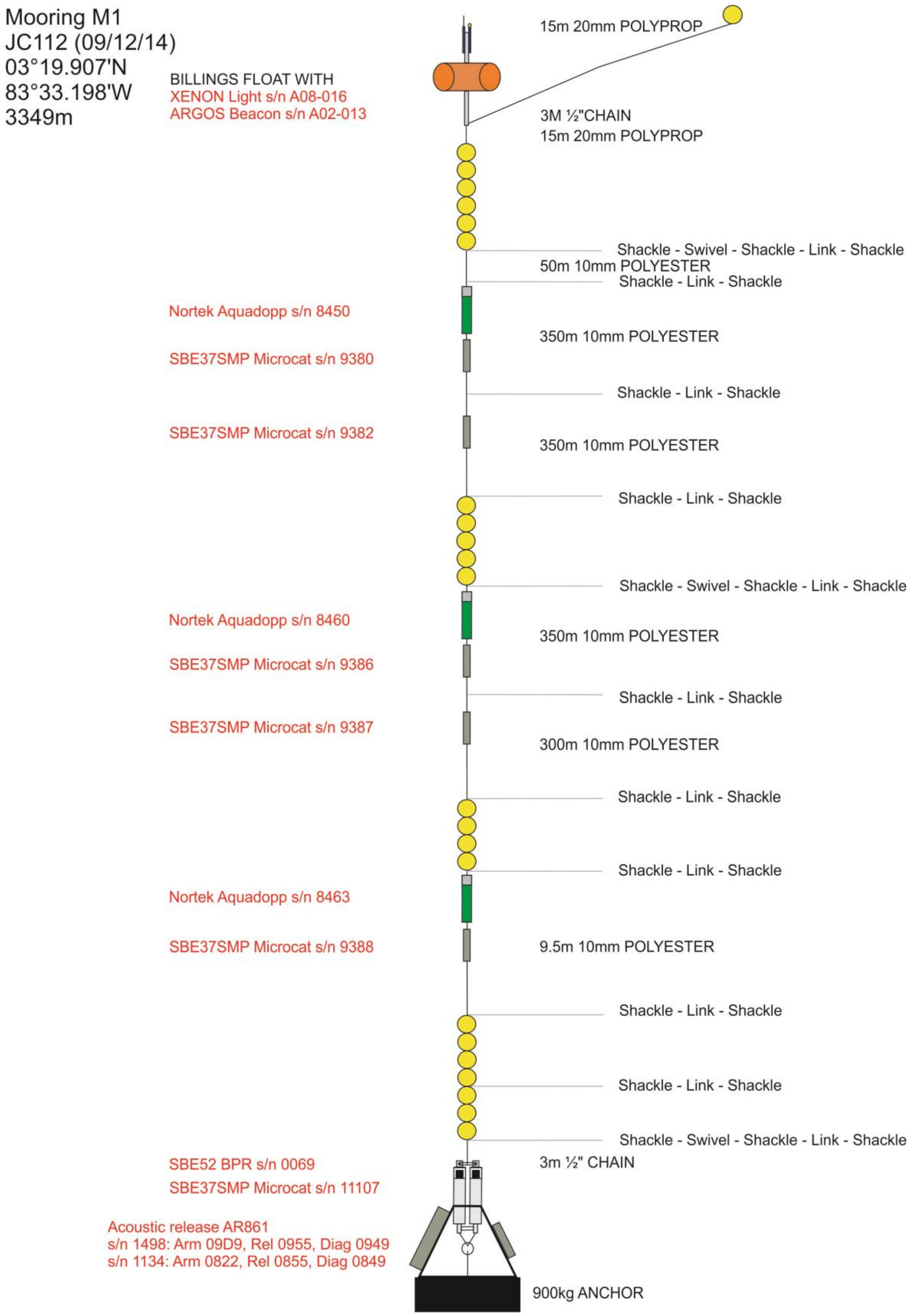
Notes and Recommendations

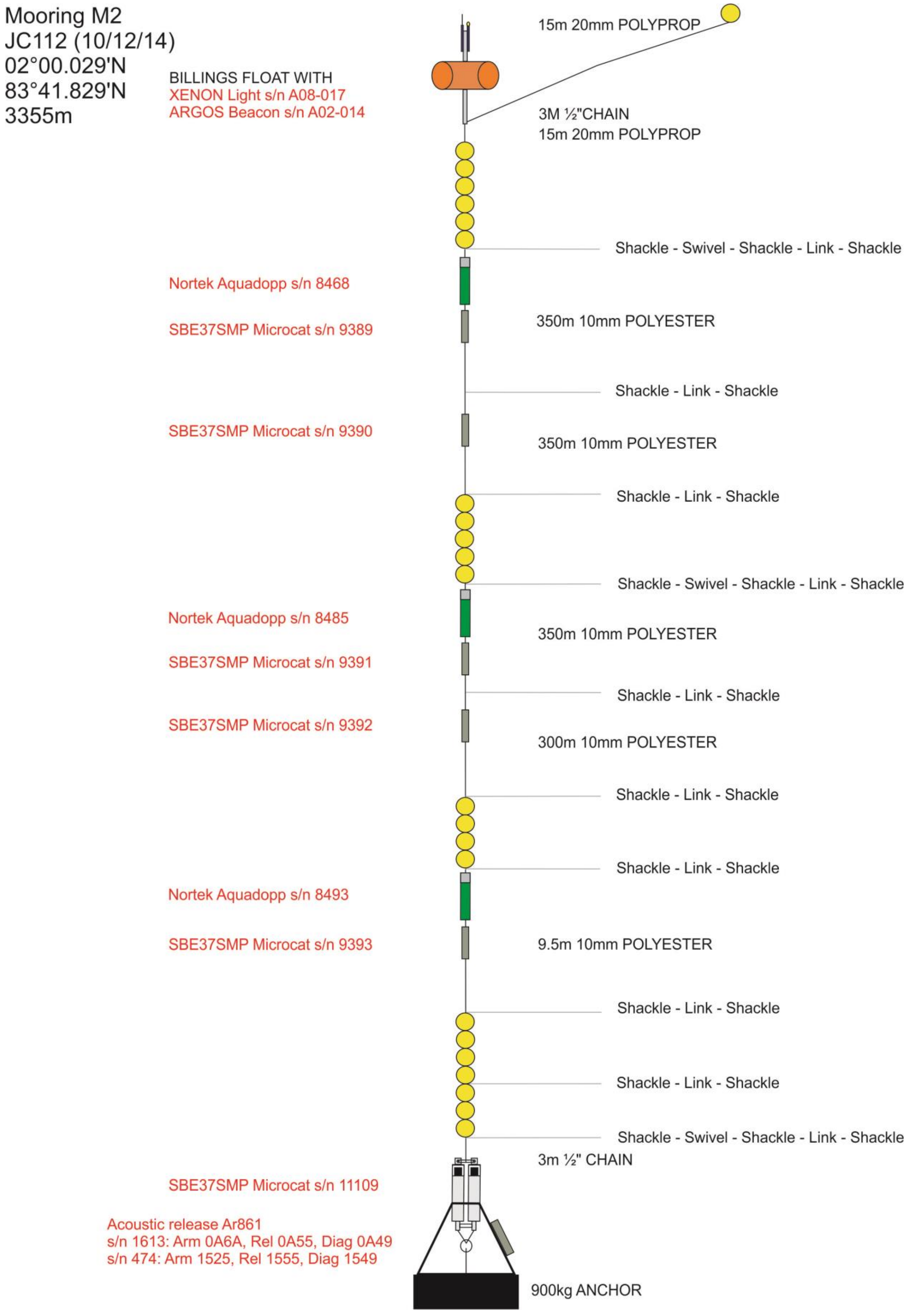
1. The sphere used on the recovery line should be larger to mitigate tangling risks with the Billings float. A larger 17 inch glass sphere has greater buoyancy than those used and will naturally try to rise faster through the water therefore pulling ahead of the Billings float rather than dragging behind. This approach appears to have been successful on the ADCP Ecuador trench deployment.

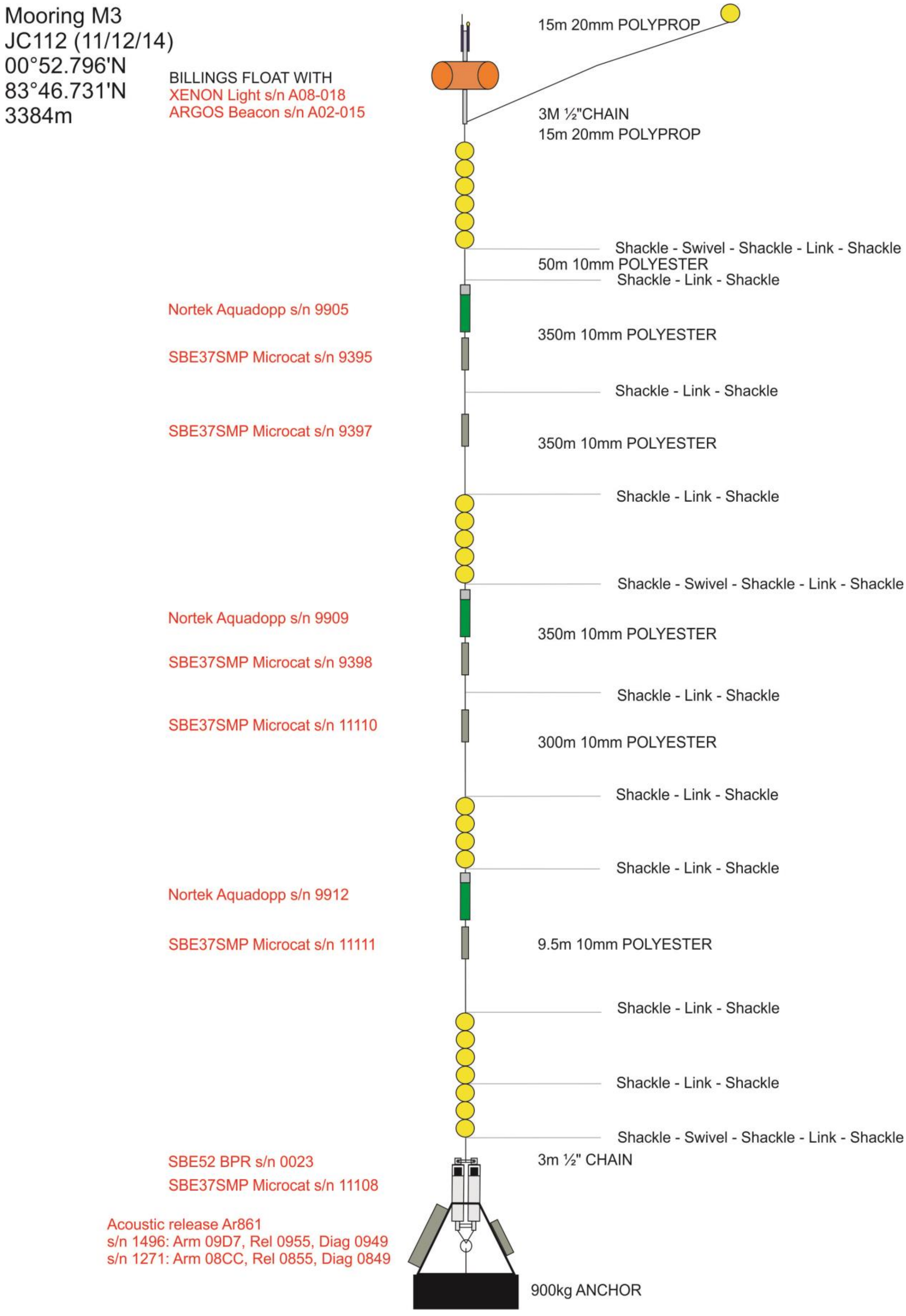
2. In very calm water like that experienced during recoveries on this cruise, the mooring does not stream out well. Using fewer buoyancy packs might possibly reduce the risk of lines tangling, instead concentrating the buoyancy into one or two packs at the top and bottom of the mooring.

3. Attention should be given to the position of the beacons on the syntactic float when using the 75kHz Deep ADCP. The weight of the ADCP transducer turned the buoy upside-down at the surface rendering the beacons useless as they were then underwater. Re-positioning the beacons to the underside of the buoy or appropriate ballasting is required.

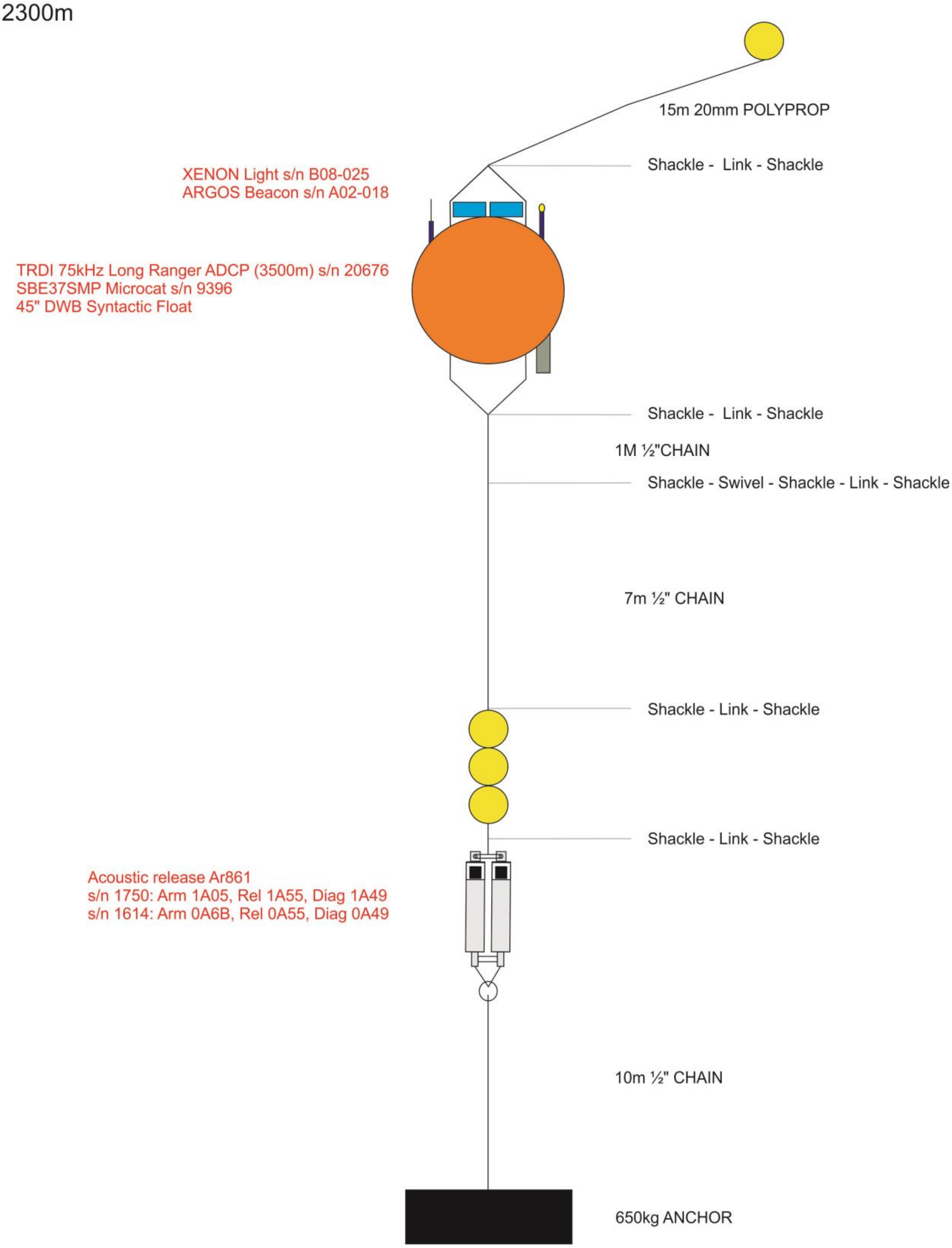
Mooring diagrams



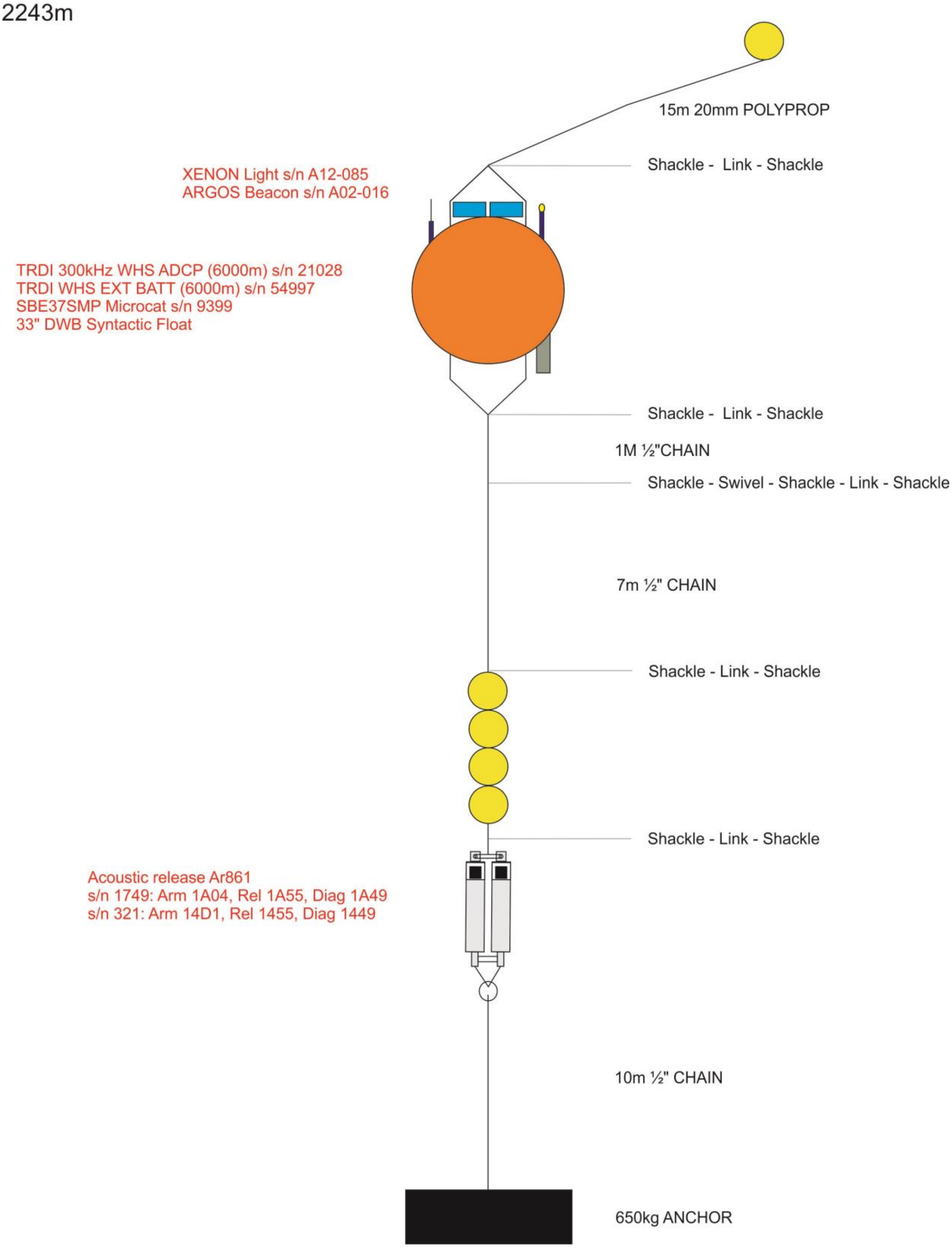

Mooring M2
JC112 (10/12/14)
02°00.029'N
83°41.829'N
3355m
15m 20mm POLYPROP
BILLINGS FLOAT WITH
XENON Light s/n A08-017
ARGOS Beacon s/n A02-014
3M ½"CHAIN
15m 20mm POLYPROP
Shackle - Swivel - Shackle - Link - Shackle
Nortek Aquadopp s/n 8468
SBE37SMP Microcat s/n 9389
350m 10mm POLYESTER
Shackle - Link - Shackle
SBE37SMP Microcat s/n 9390
350m 10mm POLYESTER
Shackle - Link - Shackle
Shackle - Swivel - Shackle - Link - Shackle
Nortek Aquadopp s/n 8485
350m 10mm POLYESTER
SBE37SMP Microcat s/n 9391
Shackle - Link - Shackle
SBE37SMP Microcat s/n 9392
300m 10mm POLYESTER
Shackle - Link - Shackle
Shackle - Link - Shackle
Nortek Aquadopp s/n 8493
SBE37SMP Microcat s/n 9393
9.5m 10mm POLYESTER
Shackle - Link - Shackle
Shackle - Link - Shackle
Shackle - Swivel - Shackle - Link - Shackle
3m ½" CHAIN
SBE37SMP Microcat s/n 11109
Acoustic release Ar861
s/n 1613: Arm 0A6A, Rel 0A55, Diag 0A49
s/n 474: Arm 1525, Rel 1555, Diag 1549
900kg ANCHOR


Mooring M3
JC112 (11/12/14)
00°52.796'N
83°46.731'N
3384m
BILLINGS FLOAT WITH
XENON Light s/n A08-018
ARGOS Beacon s/n A02-015
15m 20mm POLYPROP
3M ½"CHAIN
15m 20mm POLYPROP
Shackle - Swivel - Shackle - Link - Shackle
50m 10mm POLYESTER
Shackle - Link - Shackle
Nortek Aquadopp s/n 9905
350m 10mm POLYESTER
SBE37SMP Microcat s/n 9395
Shackle - Link - Shackle
SBE37SMP Microcat s/n 9397
350m 10mm POLYESTER
Shackle - Link - Shackle
Shackle - Swivel - Shackle - Link - Shackle
Nortek Aquadopp s/n 9909
350m 10mm POLYESTER
SBE37SMP Microcat s/n 9398
Shackle - Link - Shackle
SBE37SMP Microcat s/n 11110
300m 10mm POLYESTER
Shackle - Link - Shackle
Shackle - Link - Shackle
Nortek Aquadopp s/n 9912
SBE37SMP Microcat s/n 11111
9.5m 10mm POLYESTER
Shackle - Link - Shackle
Shackle - Link - Shackle
Shackle - Swivel - Shackle - Link - Shackle
SBE52 BPR s/n 0023
3m ½" CHAIN
SBE37SMP Microcat s/n 11108
Acoustic release Ar861
s/n 1496: Arm 09D7, Rel 0955, Diag 0949
s/n 1271: Arm 08CC, Rel 0855, Diag 0849
900kg ANCHOR

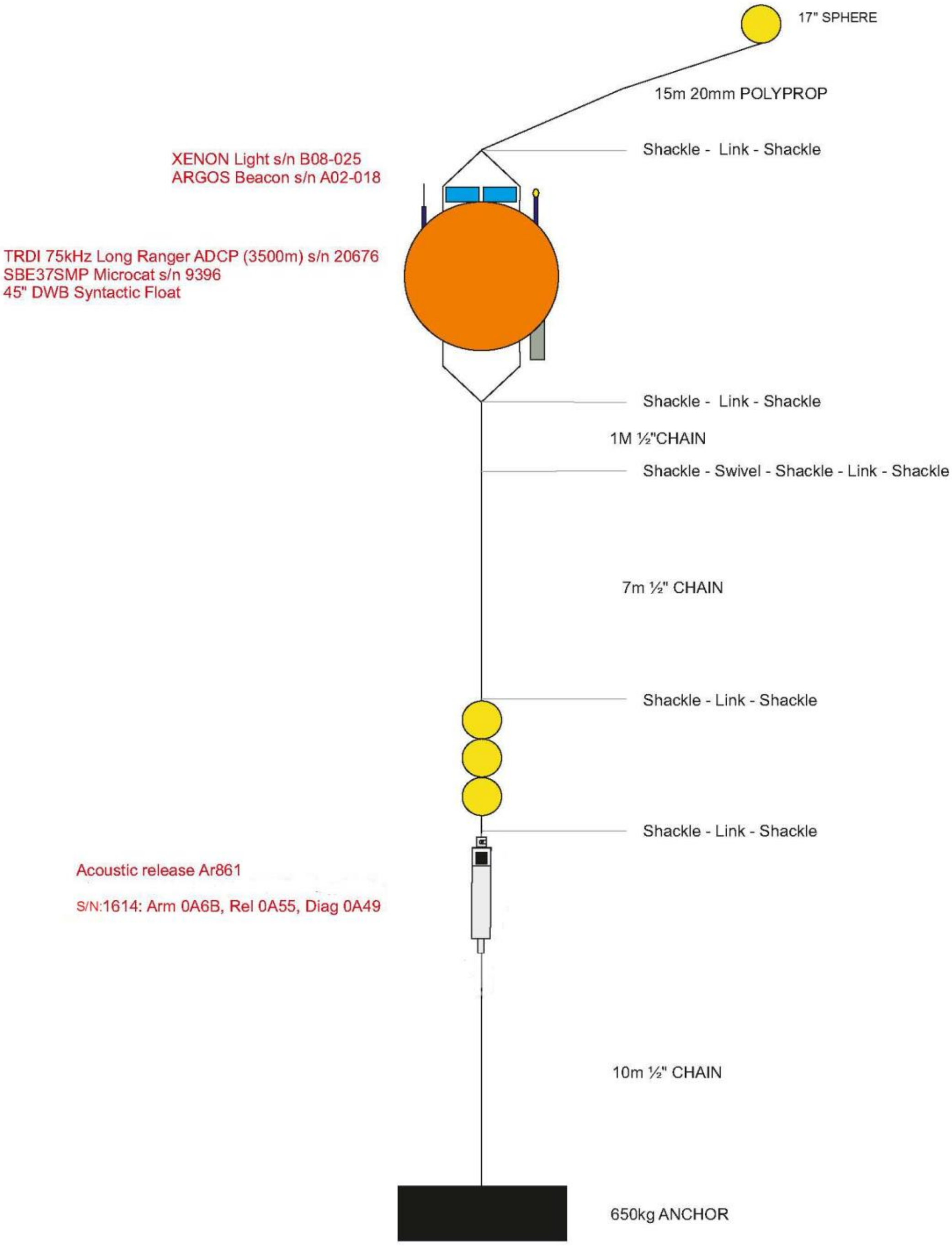
Mooring ADCP 75kHz East
JC112 (12/12/14)
01°00.17'S
85°15.32'N
2300m



Mooring ADCP 300kHz West
JC112 (12/12/14)
01°00.00'S
85°59.90'N
2243m



ADCP MOORING ECUADOR TRENCH
SO238 (21/2/15 - 22/2/15)
0 19.451'S, 81 08.178'W
WATER DEPTH: 2921m



CTD Operations

Simona Aracri (NOC), Rafael Catany (NOC) , Martyn Roberts (University of Bangor) and Miguel A. Morales Maqueda (NOC)

CTD system specification

Underwater Unit for 911 plus CTD Model SBE-9plus
24 Hz sampling rate.
Includes modular Temperature and Conductivity sensor
with TC Duct, SBE 5T submersible pump,
redundant T and C input channels, 8 differential input,
low pass-filtered A/D channels, water sampler modem channel,
stainless steel guard cage, seacable pigtail,
SEASOFT software, and complete documentation
- Aluminum housing, 6.800 meter depth rating with
  standard connectors on CTD, T&C sensors, pump
  and related cables, p/n 9p-1a,
- 0-10,000 psia (6,800 meters) pressure sensor, p/n 9p-2d

SBE 43 Dissolved Oxygen Sensor p/n 9p-6a
(Profiling Configuration), 7000 m (standard connectors)
Cable & mount included

Benthos Altimeter PSA-916, p/n 24204
6000 meter

PSA-916 & CTD/Carousel integration, p/n 916Int-1a
for CTD with standard connectors, including
cabling and mounting

Biospherical QCP-2300L-HP Cosine PAR sensor, p/n 24321
10,000 meters, XSG connector

WETLabs Deep Chlorophyll & Turbidity Sensor,
Model ECO-FLNTU(RT)D 6000m
0 - 50 ug Chl/l - 0-100 NTU with approx. .013 ug/l/0.025 NTU resolution

WETLabs ECO & CTD Integration, p/n ECOInt-2a
For CTD with standard connectors,
incl. cabling and mounting

SBE-11Plus (V2) Deck Unit for 911plus CTD Model SBE-11plus
(Version 2), including IEEE-488 and RS-232 interfaces,
water sampler modem channel, NMEA 0183 GPS interface,
A/D input channel for Surface PAR reference sensor, ASCII
serial data output port, CTD pressure signal output, audible
bottom contact alarm, audio tape interface, 115/230 VAC

(switchable) input power, AC power cord, 10m CTD test cable,
NMEA test cable, remote output cable, serial data cable,
rack mount kit, SEASOFT software,
and complete documentation.

Biospherical QSR-2200 Surface Scalar PAR Reference sensor,
p/n 24257
(used with SBE 11plus, 33, or 36)

Valeport MIDAS SVX2 6000 Sound Velocity Profiler (SVP) SN 43194

CAROUSEL WATER SAMPLER Model SBE-32
(standard)
Multi-bottle sampler in basic configuration for use
with modem-equipped 911plus CTD.
Includes electronics/release with mounting hub,
adapter plates, lifting bail, guard frame, CTD extension stand,
deck pads, and complete documentation
Bottles are not included
Aluminum housing, standard connectors, 6800 meter,
12 or 24 bottle carousel, p/n 32-1a

24-bottle positions, 10 liter size, p/n 32-2m EUR 15.300,--
Defines number of release latches on pylon, number of
bottle mounts and bottle stand diameter

28 x 10 Liter PVC Sample Bottle, p/n 801901
Carousel mount, Internal teflon coated spring,
with SBE's high strength titanium/plastic mount bracket
(see attached photograph)

Setting the CTD rosette: PREPARATION

When arriving to the desired station, the first thing to do is to set the CTD rosette following the following steps:

1. Open bottles fixing elastic bands at the top of the rosette
2. Make sure that spigots are properly closed by pulling them out and turning the security hole
3. Secure close the top opener
4. Flush instruments with purified water
5. Take cap off from the PAR sensor
6. Turn on the Sound Velocity profiler (SVP)

Performing the CAST

This operation is done from the control room where the person in charge of the CTD cast will communicate with the winch operator using the radio communicator. To perform the CTD cast, carry out the following steps:

1. Switch off swath bathymetry logging
2. Switch on system by pressing the **red button** located inside the SBE control cabin
3. Sit down in front of the computer where the SeaBird (SBE) software is installed
4. Open SBE program located in the desktop. **IMPORTANT: just open ONE SBE session. It can happen that older sessions are still open and can cause interference in data recording.**
5. It is possible to modify x-ranges and the variables one wishes to plot. To modify axis ranges simply waive mouse on top of the plot window and press right button and modify ranges. Do the same and press modify to choose the variables to show in the plot. During SO238 we were normally showing on screen the following: Oxygen (mg/L), temperature (˚C), Salinity (psu) and turbidity (NTU).
6. When SBE is open, start the CTD cast by going at the **Real time data** located at the top and press **Start**
7. Select the output data file: change name .**hex .** File name convention used here is **SO238-CTD-NN-Dr-YYYY-MM-DD.hex (**cruise-CTD-ctd n°-year-month-day)

NN: CTD number
Dr: Direction. Down (DW) or up (UP)
YYYY : year
MM: month
DD: day

8. Check that "begin archiving data" immediately is selected
9. Give order to lower the CTD to 10 m and wait until the sensors stabilize. NOTE: ideally, potential temperature oscillations should be <0.001 ˚C and practical salinity difference should be <0.01.
10. Go up to 3 m to initiate the cast proper.
11. Go down to about 100 m above maximum depth **without touching the sea floor**.
12. Move slowly down to about 10 m above the bottom. Use the altimeter mounted on board of the CTD frame to get a better insight of the distance to the sea bed. NOTE: To get close to the sea bed it is possible to use the order "Winch Lab go down at 0.3 m/s until I say **STOP**". Please pay special attention when using this order and make sure the CTD does not touch the sea bed.
13. Once the CTD reaches the maximum depth generate a pdf file of the plot window (file>print>generate pdf). Save pdf in the corresponding CTD folder.
14. In this cruise we are generating a file for each of the DOWN and UP casts. To do so, it is necessary to stop the archiving data and restarting it changing the filename for the up cast.
15. Once the CTD reaches the maximum depth wait at least **30 seconds and fire bottle no 1**. **NOTE**: we determined the DEPTHS where to fire the bottles using an EXCEL routine (bottle calculator 2000.xlms and bottle calculator 3000.xlms), which is included in the CTD folder in the cruise folder SO238.
16. Go up to the next dept.
17. When the CTD is on board generate a pdf (File>print>pdf). Check/change filename. **NOTE: make sure you are getting the plot window**
18. Stop the SBE program and switch the power off (**RED BUTTON**)

19. Copy all the new files across to the science folder. Each should contain four files, which are the following: .XMLCON, .bl, .hex, .hdr and .pdf.
20. Tell the bridge that the operation is finished
21. Go to take the water samples from the Niskin bottles.

Salinity sampling

1. Write a label with the time when the salinity analysis can start: typically, 24 hours after the sampling
2. Attach the label to the crate that you are going to use
3. Write down crate number, bottles color and range of numbers in the CTD cast log sheet.
4. Next to every Niskin bottle number in the CTD cast log sheet write the salinity bottle that you used
5. If there are two or more people sampling, it is better to keep one person just to fill the log sheet with the bottle numbers
6. Rinse the sampling bottle at least 3 times with the water from the Niskin from which you are collecting the water
7. Once finished, bring the crate in the Autosal dry lab and leave it in a save place, from where it cannot fall.
8. Rinse the rosette with fresh water.
9. Reposition the three caps (scatterometer, PAR sensor and SVP)
10. Flush the pump with MilliQ water three times and leave the syringe attached to it.

Helium sampling

Jowan Barnes (NOC) and Miguel Morales Maqueda (NOC)

Over the course of the cruise we took many water samples to be sent for helium analysis at Woods Hole Oceanographic Institution. Following the cold welding procedure instructions provided by the institution, we collected these samples inside copper tubing, since copper is not permeable to helium.

Equipment

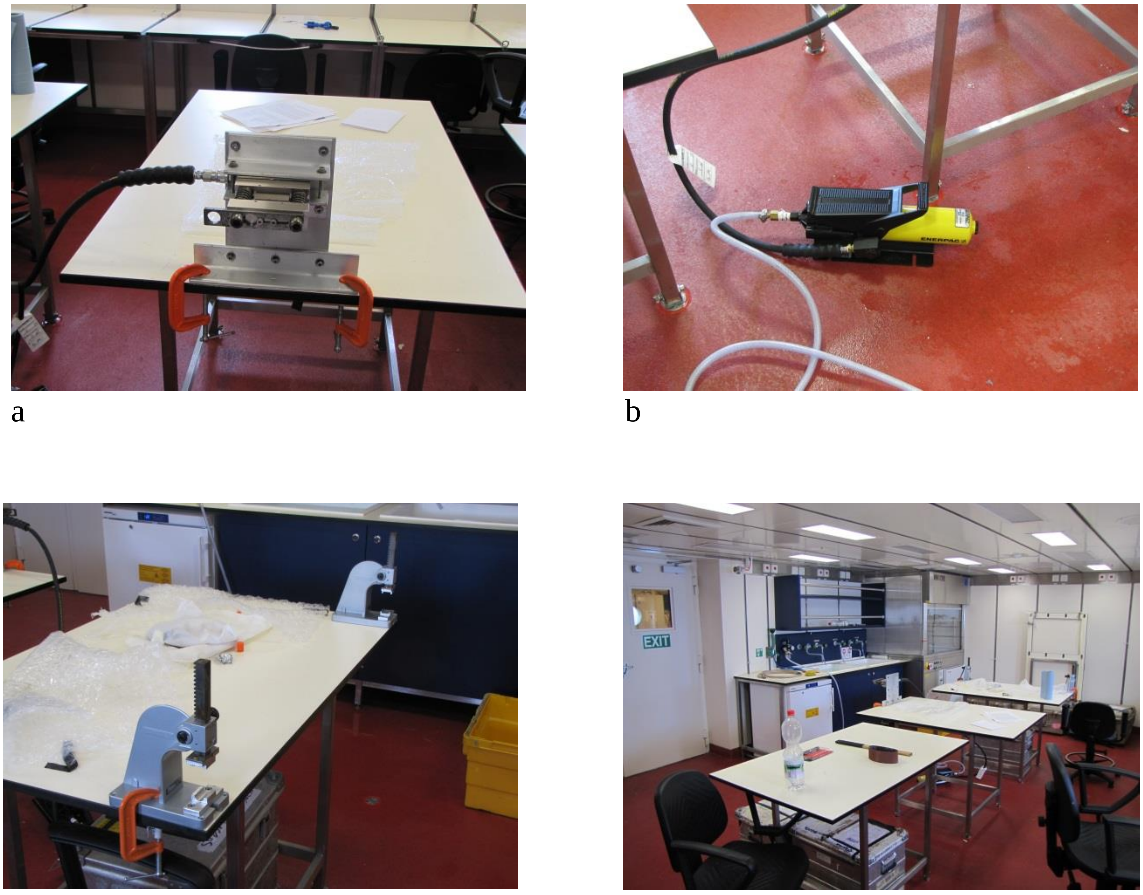
The equipment provided by Woods Hole Oceanographic Institution for this cruise comprised of:

- Mounting bracket for the cold welder
- Two pairs of cold welder jaws
- Foot pump
- Two flatteners
- Two re-rounders
- Copper tubing (12 x 50’ coils)
- Two pairs of tube cutters
- Tygon tubing
- Adapters to attach the Tygon tubing to the copper tubes
- Plastic pinch valves

In addition we required:

- Permanent markers
- Bubble wrap
- 2 plastic containers in which to store the Tygon tubing under water, and the copper offcuts from the cold welding process.
- A wooden stick

Setup



a b c d

Figure 28. Arrangement of Helium sampling equipment. (a) Crimping tool, (b) foot pump, (c) rounder and flattener, (d) general view of the laboratory space.

We set up the equipment in one of the ship's wet laboratories. The mounting bracket, one flattener and one re-rounder were screwed down to prevent them moving around while in use or due to the motion of the ship. The foot pump was connected to a pressurised air source set to 85psi. We used bubble wrap sheets to cover the instruments when they were not in use. On the floor near the apparatus was the plastic container used to store the Tygon tubing when not in use, and at the other end of the workbench was the second plastic container, in which we placed the copper offcuts and any failed samples.

On the edge of the opposite workbench, we marked out a 30" length, with marks at 3", 15" and 27" as specified in the procedure instructions. These marks would ensure consistency in the markings we put on the copper tubes.

The adaptors and pinch valves were attached to the Tygon tubing and remained in place for the entirety of the cruise.

Preparation for sampling

We carried out the preparations in the 24 hour period before a CTD cast from which helium was to be sampled. This was to avoid the copper tubes being contaminated by being open to the air for too long.

Copper tubing was supplied in 50’ coils, with plastic caps at either end to prevent air flowing through them. These were cut into 30” lengths as instructed by the procedure. This should have allowed us to get 20 sample tubes from each coil, but we found that on the first few coils the last tube came out a few inches too short. From that point we began to cut the tubes an inch or two shorter, which meant we could easily get 20 tubes, and sometimes 21, from each coil without making the sampling process any more difficult.

The tubes were cut from the coil using the tube cutters provided with the rest of the equipment. Once all tubes were cut, the plastic cap was replaced on the end of the coil, and it was stored safely under the workbench.

The tubes were to be cut in half during the cold welding process, in order to take a duplicate of each sample. The locations of the cuts were marked on the tubes, halfway along the sample and 12” either side of the halfway point. We used our marks on the workbench to measure these distances. We labelled each half with

A or B, SO238, CTD #, Niskin #, Depth,

where A and B indicate the two identical samples. We wrote the labels twice on each tube, on opposite sides, to make sure there would be no chance of misidentification.

We found that the permanent markers used for labelling ran out more quickly than expected, and that the ink from the blue ones ran a little when the tubes became wet in the sampling process.

Each sample length (between the halfway and 12” marks) was flattened slightly in the middle to reduce the volume of the tube before taking the water sample.

Sampling

The sampling process involved a scientist carrying the Tygon tubing between the chemistry lab and the CTD hanger. We realised that it may have been better to set up the apparatus in the wet lab instead, and would recommend this location be used on future cruises.

At the CTD, a scientist would collect a water sample from the desired niskin bottle via the Tygon tubing, as described in the procedure instructions. We had a wooden stick stored in the CTD hanger for hitting the tube with, in order to dislodge air bubbles. Once there were no more bubbles, the pinch valves on the outflow and inflow tubing were closed and the sample was taken back to the chemistry lab.

We used the cold welder to seal the ends and create two enclosed samples from the tube. We always sealed the sample labelled 'A' first. We found that the samples sometimes leaked when the cold welding process did not form the seal correctly. We guessed that this might have something to do with the jaws of the cold welder becoming wet or contaminated with dust. Wiping the blades down between each use improved the situation. We also applied WD40 between CTD casts to keep the jaws operating smoothly.

We re-rounded the flattened section of each sample, to restore the original volume of the tube and create a small vacuum inside to reduce the water pressure acting on the sealed ends of the sample tube. A successful sample should click when shaken for the first time after re-rounding, which was a useful way of checking that the sample was not leaking.

As the cold welding process is quite lengthy and there were other samples to be taken from the CTD for oxygen and salinity analysis, we found it useful to have two people working on the helium sampling when the manpower was available. One person would collect the water samples and the other would work the equipment in the chemistry lab. There were two sets of Tygon tubing, allowing us to complete the sampling process much more quickly this way. Helium samples took priority over oxygen and salinity due to the higher chance of contamination once the water in the niskin bottles was exposed to the air.

Storage

All successful samples were stored in the crates we brought with us. We layered them as suggested in the procedure instructions, with the effect of 'weaving' bubble wrap around the samples to avoid them bashing against each other in transit.

CTD processing during the cruise

A preliminary data post processing was carried out during the cruise, as succinctly described below in this section. However, a complete reprocessing was completed by Donata Banyte (see section on calibration and quality control of CTD and SBE37 data below).

We used the on-board data processing guidelines for the sbe-911 ctd given by the British Oceanographic Data Centre (see below).

The processed CTD data were located in the folder ctd_all>ctd_processed.

The BODC guidelines suggested keeping track of each step that is applied to the data. Hence, for each processing step, we kept a copy of the resulting data which was stored in the its corresponding folder. We applied ten different processing steps, and so in the processed folder there are ten subfolders, plus one additional folder containing plots of the post processed CTD data. These folders are:

1_convert
2_filter
3_alignCTD

4_CellTM
5_loopEdit
6_derive
8_BinAverage
9_bottleSum
12_WildEdit
13_strip
20_SeaPlot

The naming of the files is descriptive of the processing step applied to data. For example File 'so238-ctd-03-up-2015-02-15_filter_alingctd.cnv' it is a file contained in folder '3_alignctd' and it has been applied the post-processing steps: 'filter' and 'alignctd'.

Notes on post processing

1) The SBE software allows us to compute derived variables using both EOS-80 and TEOS-10. In order to keep some consistency in the structure of the data for SO238 we just applied the EOS-80.

2) We created two different records for up and down ctd casts. Therefore it was not necessary to apply the post-processing step 'split', which is used to separate up and down casts.

3) The instrumentation file is the same for all the casts. Here we used the instrumentation file generated during the ctd cast 01 (so238-ctd-01-2015-02-08.xmlcon).

Recommended steps for basic processing of SBE-911 CTD data.

Document version: 1.0 October 2010
Based on a full revision of the guidelines set up for the UK SOLAS project with input from Jeff Benson and Dave Teare; also checked procedure against recommendations from Taggart et al (2010) and Uchida et al (2010), IOCCP Report No. 14, ICPO Publication Series No. 134, Version 1, 2010.

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Introduction
This procedure was first developed in the frame of the UK SOLAS project as a mean to obtain a standard set of semi-processed CTD data at the end of each cruise. The semi-processed data were then sent to BODC for further QC and calibration. It is not intended that these recommendations supersede processing routines developed by individual scientists or scientific teams embarked on NERC ships and from whom we would expect to receive fully calibrated, documented and quality controlled CTD data.

This document focuses on post-acquisition data processing routines. Pre-cruise preparation, sensor configuration and maintenance, record keeping, deployment and data acquisition should be done according to the best recommended practices for optimum data quality (e.g. SeaBird manual, GO-SHIP Repeat Hydrogaphy Manual, …).

The basic data processing procedure is carried out on the full resolution (24Hz) raw binary data using **the latest version** of Sea-Bird processing software. It should include the following modules: Data Conversion (DATCNV), Bottle Summary (BottleSum), WildEdit on pressure, FILTER on pressure, AlignCTD, CellTM, LOOPEDIT, DERIVE, BINAVG, and STRIP.

Oxygen units

BODC used to require submission of oxygen sensor data in µmol/l or ml/l. However, we have now adapted our procedures to enable us to handle data submitted in µmol/kg providing the data are submitted alongside the pressure, temperature and salinity used to generate the µmol/kg value in the first place.

Basic processing routine

1. Data conversion (DATCNV)

This step converts the raw files to ASCII and applies calibrations as appropriate through .CON file. Our recommended procedures are as follows:

- CON file must be checked for accuracy and updated as required; checks should be carried out for **ALL** the sensors present on the CTD package – extra caution should be taken with the records for PAR and transmissometer to ensure that voltage conversion coefficients are correct and match the manufacturers' latest calibration and SeaBird latest recommendations.
- All sensors' output should be converted to engineering units as recommended by the manufacturer.
- Output at full 24 Hz resolution.
- Other recommended settings are as follows:

Process scans to end of file: yes
Scans to skip over: 0
Ouput format: ASCII
Convert data from: Upcast and downcast
Create file types: both data and bottle file
Source of scan range data: Bottle log .BL file
Scan range offset: -2.5 seconds (changed from 0 second as advised by Dave Teare, NMF-SS during D325 cruise)
Scan range duration: 5 seconds for standard casts, 1.5 seconds for bottles fired "on the fly"
Note: the values above were recommended by NMF-SS technical staff as a guideline but optimum settings for scan range offset and scan duration are best decided at the time of collection.
Merge separate header file: No

Select Output Variables:
ALL sensors logged by the SeaBird software should be selected as variables for output even if not specifically requested by the PSO. For a standard package, the selection would include:

Variable	Status
Time elapsed in seconds	Must be selected
Pressure, digiquartz in db	Must be selected
Primary temperature ITS-90 in deg C	Must be selected

Secondary temperature ITS-90 in deg C	Select if present
Primary conductivity S/m	Must be selected
Secondary conductivity S/m	Select if present
Primary salinity PSU (see note below)	Must be selected
Secondary salinity PSU	Select if present
Oxygen voltage SBE 43	Must be selected if oxygen probe is SBE43
Oxygen concentration in ml/l, mg/l µmol/l, (or µmol/kg if requested by scientists)	Must be selected
Oxygen current	Must be selected if oxygen probe is Beckman/YSI
Oxygen temperature	Must be selected if oxygen probe is Beckman/YSI
Beam attenuation or Beam transmission	Select if transmissometer present
Fluorescence/chlorophyll	Select if fluorometer present
Upwelling and downwelling PAR channels in W/m^2 or other more appropriate units	Select if light sensors present
Light backscattering sensor/nephelometer	Select if present
Voltage channels V0, 1, 2, 3, 4,etc…	Must be selected if used

Other channels can be selected if required by the PSO or by other cruise participants but they should not replace the variables listed above.

If auxiliary sensors are connected to the **voltage channels,** then a mapping between voltage channels and the sensors should be provided in a separate file and also included in the cruise report. If the configuration was changed during the cruise then this should also be indicated alongside the cast identifier from which the new configuration applies. See below a good example of CTD system setup report as provided in Mc Taggart et al (2010) in their article "Notes on CTD/O2 Data Acquisition and Processing Using Seabird Hardware and Software (as available)"

Instrument/Sensor	Mfr./Model	Serial Number	A/D Channel	Stations Used
Carousel Water Sampler	Sea-Bird SBE32 (36-Pl.)	3213290-0113	n/a	1-127
CTD	Sea-Bird SBE9*plus*	796	n/a	1-127
Pressure	Paroscientific Digiquartz	98627	n/a	1-127
Primary Temperature (T1)	Sea-Bird SBE3*plus*	03P-4907	n/a	1-127
Primary Conductivity (C1a)	Sea-Bird SBE4C	04-3369	n/a	1-102
Primary Conductivity (C1b)	Sea-Bird SBE4C	04-3430	n/a	103-127
Dissolved Oxygen	Sea-Bird SBE43	43-1508	Aux4/V6	1-127
Primary Pump	Sea-Bird SBE5T	05-4160	n/a	1-127
Secondary Temperature (T2)	Sea-Bird SBE3*plus*	03P-5046	n/a	1-127
Secondary Conductivity (C2)	Sea-Bird SBE4C	04-3578	n/a	1-127
Secondary Pump	Sea-Bird SBE5T	05-5124	n/a	1-127
Transmissometer	WETLabs C-STAR	CST-1115DR	Aux2/V2	1-67,73-127
Transmissometer	WETLabs C-STAR	CST-327DR	Aux1/V1	68-72
Fluorometer	WETLabs CDOM	FLCDRTD-428	Aux1/V0	1-127
Altimeter	Simrad 807	9711091	Aux3/V4	1-127
Reference Temperature	Sea-Bird SBE35	35-0035	n/a	1-127
LADCP	RDI WHM300-I-UG50	13330	n/a	1-127
Deck Unit (in lab)	Sea-Bird SBE11	11P31807-0654	n/a	1-127

Table 1. Example of system setup record excerpted from a recent U.S. repeat hydrography cruise report.

Note that we (BODC) find it easier to have salinity and oxygen concentrations selected at this stage and later stripped once the final version of the derived variables has been generated by DERIVE. This enables us to easily check/plot the data and also to output them to the bottle file alongside all the other measured variables. However, it is possible to omit these channels from the DATCNV if preferred. In that case, one must ensure that they are selected as derived variables in BottleSum and then derived again during DERIVE.

2. Bottle file generation (BottleSum)

a) It is important to always use **Bottle rosette position** to reference the bottles. For this reason, one needs to ensure that the .ROS files created during DATCNV are in the same directory as the raw .BL files when running Bottle Summary. If this is not the case then, by default, the SeaBird processing software will output Bottle firing sequence numbers instead of Bottle rosette position numbers.

b) Data Setup

Output min/max values for averaged variables: yes
Select Averaged Variables:
All variables except time elapsed (and cell counts if present) need to be selected.
Select Derived Variables: Primary and secondary salinities.

Other derived variables (i.e. Density, etc) may be added if requested by the scientists.

c) If not automatically selected then date and time of bottle firing stamp need to be selected for output.

3. Removal of pressure spikes (WildEdit on pressure)

This step should be carried out to remove pressure spikes if present. Pressure spikes are easily identified by plotting pressure versus time in SeaPlot.

WildEdit must be run on pressure <u>only</u> and before FILTER as pressure spikes can cause FILTER to smooth the data incorrectly.

The typical settings are:

- Standard deviation for pass one: 2
- Standard deviation for pass two: 20
- Scans/block: 100
- Keep data within this distance of the mean: 0
- Exclude scans marked bad.

- Select WildEdit variables: Pressure only.

Note that if the data file is particularly corrupted, WildEdit might need to be run more than once, with different block sizes and number of standard deviations. Use SeaPlot to check whether prominent spikes have been removed.

Write the output to a new file by appending "_wildedit" to the filename.

4. Run FILTER on pressure

FILTER must be run on the pressure channel before any editing is carried out.

FILTER smoothes out response-time issues in the sensors, which may affect processing at later stages such as for CellTM. The typical filter time constant is equal to four times the scan rate. For the SBE911*plus* pressure sensor, this is 0.15 seconds.

5. AlignCTD

AlignCTD aligns parameter in time, relative to pressure. This ensures that calculations of salinity, dissolved oxygen concentration, and other parameters are made using measurements from the same parcel of water. Depending on which SBE11 plus deck unit is used, requirements will be different.

The SBE11plus V1 deck unit is factory-set to advance the primary conductivity by +1.75 scans (equivalent to 0.073 seconds at 24Hz). Note that further alignment may be required if the salinity channel is particularly spiky. The SBE11plus does not advance secondary conductivity so this channel will need to be advanced by 0.073 seconds.

If using a SBE11plus V2 deck unit, both the primary and the secondary conductivity will have been automatically advanced by +1.75 scans so AlignCTD will only be needed to remedy excessive salinity spiking caused by slight misalignment of the sensors or to align the oxygen sensor.

For the oxygen measurements (Oxygen voltage for SBE43 or Oxygen voltage plus Oxygen temperature for a Beckman/YSI probe), the optimum alignCTD advance value will vary depending upon the package used (e.g. whether the 12-way and 24-way bottle frames are used), difference in the CTD unit orientation (i.e. vertical or horizontal), number of sensors on the frame and subsequent effect on entraining water, length of the tubing, etc. It is therefore strongly recommended that the CTD operator and data processing person on board try different lag times in order to find the best fit for the specific package.

According to observations made on NERC equipment, the SBE recommendations (+2 to +5 seconds for pumped systems and +1 to +5 seconds for non-pumped systems) seem to work best for vertical mounted CTDs, whereas 6 to 8 seconds are more typical with horizontal mounted underwater unit (Jeff Benson, NMF-SS, personal communication).

6. CellTM

Cell Thermal Mass filters conductivity cell thermal mass effects from the measured conductivity. The recommended SeaBird settings should be applied to both primary and secondary sensors.

For SBE9plus with TC duct and 3000 rpm pump the recommendation is as follows:

alpha=0.03
1/beta=7

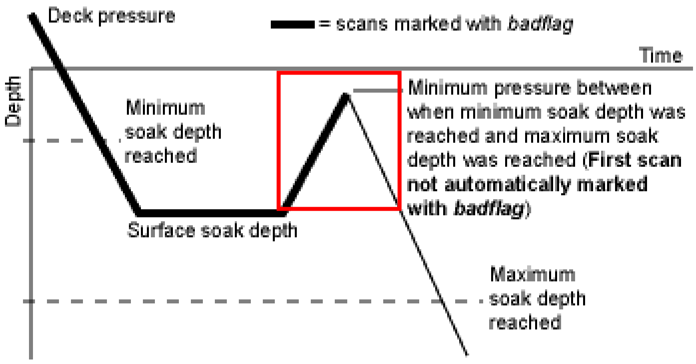
7. LOOPEDIT

LOOPEDIT marks scans with a bad flag wherever there is a pressure slowdown or reversal (typically caused by ship heave). Three successive scans are used to determine velocity. If the profiles are affected by ship’s heave then, if time allows, LOOPEDIT should be run as part of the basic processing.

LOOPEDIT should not be run if the CTD was deployed in a "yo-yo" mode.

The output from LOOPEDIT should be saved in a new file (appending "_loopedit" to the filename for example).

If a surface soak was used, select ***Remove Surface Soak*** in the ***Data Setup*** window and enter the minimum and maximum soak depth in metres. If this is not selected then LOOPEDIT will wrongly identify the initial surface soak as a loop and flag the upper part of the downcast bad as a result. Surface soak depth entry is not actually used in the processing but needs to be set at an appropriate number for the module to run. See schema reproduced from the SeaBird manual below.



In the ***Data Setup*** window, select ***Fixed minimum velocity*** and enter the desired velocity so that all scans below this level are marked with a bad flag. Since we are interested in removing only loops caused by ship's heave the minimum velocity value should be set to zero. Select ***Exclude scans marked bad***. This will exclude all the bad data points when determining velocity. ***Use deck pressure as pressure offset*** should normally be left unchecked.

8. Derive

Once all the adjustments have been made to the data, the final oxygen concentration and salinity values can be calculated and added to the ASCII file by running DERIVE.

Note that salinity and oxygen concentration may already be present in the CNV file if they were selected in the initial running of DATCNV. However now that the adjustments to conductivity and oxygen measurements have been made through ALIGN and CELLTM, a better version of these variables can be made.

Derived Variables to be selected are:

- Salinity from both primary and secondary sensors if present;
- Oxygen concentration: always double check that you selected the actual oxygen concentration and not the oxygen saturation. Oxygen saturation can also be selected at this stage if requested by the scientists.

Other derived variables (potential temperature, sigma-t, oxygen percent saturation) are not required by BODC at this stage because they will be re-generated as part of our in-house processing routines. However, they can of course be selected if requested by PSO and scientists on board.

9. BINAVERAGE

BINAVERAGE needs to be run to average the data to 2Hz. This version needs to be saved under a new name (appending _2Hz to the filename for example) so that the 24Hz version of the data is not overwritten.

Data Setup:

Bin type:	Time, seconds
Bin size:	0.5
Include number of scans per bin:	no
Exclude scans mark bad:	yes
Scans to skip over:	0
Cast to process:	upcast and downcast

The reduced version of the data should be submitted to BODC alongside the 24Hz version and all the other raw and processed data files. BODC will archive both versions but will use the 2Hz version for further visual screening, QC and calibration prior to banking the data into its database. This is unless a better fully quality controlled and calibrated version of the data is expected from the scientists responsible for CTD data processing.

10. STRIP

This step may be used to remove the channels generated during DATCNV and regenerated later during DERIVE. In order to do this, in Data Setup>Select included variables, just unselect the first set of channels that appear in duplicate (e.g. Salinity or Oxygen).

11. References

McTaggart K.E., G. C. Johnson, M. C. Johnson, F. M. Delahoyde, and J. H. Swift. 2010. Notes on CTD/O2 Data Acquisition and Processing Using Seabird Hardware and Software (as available). In *The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines*. Hood, E.M., C.L. Sabine, and B.M. Sloyan, eds. IOCCP Report Number 14, ICPO Publication Series Number 134. Available online at: *http://www.go-ship.org/HydroMan.html.*

End of Document.

Autosalt protocol

A Guildline 8400B, was installed in one of the dry laboratories as the main instrument for salinity analysis. The Autosal set point was 21°C, and samples were processed according to WOCE cruise guidelines.

The following document contains the steps to use the Autosalt to measure the conductivity of the water samples collected in each CTD cast and from the thermosalinograph (TSG).

1. Open 'autosalt' software located in the Desktop. Initial set up: **COM6**
2. Choose the standard deviation. In this exercise we leaved the default value, which is **0.00012**.
3. Create a new file using the following name hierarchy:
   CRUISEID_CRATE_CTD_XXX_DAY_MONTH_YEAR.xls
   (i.e. SO238_013__CTD_003_18 Feb_2015.xls)
4. Introduce bottle name: **CTDxx**, where 'x' is the CTD cast number.
5. **Run the standard**. This means that you must read the conductivity of the standard water. Flush and Repeat the reading three times. The bottle number of the standard is **ZERO**.

NOTE: you must run the standard at the beginning of each exercise and then once you have complete TWO crates. **Please do NOT confuse running the standard with standardising the Autosalt**. Standardising the Autosalt consist in calibrating the Autosal to zero. To this you must use the 'standardization' button until you get a double value of the conductivity reading than the one noted in the standard bottle label. For instance conductivity label in the standard water is **K_{15} = 0.99985**, so you want **Autosalt_zero = 0.99985x2 = 1.9997**.

It was performed ONE standardization at the beginning but there were no more standardization during the cruise. Doing so it is possible be to find out the instrumental drift and to compute the instrumental error.

6. Take out the bottle of the standard water and dry the intake tube to avoid cross contamination between samples. **NOTE**: **repeat this every time you change the bottle sample.**
7. Get the first bottle sample from the **START** section in the crate.
8. Give a super energetic shake to homogenize the sample and place the intake tube into the bottle sample.
9. Turn Autosalt to **STANDBY**.
10. Turn on the pump and **FLUSH** Autosalt.
11. Clean the cells containing the electrodes by filling the cell and **flushing it three times**.
12. Fill the cell and making sure there are no air bubbles.

13. Turn Autosalt to **READ** and wait until reading is processed (about 13-16 seconds)
14. If the reading is out of the accepted threshold (standard deviation), it is possible to repeat the reading until obtaining a more satisfying reading.
15. Get next bottle sample from the crate and repeat steps 8-14.

Summary of CTD casts

Forty CTD casts were performed in total. The following table and figure (Fig. 29) serve as a summary.

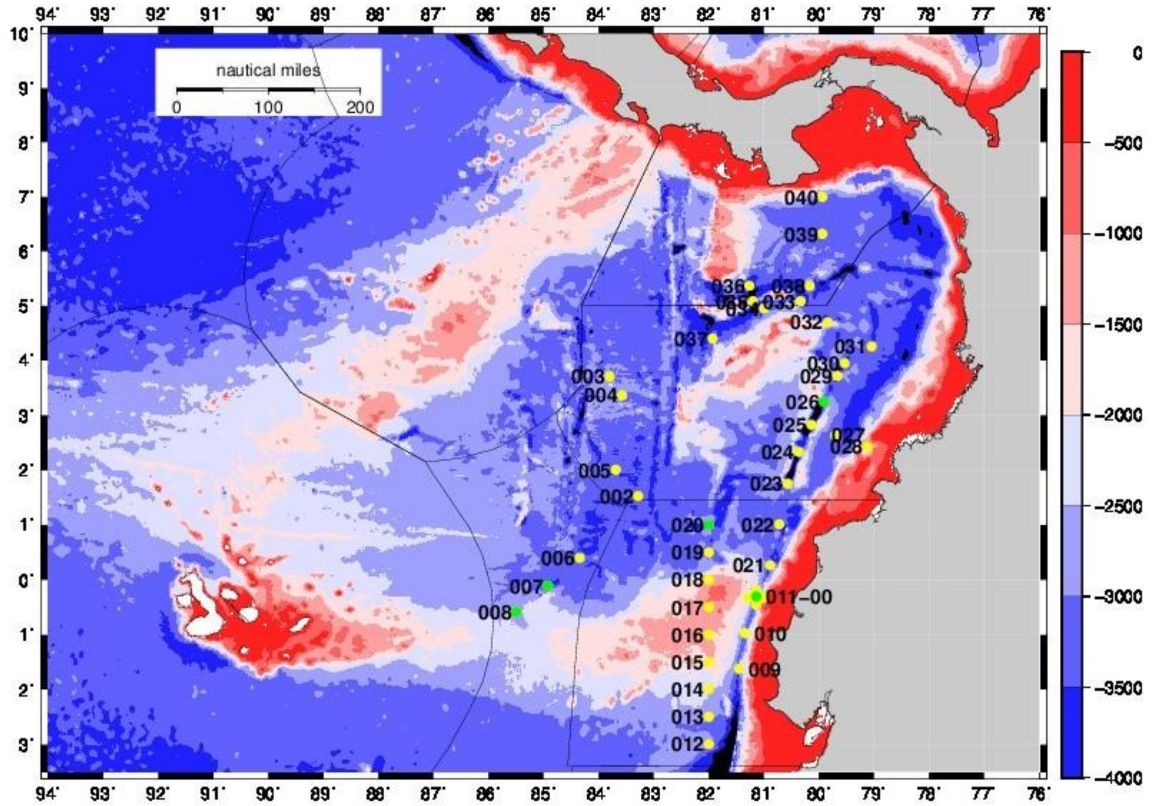


Figure 29. Summary of CTD casts during SO238 (yellow and green dots). Green dots correspond to casts where Helium samples were taken.

CTD No.	Date (DD-MM-YY)	UTC Time (Start)	Lat.	Long.	Water Depth Start (m)	No. of Helium Samples Taken
001			Test Cast	No information		N/A
002	10.02.15	01:17	1° 31.502' N	83° 17.166' W	3354	N/A
003	15.02.15	20:47	3° 42.312' N	83° 48.286' W	2323	N/A
004	16.02.15	02:26	3° 21.700' N	83° 34.694' W	2914	N/A
005	17.02.15	20:43	2° 0.218' N	83° 41.406' W	3331	N/A
006	18.02.15	19:35	0° 23.870' N	84° 20.843' W	3185	N/A
007	19.02.15	03:33	0° 6.607' S	84° 55.704' W	3536	5 samples
008	19.02.15	22:40	0° 35.184'S	85° 30.166' W	2759	10 samples
009	20.02.15	22:05	1° 37.396'S	81° 27.174'W	3404	N/A
010	21.02.15	05:54	0° 58.318'S	81° 20.898'W	3155	N/A
011-00	21.02.15	21:30	0° 18.396'S	81° 8.216'W	3030	10 samples
011-01	22.02.15	02:05	0° 19.628'S	81° 0.568'W	1440	N/A
011-02	22.02.15	04:59	0° 11.225'S	81° 8.304'W	2578	N/A
011-03	22.02.15	08:54	0° 19.537'S	81° 17.298'W	2074	N/A
011-04	22.02.15	12:08	0° 27.265'S	81° 8.630'W	2488	N/A
012	23.02.15	06:11	2° 59.939'S	81° 59.929'W	2985	N/A
013	23.02.15	12:16	2° 29.995'S	81° 59.994'W	2909	N/A
014	23.02.15	18:46	1° 59.6'S	82° 0.054'W	2401	N/A
015	24.02.15	00:52	1° 29.999'S	81° 59.996'W	1642	N/A
016	24.02.15	05:13	0° 59.988'S	82° 0.026'W	1380	N/A
017	24.02.15	11:16	0° 29.993'S	81° 59.992'W	1331	N/A
018	24.02.15	14:00	0° 0.018'N	82° 0.012'W	1320	N/A
019	24.02.15	18:45	0° 29.989'N	81° 59.983'W	3225	N/A
020	25.02.15	01:13	0° 59.982'N	82° 0.002'W	3667	6 samples
021	25.02.15	17:20	0° 15.772'N	80° 53.044'W	3666	N/A
022	26.02.15	01:56	1° 0.691'N	80° 43.31'W	3325	N/A
023	26.02.15	09:25	1° 44.975'N	80° 33.974'W	3954	N/A
024	26.02.15	16:56	2° 19.932'N	80° 21.978'W	3489	N/A
025	27.02.15	00:36	2° 49.518'N	80° 8.332'W	4854	N/A
026	27.02.15	08:56	3° 14.724'N	79° 54.650'W	4811	7 samples
027	27.02.15	17:49	2° 37.934'N	79° 42.50'W	3476	N/A
028	27.02.15	23:39	2° 25.460'N	79° 6.967'W	1337	N/A
029	28.02.15	08:04	3° 42.983' N	79° 39.985'W	3988	N/A
030	28.02.15	13:28	3° 56.960'N	79° 31.992'W	3296	N/A
031	28.02.15	19:00	4° 15.253'N	79° 2.490'W	3560	N/A
032	01.03.15	04:17	4° 41.9'N	79° 50.4'W	3248	N/A
033	01.03.15	10:40	5°4.981'N	80° 20.014'W	3634	N/A
034	01.03.15	18:00	4°57'N	80° 60'W	3469	N/A
035	01.03.15	23:23	5°4.950'N	81°11.958'W	3903	N/A
036	02.03.15	04:24	5°21.9'N	81°16.0'W	3970	N/A
037	02.03.15	15:09	4°23.99'N	81°56'W	3060	N/A
038	03.03.15	07:55	5° 21.828'N	80°10.074'W	3944	N/A
039	03.03.15	07:25	6° 19'N	79°56.4'W	3165	N/A
040	03.03.15	23:38	6° 59.542'N	79°56.390'W	3115	N/A

Table 7. Summary of CTD casts during SO238.

Calibration of CTD and MicroCAT sensors for cruises JC112 and SO238

Donata Banyte (NOC)

CTD conductivity sensor calibration (JC112)

JC112 cruise CTD station summary

JC112 (RRS James Cook) cruise was carried from 2014 December 06 to 2015 January 14 at the Panama Basin. The hydrography of the water column was measured using Sea-Bird 911-plus CTD instrument with two temperature, two conductivity, one oxygen, and one pressure sensors. In total 87 CTD casts were deployed, from which, 65 were full water column casts and 20X were Tow-yo casts recording hydrography below about 3000 m depth to the bottom. After each cast, the raw CTD data was run through the Sea-Bird Electronics data processing software. The processing steps are listed in Table 8. For the calibration of two conductivity sensors, water bottle samples were taken at each cast at discrete intervals: about 100 m apart for the shallower levels, and 250 m to 500 m apart at the deeper levels. In total, about 1560 water samples were analysed in the lab using Autosalinograph for conductivity comparison with CTD sensor measurements.
SO238 (RRS SONNE) cruise was carried from 2015 February 08 2015 to 2015 March 04 at the Panama Basin. The hydrography of the water column was measured using Sea-Bird 911-plus CTD instrument with two temperature, two conductivity, two oxygen, and one pressure sensors. In total 45 full depth CTD casts were deployed. For 1the calibration of two conductivity sensors, water bottle samples were taken at each cast at discrete intervals: about 100 m apart for the shallower levels, and 250 m to 500 m apart at the deeper levels. In total, about 720 water samples were analysed in the lab using Autosalinograph for conductivity comparison with CTD sensor measurements.

CTD conductivity calibration

The on board Autosal Salinometer measures conductivity ratio of Rosette bottle seawater sample to the standard IAPSO seawater sample. The salinometer reading (SR) was converted to the conductivity ratio by formula: Rt = SR/2 + OS, where OS is a small offset of the salinometer. For the cruise JC112, the offset was in the range of $-4x10^{-5}$ to $3x10^{-5}$. However, during the cruise SO238, the salinometer offset reading was false and was set to zero. Thus, the calibration of SO238 CTD data requires additional uncertainty evaluation due to false offset reading (see below). The conductivity ratio was converted to the bottle sample practical salinity using Gibbs Seawater Oceanographic Toolbox (**gsw_SP_salinometer.m**). Then, the calibrated bottle salinities were converted back to conductivities using **gsw_C_from_SP.m** and the corresponding pressures and temperatures at the location where water samples were taken. Those were recorded by the Sea-Bird CTD software in . ros file (bottle file). Comparing the conductivities as measured by two CTD conductivity sensors and the calibrated bottle conductivity estimates the outliers were identified as having the larger difference in the readings than 0.01 mS/cm. Finally, the linear regression was applied to the calibrated versus uncalibrated CTD bottle data and conductivity calibration parameters for each of the two CTD sensors were estimated. For JC112 cruise, the final CTD calibration used 1545 "good" data points, after removing outliers. The linear regression revealed: $C_{calibr} = 0.9996 \cdot C_{insitu1} + 0.01170$ mS/cm for CTD sensor 1, and $C_{calibr} = 1.0003 \cdot C_{insitu2} - 0.01027$ mS/cm for CTD sensor 2 (Figure 30). The difference in conductivity for two sensors over depth before and after calibration is shown in Figure 31. Above 2000 m depth, the water column is much less stable leading to large differences between autosal and in-situ conductivity measurements, more than 0.005 mS/cm. Thus, higher precision of CTD conductivity calibration is achieved sampling waters below about 2000 meters, i.e. below water masses of shallow overturning circulation. In addition, the difference between the two CTD conductivity sensors was tested at profile (JC112 002.hex) with 20 minute stops at different depths, designed to calibrate MicroCATs. We have found that the difference was less than 0.001 mS/cm most of the time in the stable waters, however, in the presence of turbulence, the difference could reach almost 0.005 mS/cm (Figure 32). In the tested profile, sensor 1 was more stable, having smaller variability, than sensor 2 (Figure 33).

For SO238 cruise, the final CTD calibration used 685 “good” data points. The linear regression revealed: $C_{calibr} = 1.0003 \cdot C_{insitu1} - 0.00329$ mS/cm for CTD sensor 1, and $C_{calibr} = 1.0001 \cdot C_{insitu\,2} + 0.00179$ mS/cm for CTD sensor 2 (Figure 34). As the offset reading of salinograph was not recorded, it was assigned everywhere to be zero. We expect that by introducting zero offset at each measurements of the salinograph reading, the precision of the measurement got worse, but it did not affect the accuracy of the measurement significantly. The test of zero offset with JC112 data revealed the difference between readings with the true and zero offsets of only $2x10^{-4}$ mS/cm, which is one order smaller than the accuracy of the calibrated CTD measurement. Thus, we judge the calibration of SO238 CTD conductivity sensors to be of the same accuracy as of JC112 cruise CTD conductivity sensors. The difference in conductivity for two sensors over depth before and after calibration is shown in Figure 35. The uncalibrated SO238 CTD conductivity sensors had about twice larger offset than uncalibrated JC112 CTD conductivity sensors, but slightly better precision, i.e. data scatter was smaller throughout the water column.

Data Conversion	Convert raw .hex data to engineering units, and store converted data in .cnv file and .ros file (water bottle data)
Filter	Low-pass filter = 0.15s was run for pressure
Cell Thermal Mass	A recursive filter was applied to remove conductivity cell thermal mass effects from the measured conductivity (alpha =0.03, 1/beta= 7)
Loop Edit	Marked bad scans by setting the flag value of 9.990e-29 that have pressure slowdowns of reversals. The criteria was fixed minimum velocity of 0.25m/s
Bin Average	Data was averaged over 1db bins

Table 8: CTD raw data processing steps using Sea-Bird Electronics software.

CTD oxygen calibration

The CTD oxygen sensors were calibrated only during JC112 taking water bottle samples at 62 stations. The comparison of oxygen values as measured by the CTD sensor and calibrated water bottle samples in the lab are shown in Figure 36. The higher the oxygen concentration, the higher is mismatch between in-situ and corresponding lab oxygen values. Above about 100 µmol/L, the in-situ oxygen values from CTD sensor is about 15 µmol/L to 20 µmol/L smaller than as measured in the lab bottle samples. Furthermore, the noice in the data also increases with oxygen concentrations (Figure 37).

Matched over the whole observed oxygen concentration range, the linear regres- sion reveals: Oxcalibr = 1.058 · Oxinsitu + 1.987µmol/L. But because the range of oxygen concentrations up to 100 µmol/L is better sampled and less noicy than the upper range of oxygen concentrations, we performed additionally two separate linear regression fits to the data below and above 100 µmol/L. For the final CTD oxygen sensor calibration we used those two separate linear regression parameters: Ox_{calibr} = 1.085 · Ox_{insitu} + 0.161µmol/L for low oxygen concentrations, and Ox_{calibr} = 1.000 · Ox_{insitu} + 8.805µmol/L for high oxygen concentrations. During SO238 the water samples were not taken for oxygen calibration. However, the comparison of the data from two cruises on similar location showed about 10µmol/L oxygen difference for the same density layers in the deep waters. We have matched the profiles from each cruise to profile pairs such that each pair was less than 0.5° spatial degree apart. Overall, seven such pairs were matched. The calibration steps of SO238 CTD oxygen sensors are as follows. Wanting to compare the same water masses, the oxygen data had to be interpolated on neutral density surfaces before the comparison. The visual inspection of the oxygen data in JC112 versus SO238 (Figure 38) revealed a range of oxygen values where scatter was minimal: above 80µmol/L, that enclose waters below about 2000 m. This is not surprising, as deep waters have much smaller oxygen gradients, are more stable, and have a smaller tendancy to vary in its properties over the time period of one month, which is the time elapsed between the two cruises. Thus, for the secondary oxygen calibration of SO238 CTD sensors the linear regression was applied only for oxygen data above 80µmol/L. The resulting SO238 oxygen calibration coefficients are: Oxcalibr = 1.099 · Oxinsitu + 1.163µmol/L and as a best calibration available can be applied to the oxygen data through the whole water column.

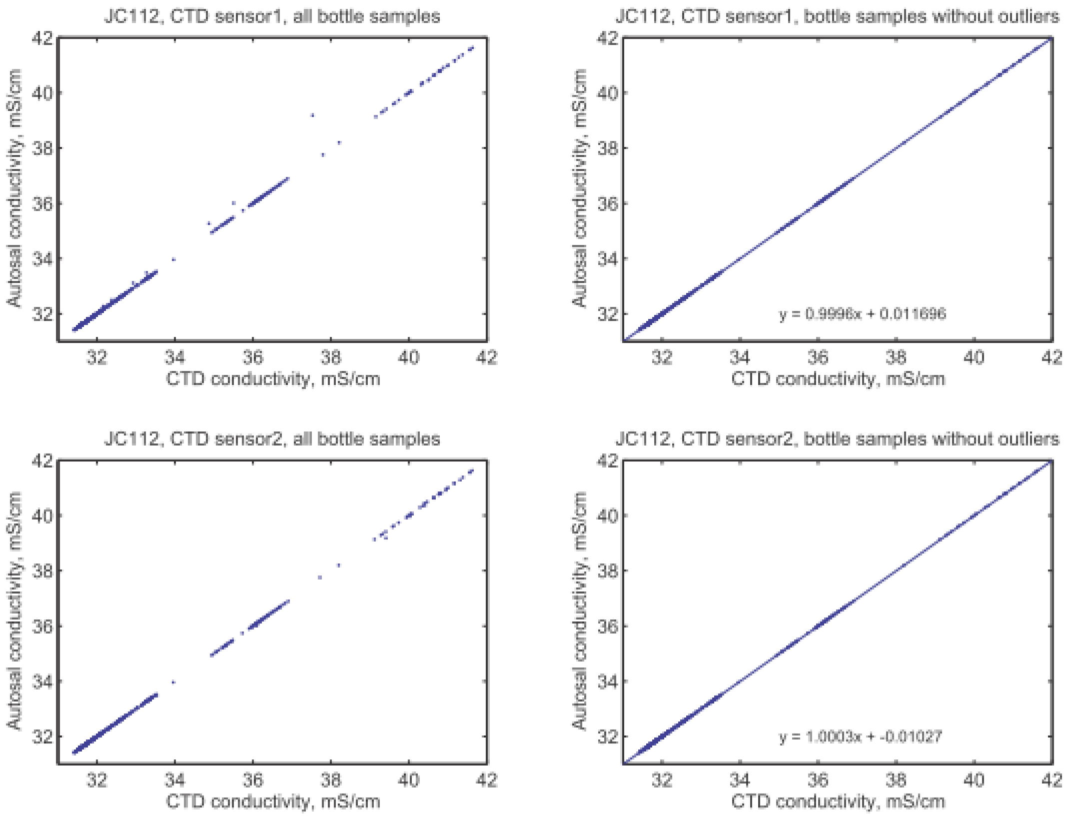


Figure 30. Calibration of CTD conductivity sensors during JC112. bottle seawater sample conductivity plotted over measurements of CTD sensor 1 (upper graphs) and sensor 2 (lower graphs). Right side is without outliers, identified as having larger offset than 0.0.

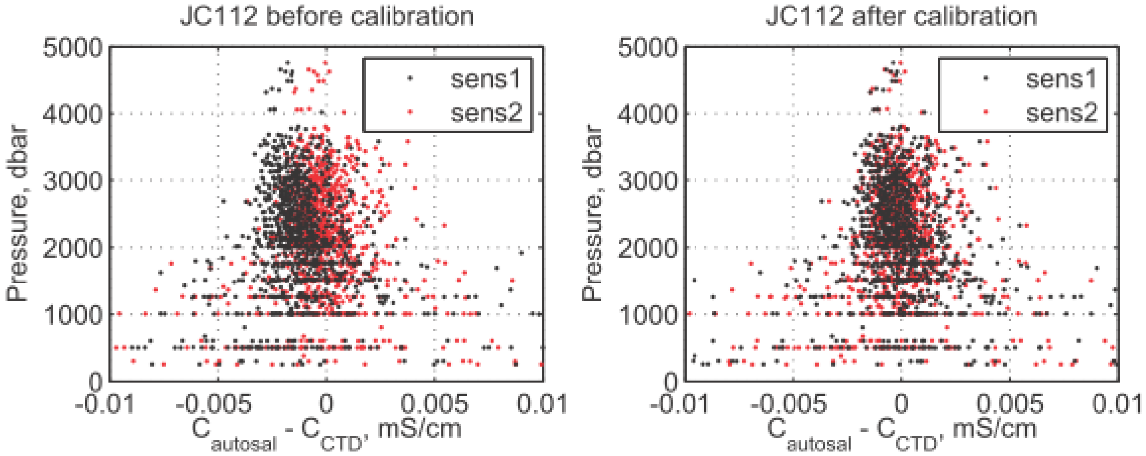


Figure 31. Difference of conductivity in the bottle samples as measured during JC112 in the lab and in-situ by two CTD conductivity sensors (sensor 1 in red, sensor 2 in black) plotted over depth, before (left) and after (right) the calibration.

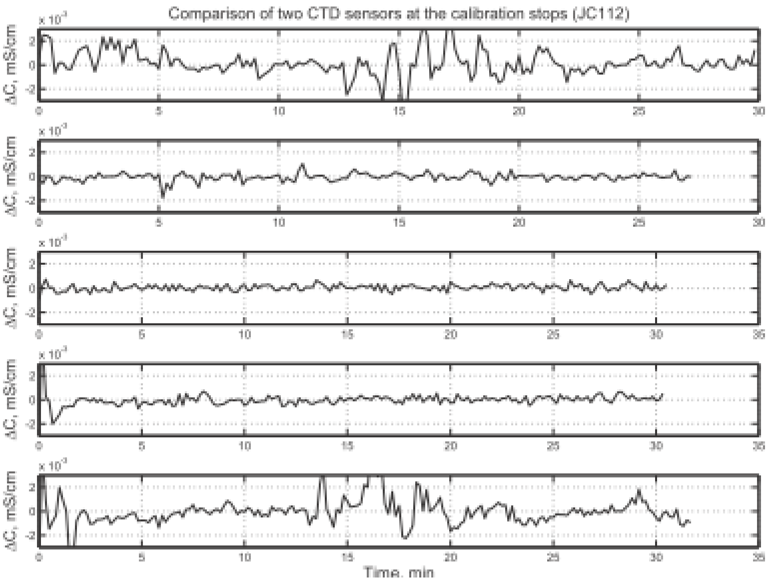


Figure 32. Comparison of two CTD sensor measurements at each MicroCAT calibration stop in cast number 02 (JC112 002.hex). The stops were located at the approximate depths of 2950 m, 2730 m, 2380 m, 2020 m, and 1670 m, looking from upper to lower graphs, respectively. The sensors were already calibrated by taking bottle water samples at each cast and performing on-board calibration with the IAPSO standard sea-water. The difference between calibrated measurements of two conductivity sensors is lower than 0.001 mS/cm in the stable waters, but can reach above 0.005 mS/cm in the unstable waters. However, sensor 1 proved to be more stable with smaller variability than sensor 2 (figure below).

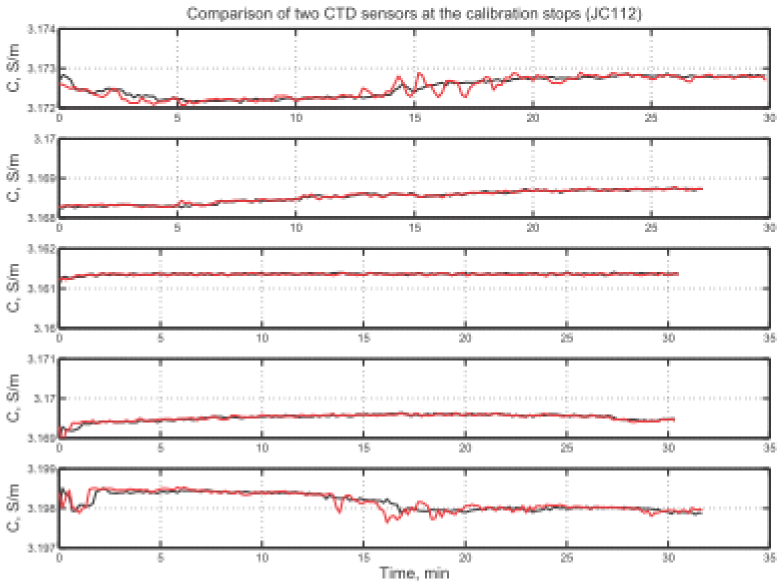


Figure 33. Comparison of two CTD sensor measurements at each MicroCAT calibration stop in cast number 02 (JC112 002.hex). The stops were located at the approximate depths of 2950 m, 2730 m, 2380 m, 2020 m, and 1670 m, looking from upper to lower graphs, respectively. The sensors are already calibrated by taking bottle water samples at each cast and performing on-board calibration with the IAPSO standard sea-water. Sensor 1 (black line) is more stable with smaller variability than sensor 2 (red line).

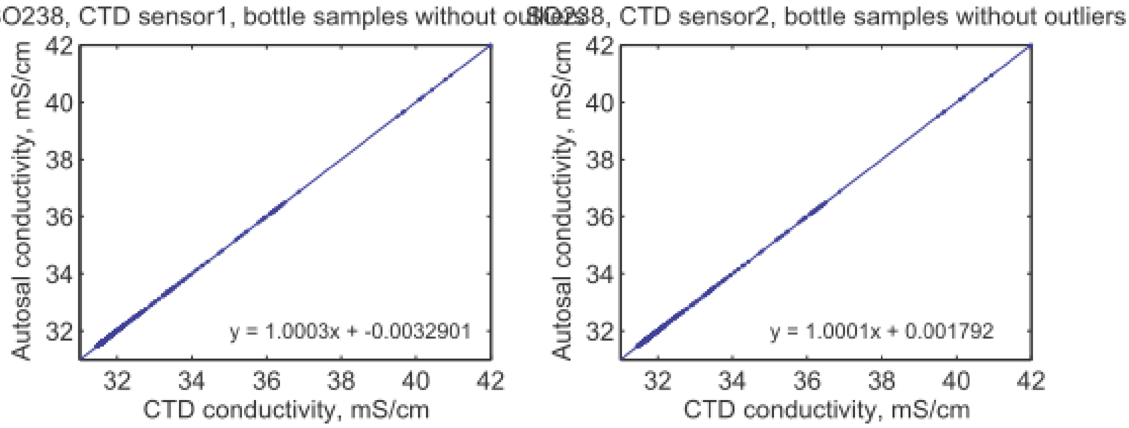


Figure 34. Calibration of CTD conductivity sensors during SO238. Bottle seawater sample conduc- tivity plotted over measurements of CTD sensor 1 (left) and sensor 2 (right) with outliers removed.

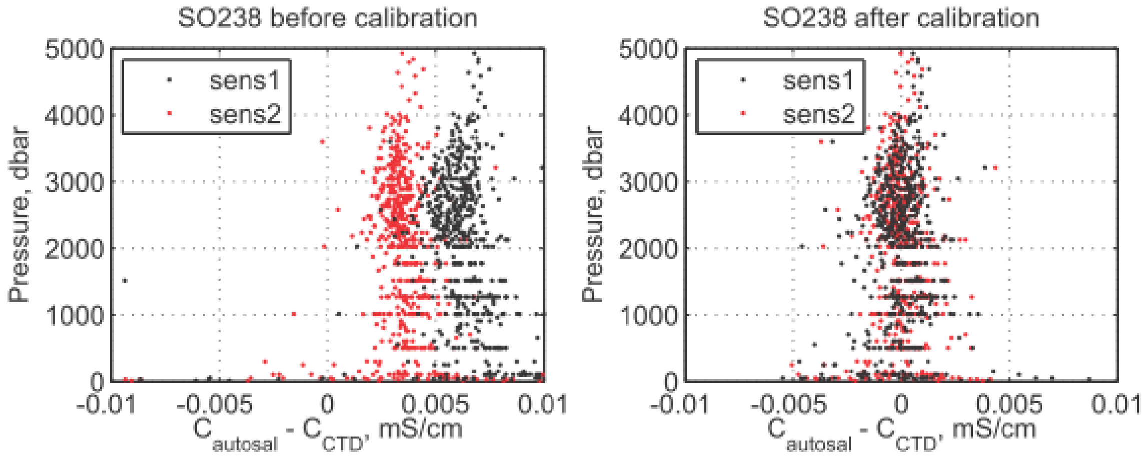


Figure 35. Difference of conductivity in the bottle samples as measured during SO238 in the lab and in-situ by two CTD conductivity sensors (sensor 1 in red, sensor 2 in black) plotted over depth, before (left) and after (right) the calibration.

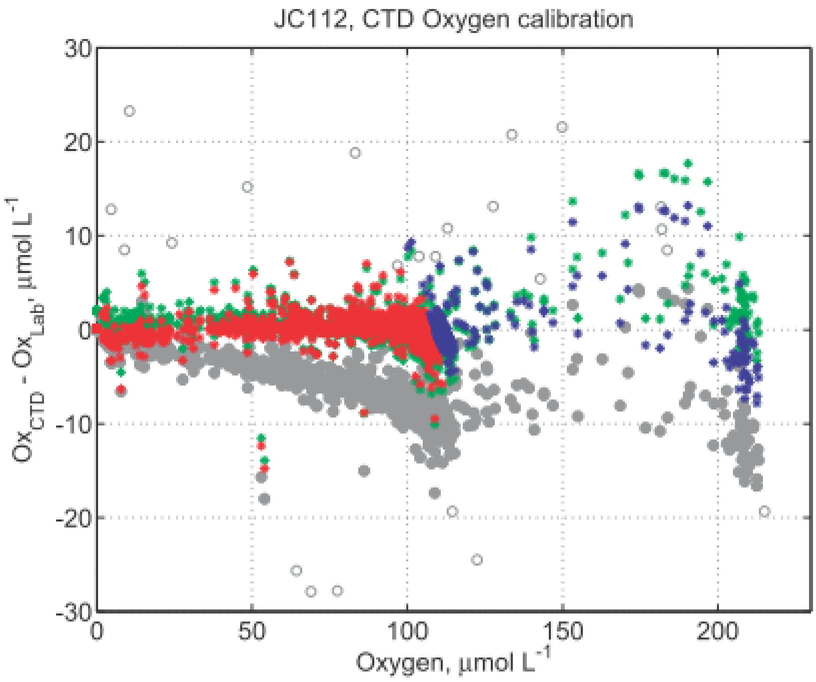


Figure 36. CTD in-situ oxygen data versus the data measured in the lab from the taken bottle samples. The empty grey dots mark the removed outliers. Green line indicates the linear fit over the whole dataset, while red and blue lines mark the linear fit over only low oxygen values and high oxygen values, respectively.

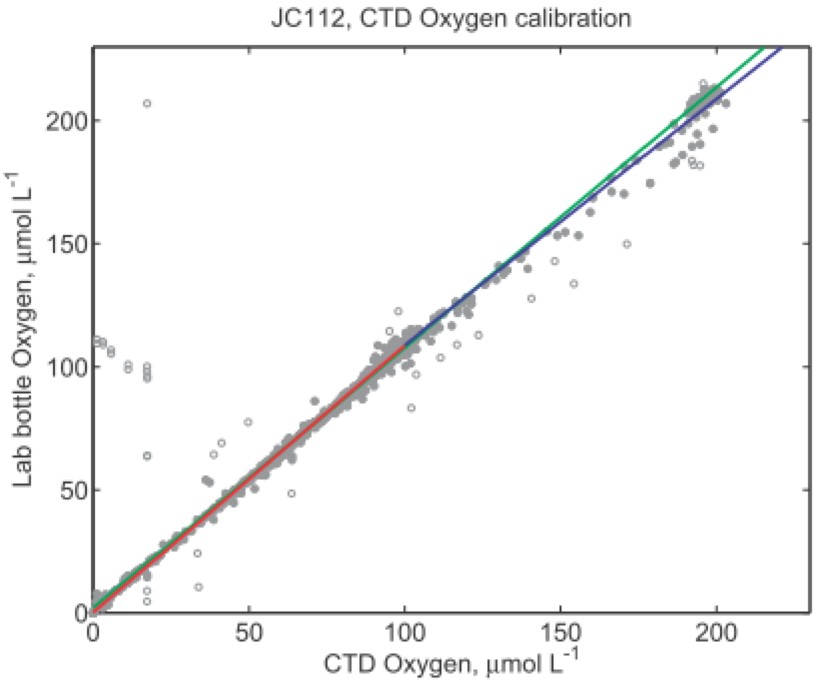


Figure 37. Difference between oxygen concentrations as measured in situ and in the lab versus oxygen concentrations. Higher differences appear for the higher oxygen concentrations. The grey dots mark the differences from the uncalibrated CTD sensor measurements, the green dots stand for the calibrated CTD sensors with the calibration for the whole dataset, red dots mark the CTD calibration for just lower oxygen values, while blue dots for only high oxygen values.

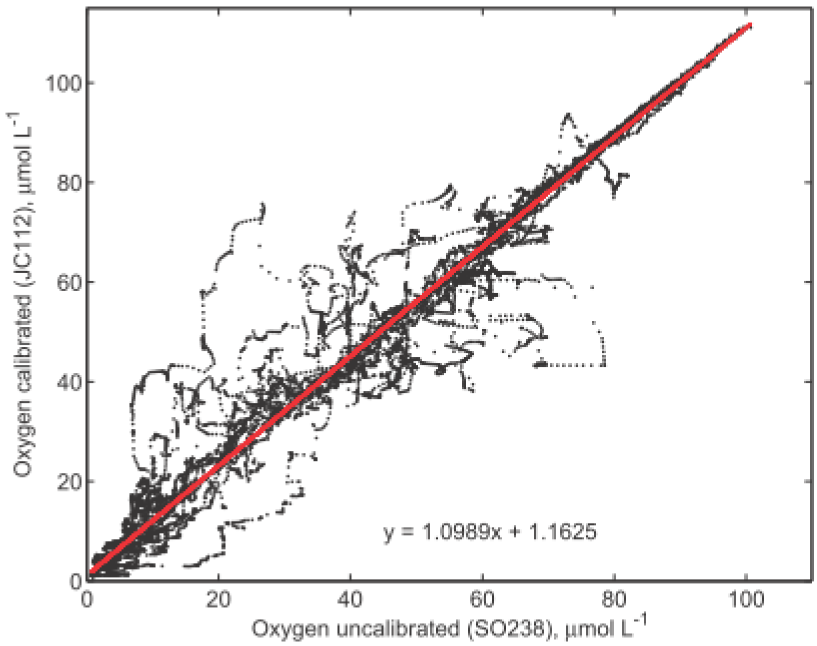


Figure 38. SO238 CTD oxygen calibration using JC112 calibrated CTD data. Profiles from each cruise that are less than 0.5◦ spatial degree apart were paired (seven pairs in total). Each oxygen point corresponds to the same neutral density. The linear regression was performed for only oxygen values above 80µmol/L.

Calibration of MicroCATs on cruises JC112 and SO238

The project deployed 20 MicroCATs on five moorings (Table 9), called 'Mooring 1', 'Mooring 2', 'Mooring 3', 'Mooring ADCP EAST', and 'Mooring ADCP WEST' for a period of about 70 days. The calibration of temperature, conductivity, and pressure sensors of all MicroCATs was performed before and after the deployment to reduce the uncertainty of the estimates and to evaluate the drift during the deployment. The reference temperatures, conductivities, and pressures of CTD SBE 9plus probe have the uncertainties of ±0.001◦C, ±0.003 mS/cm, and 0.02%, respectively. The MicroCAT sensors have similar standard accuracies for T, S, and P of ±0.002◦C, ±0.003 mS/cm, and 0.1%, respectively. The goal of the MicroCAT calibration was to reduce the uncertainties relative to CTD. The typical stability of MicroCAT sensors given by the manufacturer are ±0.0002◦C/month, ±0.003 mS/cm/month, and 0.05%/year, respectively. A much larger drift may question the assumption of a predominantly linear drift during the deployment and may not be a reasonable approximation. However, no significant drift was found after post-deployment calibration for almost all of the MicroCATs (except for MicroCAT no. 09395 deployed on Mooring 3, see below).

MicroCATs were calibrated with respect to CTD measurements before (cruise JC112) and after (cruise SO238) the mooring deployments. During JC112, the MicroCATs were attached to the rosette for the cast no. 02, corresponding to the CTD file: JC112 002.hex; during SO238_- for the cast no. 20, corresponding to CTD file: SO238-CTD-20-2015-02-25.hex. Due to the equilibration time of the MicroCAT sen- sor and the relatively low sample rate, accurate calibrations can only be obtained during bottle stops, which were chosen to be about 20 min long. Upon arriving at the depth of a particular bottle stop (minute 0), the induced water turbulence takes time to subside, which can last up to several minutes, slightly reducing the available calibration time. In addition, there is a small inertia of MicroCAT measurements due to change in pressure. Overall, there were five stops carried during each calibration cast. The CTD sampling frequency was set to 24 Hz during JC112, and to 4 Hz during SO238, while MicroCAT sampling frequency on both calibration casts was set to 0.1 Hz.

MicroCAT pressure sensor calibration

The pressure sensor on each MicroCAT was calibrated by estimating the mean offset from the CTD pressure sensor's measurement for each calibration stop. The pressure measurements for six MicroCATs of Mooring 1 during SO238 at each step are shown in Figure 10. The pressure sensors on all of the MicroCATs had a positive offset, i.e. MicroCAT pressure measurement was consistently larger in comparison with CTD. One MicroCAT (no. 11107) had significantly larger offset from CTD pressure measurement (10 dbar) and the strongest dependence on pressure. The mentioned MicroCAT No. 11107 was deployed at the bottom of Mooring 1. Interestingly, other two bottom MicroCATs for Moorings 2, and 3, had similarly large calibration offset. In general, MicroCAT pressure calibration offset is slightly dependent on pressure, thus, the final pressure correction for each MicroCAT at the depth of deployment was computed by the linear interpolation from two adjacent calibration stops and is shown in Table 9. In summary, the pressure sensors on all of the MicroCATs needed only the small calibration correction of only couple of decibars with the largest correction for the bottom deployed MicroCATs of about 10 decibars. The drift for the whole deployment period of about one month was insignificant for all pressure sensors

Mooring serial no.	P, dbar	P_{offset} (JC112), dbar	P_{offset} (SO238), dbar	P_{drift}, dbar
M1 09380	1921	−2.0	−0.9	−1.0
M1 09382	—	—	—	—
M1 09386	2663	−3.7	−2.6	−1.1
M1 09387	3034	−2.8	−2.2	−0.6
M1 09388	3362	−2.1	−1.8	−0.3
M1 11107	3386	−11.0	−11.0	0.1
M2 09389	1927	−5.6	−4.5	−1.1
M2 09390	2298	−4.5	−3.1	−1.4
M2 09391	2670	−5.5	−4.4	−1.1
M2 09392	—	—	—	—
M2 09393	3373	−3.8	−3.0	−0.8
M2 11109	3397	−13.5	−13.5	0.1
M3 09395	1954	−3.3	−2.0	−1.4
M3 09397	2327	−5.0	−4.0	−0.9
M3 09398	2703	−6.5	−6.8	0.3
M3 11110	3074	−3.0	−2.8	−0.2
M3 11111	3403	−3.7	−3.4	−0.3
M3 11108	3426	−12.4	−12.6	0.1
M ADCP East 09396	2311	—	−3.0	—
M ADCP West 09399	2240	—	−2.9	—

Table 9: Calibration of the pressure sensor of MicroCATs during JC112 and SO238 cruises. Here P is a median depth of deployment of the MicroCAT on the mooring, P_{offset} is a calibration of the pressure sensor respective to CTD measurement during JC112 and SO238, and P_{drift} is drift estimated at the end of the deployment.

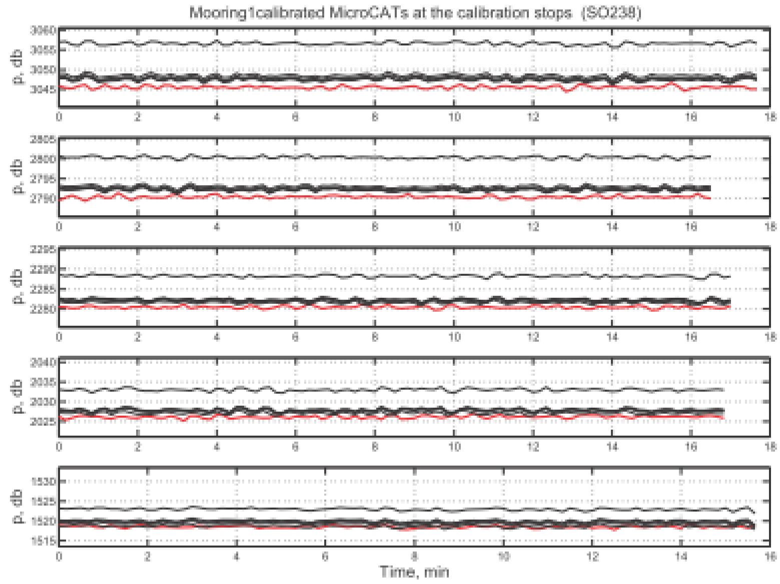


Figure 39. Pressure as measured by six, Mooring no. 1, MicroCATs (black lines) at five calibration stops during SO238 in comparison to CTD pressure sensor measurements (red line). The axes scale is kept the same for all five stops for comparison

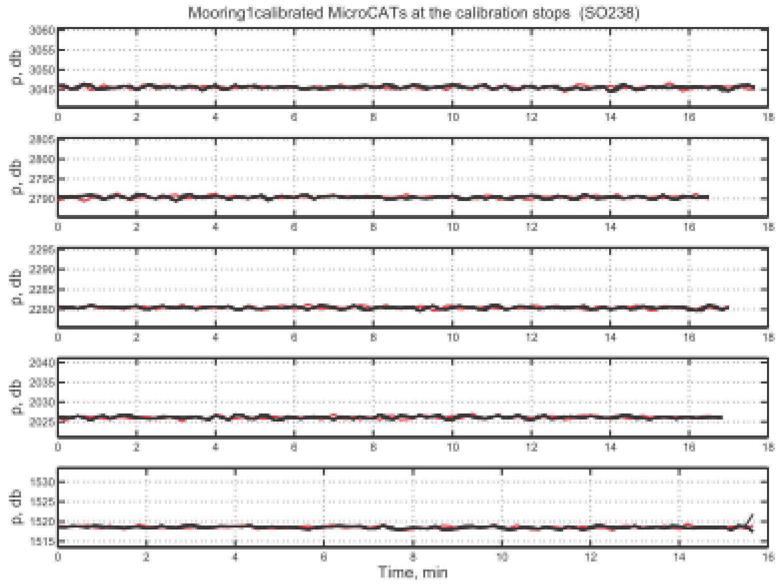


Figure 40. : Calibrated pressure as measured by six, Mooring no. 1, MicroCATs (black lines) at five calibration stops during SO238 in comparison to calibrated CTD sensor measurements (rot line. The axes scale is kept the same for all five stops for comparison.

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MicroCAT conductivity and temperature sensor calibration

The conductivity and temperature calibration for each MicroCAT is considered depth-independent. Thus, data from all five calibration stops was merged together to evaluate the calibration constants for each MicroCAT. However, as CTD was sampled at 24 Hz, while MicroCATs at 0.1 Hz, the comparison between the instrument readings was per- formed after CTD data was filtered with the running-median filter to match the slow response of CAT instruments. Than each 240th (for JC112, or 40th for SO238) CTD conductivity and temperature reading was compared with the respective reading of the MicroCAT. Finally, the depth-independent conductivity and temperature calibration was computed by linear regression of C_{CAT} vs C_{CTD}, or T_{CAT} vs T_{CTD}, respectively. One notes that MicroCAT no. 09399 on "Mooring ADCP West had a bad conductivity reading. The linear regression coefficients for conductivity sensors are given in Table 10, and for temperature sensors in Table 10. As an example, the conductivity measured by six Mooring 1 MicroCATs are compared with CTD measurements during the cal- ibration stops before and after the MicroCAT sensor calibration. It is interesting to observe, that despite of all calibration stops being performed below 1500 m, there were always stops where relatively strong low-frequency variability in T and C measurements prevailed. The drift evaluation of all MicroCATs is shown in Figures 41-44. The conductivity sensors of most of the MicroCATs had a drift in the range of 1×10^{-3} mS/cm/month to 2×10^{-3} mS/cm/month. However, MicroCAT no. 09395, deployed on Mooring 3 at about 1960 m depth had almost one order larger drift than any other MicroCAT: about 1×10^{-2} mS/cm/month. Thus, measurements of this MicroCATs should be flaged. The temperature sensor drift for most of the MicroCATs was in the range of 1×10^{-3} K/month to 2×10^{-3} K/month. There is systematic offset between JC112 and SO238 CTD temperature readings. As CTD temperature sensors are uncalibrated, there is systematic bias of about 1×10^{-3} K between the two instruments.

Mooring serial no.	JC112	SO238
M1 09380	0.9974 · Ci + 0.0817 mS/cm	0.9955 · Ci + 0.1423 mS/cm
M1 09382	0.9989 · Ci + 0.0364 mS/cm	—
M1 09386	0.9986 · Ci + 0.0474 mS/cm	0.9960 · Ci + 0.1311 mS/cm
M1 09387	0.9979 · Ci + 0.0650 mS/cm	0.9960 · Ci + 0.1285 mS/cm
M1 09388	0.9982 · Ci + 0.0576 mS/cm	0.9961 · Ci + 0.1256 mS/cm
M1 11107	0.9983 · Ci + 0.0589 mS/cm	0.9960 · Ci + 0.1355 mS/cm
M2 09389	0.9976 · Ci + 0.0755 mS/cm	0.9961 · Ci + 0.1250 mS/cm
M2 09390	0.9986 · Ci + 0.0462 mS/cm	0.9957 · Ci + 0.1383 mS/cm
M2 09391	0.9987 · Ci + 0.0366 mS/cm	0.9955 · Ci + 0.1362 mS/cm
M2 09392	0.9976 · Ci + 0.0707 mS/cm	—
M2 09393	0.9978 · Ci + 0.0705 mS/cm	0.9964 · Ci + 0.1122 mS/cm
M2 11109	0.9972 · Ci + 0.0949 mS/cm	0.9966 · Ci + 0.1174 mS/cm
M3 09395	0.9990 · Ci + 0.0438 mS/cm	0.9969 · Ci + 0.1345 mS/cm
M3 09397	0.9970 · Ci + 0.0925 mS/cm	0.9955 · Ci + 0.1415 mS/cm
M3 09398	0.9973 · Ci + 0.0828 mS/cm	0.9964 · Ci + 0.1087 mS/cm
M3 11110	0.9976 · Ci + 0.0851 mS/cm	0.9961 · Ci + 0.1323 mS/cm
M3 11111	0.9985 · Ci + 0.0488 mS/cm	0.9960 · Ci + 0.1277 mS/cm
M3 11108	0.9980 · Ci + 0.0645 mS/cm	0.9958 · Ci + 0.1375 mS/cm
M ADCP East 09396	—	0.9961 · Ci + 0.1221 mS/cm
M ADCP West 09399	—	0.9960 · Ci + 0.1327 mS/cm

Table 10: Conductivity sensor calibration coefficients for each MicroCAT deployed on five moorings, and sorted by ascending depth.

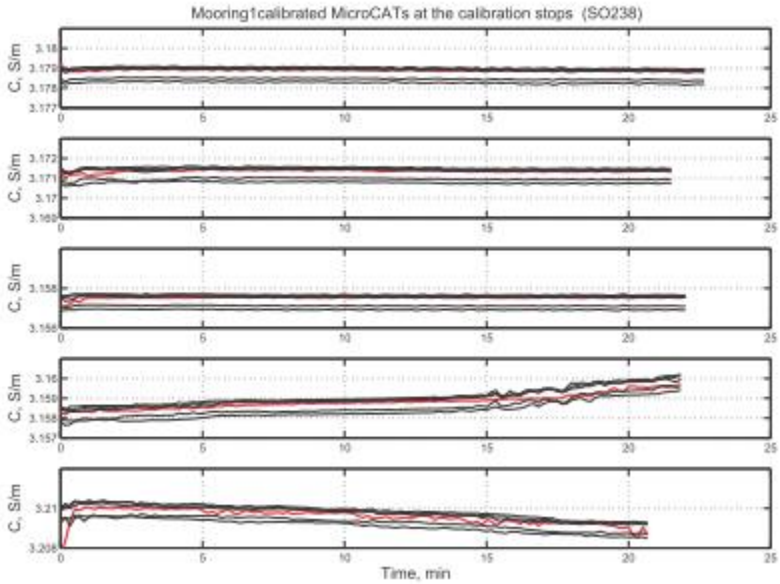

Figure 41. Conductivity as measured by six, Mooring no. 1, MicroCATs (black lines) at five calibration stops during SO238 in comparison to calibrated CTD sensor measurements (red line). The axes scale is kept the same for all five stops for comparison.

Mooring serial no.	JC112	SO238
M1 09380	0.9990 · Ti + 0.0025 K	0.9976 · Ti + 0.0046 K
M1 09382	0.9996 · Ti + 0.0010 K	—
M1 09386	0.9993 · Ti + 0.0024 K	0.9977 · Ti + 0.0048 K
M1 09387	0.9991 · Ti + 0.0020 K	0.9976 · Ti + 0.0041 K
M1 09388	0.9993 · Ti + 0.0016 K	0.9979 · Ti + 0.0036 K
M1 11107	0.9992 · Ti + 0.0038 K	0.9977 · Ti + 0.0060 K
M2 09389	0.9990 · Ti + 0.0030 K	0.9978 · Ti + 0.0044 K
M2 09390	0.9995 · Ti + 0.0018 K	0.9977 · Ti + 0.0046 K
M2 09391	0.9995 · Ti + 0.0021 K	0.9980 · Ti + 0.0043 K
M2 09392	0.9991 · Ti + 0.0036 K	—
M2 09393	0.9991 · Ti + 0.0038 K	0.9980 · Ti + 0.0050 K
M2 11109	0.9989 · Ti + 0.0025 K	0.9980 · Ti + 0.0032 K
M3 09395	0.9994 · Ti + 0.0022 K	0.9978 · Ti + 0.0047 K
M3 09397	0.9989 · Ti + 0.0038 K	0.9977 · Ti + 0.0052 K
M3 09398	0.9991 · Ti + 0.0024 K	0.9983 · Ti + 0.0032 K
M3 11110	0.9987 · Ti + 0.0041 K	0.9976 · Ti + 0.0055 K
M3 11111	0.9995 · Ti + 0.0006 K	0.9980 · Ti + 0.0029 K
M3 11108	0.9992 · Ti + 0.0039 K	0.9976 · Ti + 0.0063 K
M ADCP East 09396	—	0.9981 · Ti + 0.0035 K
M ADCP West 09399	—	0.9977 · Ti + 0.0041 K

Table 11: Temperature sensor calibration coefficients for each MicroCAT deployed on five moorings, and sorted by ascending depth.

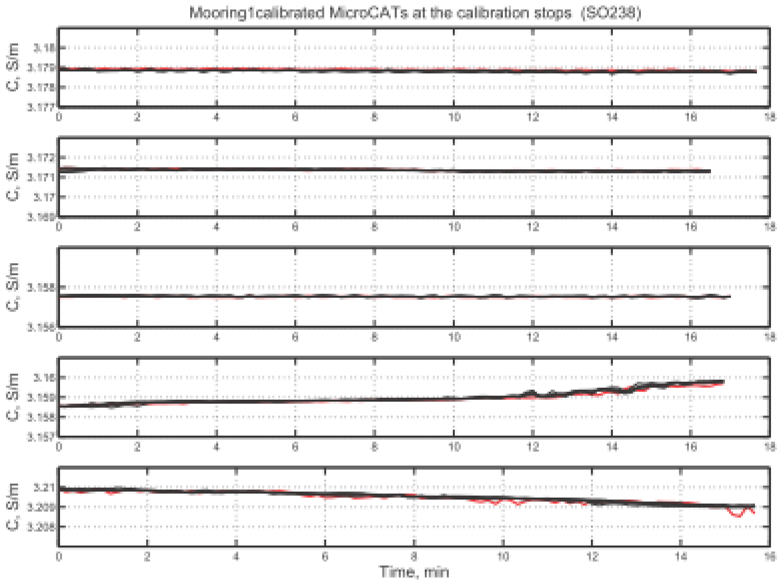

Figure 42. Calibrated conductivity as measured by six, Mooring no. 1, MicroCATs (black lines) at five calibration stops during SO238 in comparison to calibrated CTD sensor measurements (red line). The axes scale is kept the same for all five stops for comparison

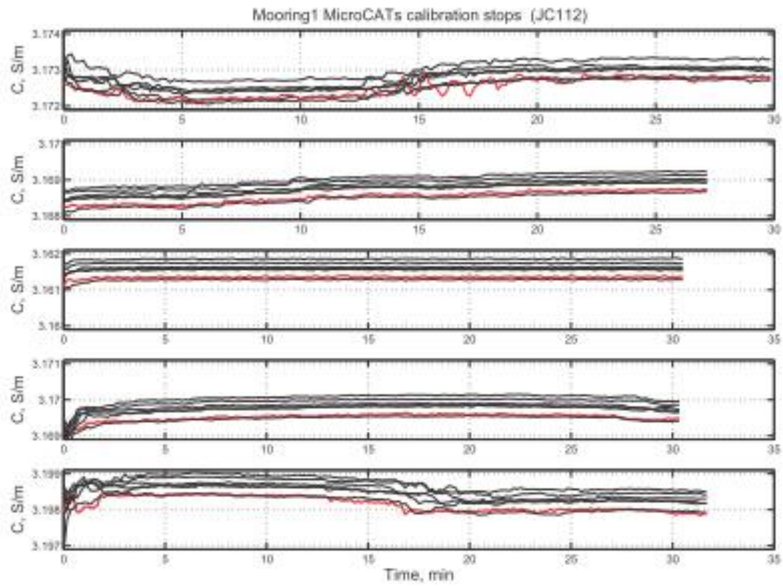

Figure 43. Conductivity as measured by six, Mooring no. 1, MicroCATs (black lines) at five calibration stops during JC112 in comparison to calibrated CTD sensor measurements (red line). The axes scale is kept the same for all five stops for comparison.

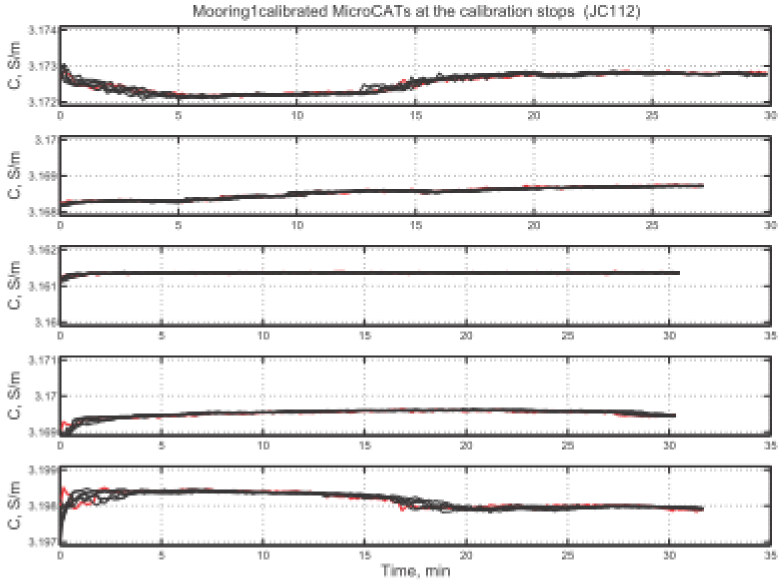

Figure 44. Calibrated conductivity as measured by six, Mooring no. 1, MicroCATs (black lines) at five calibration stops during JC112 in comparison to calibrated CTD sensor measurements (red line). The axes scale is kept the same for all five stops for comparison.

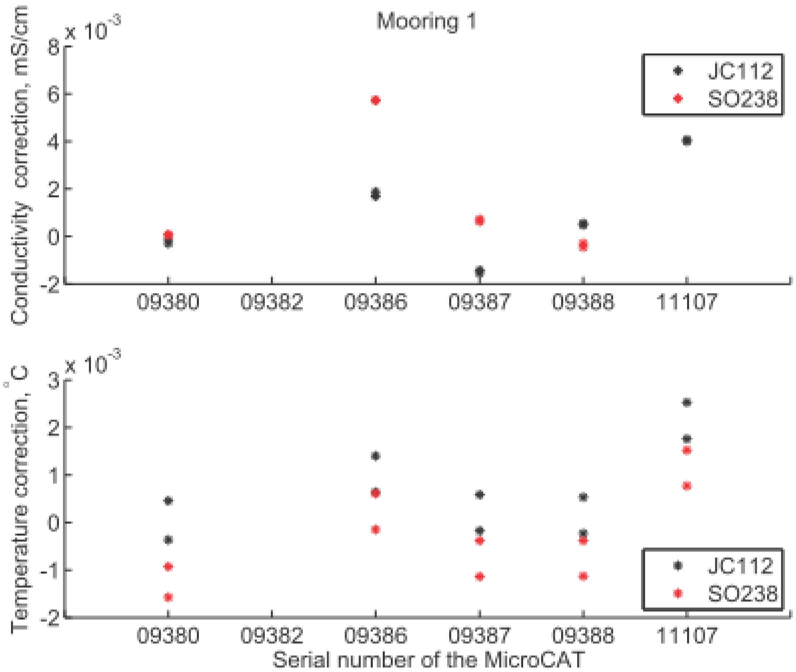

Figure 45. Drift of conductivity (above) and temperature (below) sensors at the end of Mooring 1 deployment period. Two same color dots for each MicroCAT represent calibration of the sensor with two available CTD conductivity and temperature sensors.

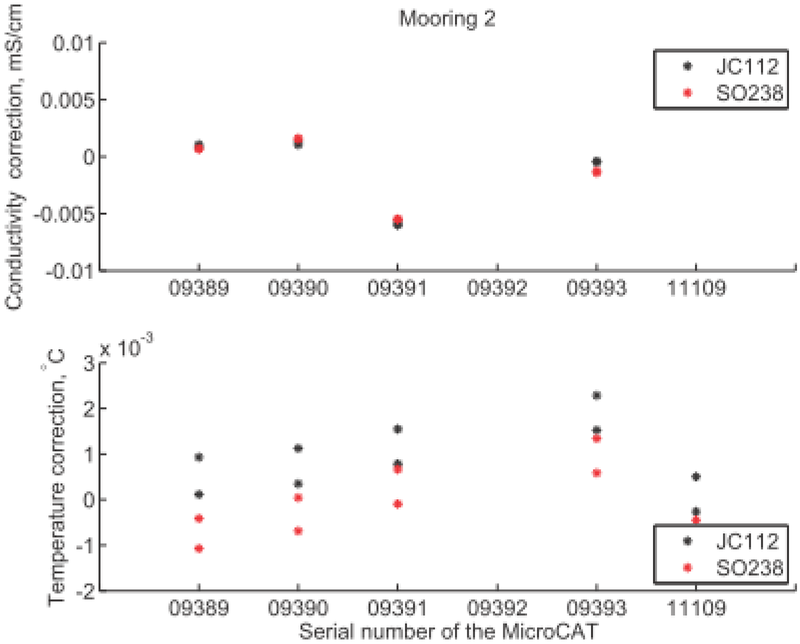

Figure 46. Same as Figure 45, but for Mooring 2.

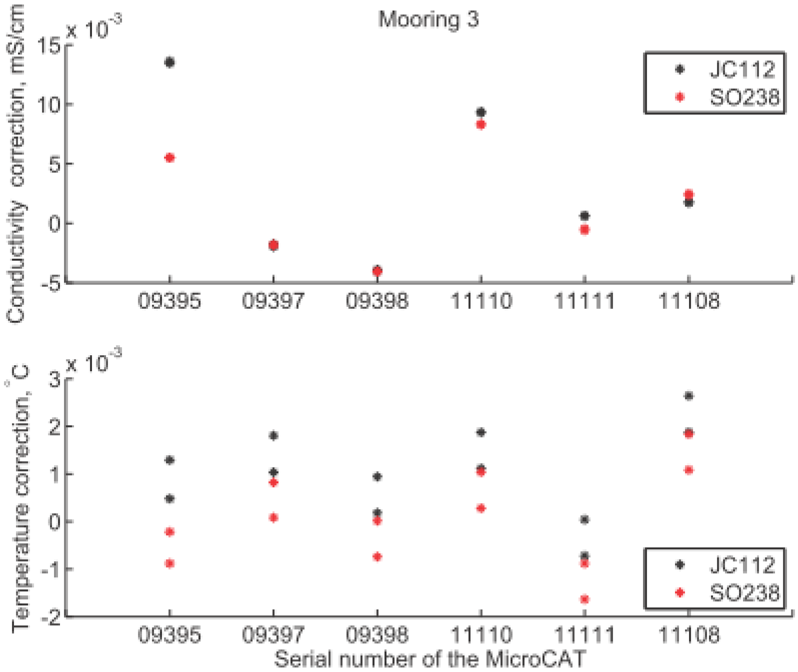

Figure 47. Same as Figure 45, but for Mooring 3.

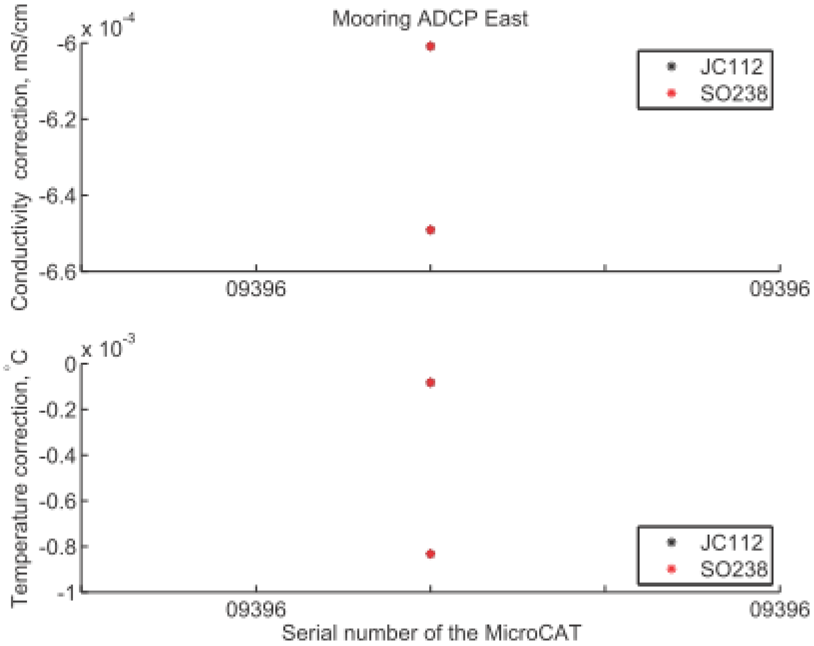

Figure 48. Same as Figure 45, but for Mooring ADCP EAST.

Appendix

The list of matlab routines to read and calibrate CTD sensors and MicroCATs:

- read ctd.m – reads JC112 and SO238 CTD data and saves in .mat format.
- read autosal.m – calibrates JC112 conductivity sensors.
- read autosal SO.m – calibrates SO238 conductivity sensors with conductivity ratio offset reading of the salinograph set to zero.
- read_oxygen.m – calibrates CTD oxygen sensors for cruise JC112.
- overwrite_ctd JC112.m – creates new calibrated and binned CTD files for JC112 cruise.
- overwrite_ctd SO238.m – creates new calibrated and binned CTD files for SO238 cruise.
- read ctd_small.m – reads calibrated and binned CTD files, computes additional parameters: neutral density, conservative temperature, absolute salinity. Saves the output in e.g. CTD JC112 cal.mat file.
- spatial_distrib.m – combines data from two cruises and interpolates on density surfaces
- spatial_distrib p.m – combines data from two cruises and interpolates on pres- sure surfaces
- calibr_ox_secondary.m – calibrates SO238 oxygen data by using nearby sta- tions of JC112 profiles. The uncalibrated SO238 oxygen data at the deep waters (oxygen values larger than about 70µmol/L) is about 10µmol/L smaller than JC112 calibrated oxygen data for the same density.
- read microcat.m – reads raw microcat data and saves in .mat format.
- calibr_microcats up3.m – calibrates MicroCATs during JC112 cruise, taking into account the calibration of JC112 CTD conductivity sensors. The rutine uses raw

CTD data as calibration steps were during upcast and not downcast. Uses additional routines calibr parameters.m and find step ctdprof.m.

- calibr_microcats up4.m – same as above, but to calibrate MicroCATs during SO238 cruise.
- find step_ctdprof.m – find the position of the 20 min calibration stops in the upward CTD and MicroCAT cast.
- calibr_microcats final.m – computes the drift of the pressure, temperature, and conductivity sensors of the MicroCATs.
- overwrite_cat SO238.m – creates new calibrated MicroCAT files.