

# AMT RRS James Cook Cruise JC053 AMT20 Underway Meteorology and Surface Hydrography Document

## Cruise details

<b>Dates</b>	2010-10-12 to 2010-11-25
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<b>Data supplied by</b>	Jon Seddon (NMF-SS)

These notes refer to underway data collected during the RRS James Cook cruise (JC053) AMT20, between 12th October and 25th November 2010. The cruise departed from Southampton (UK) and finished in Punta Arenas (Chile). All time quoted in this document are UTC.

The data provided to BODC cover the period from 12/10/2010 to 22/11/2010.

The data did not fully cover the period of the cruise as the sea surface hydrography sensor suite was not turned on until clear of land at the start of the cruise (13/10/2010 07:00) and turned off prior to entering Argentinean territorial waters (22/11/2010 21:10). The ship's non-toxic sea water supply was stopped between 08:49 and 21:22 on 19th October 2010 during the port call in the Azores. It was again stopped between 07:30 and 15:58 on 8th November 2010 during the boat transfer at Ascension Island.

## Content of data series

Parameter	Units	Parameter code	Comments
Latitude	Degrees (+ve N)	ALATGP01	-
Longitude	Degrees (+ve E)	ALONGP01	-
Ship's heading (Gyro)	degrees	HEADCM01	-
Ship's eastward velocity	cm s <sup>-1</sup>	APEWGP01	-
Ship's northward velocity	cm s <sup>-1</sup>	APNSGP01	-
Distance run	km	DSRNCV01	-
Bathymetric depth	m	MBANCT01	-
Atmospheric pressure	mbar	CAPHTU01	-
Air temperature	°C	CDTASS01	-
Relative humidity	%	CRELSS01	-
PAR irradiance	W m <sup>-2</sup>	DWIRRXMX	-
Total irradiance	-2	CSLRR1XS	-

	W m		
Relative wind direction	Degrees	ERWDSS01	-
Relative wind speed	m s <sup>-1</sup>	ERWSSS01	-
Absolute wind direction	Degrees	EWDASS01	Corrected for ship's heading and speed
Absolute wind speed	m s <sup>-1</sup>	EWSBSS01	Corrected for ship's heading and speed
Salinity - calibrated	Dimensionless	PSALSG01	Calibrated against samples
Temperature (sea surface, remote housing at non-toxic seawater supply inlet) - calibrated	°C	TEMPHG01	Calibrated against samples
Temperature (TSG housing)	°C	TMESSG01	-
Fluorometer output: voltage	V	FVLTWS01	-
Chlorophyll fluorescence (calibrated)	mg chl_a m <sup>-3</sup>	CPHLUT01	Calibrated against samples
Beam transmission	%	POPTDR01	-
Beam attenuation	m <sup>-1</sup>	ATTNDR01	-

## Instrumentation

### Navigation and bathymetry (HIPLAT)

Instrument	Type
Ashtech ADU5 GPS based attitude measuring system	GPS
Seapath 200 GPS unit	GPS
Applanix POSMV GPS unit	GPS
DPS116 GPS unit	GPS
CNAV GPS unit	GPS
Ship's Gyrocompass	Gyro compass
Simrad EA500 Precision Echo Sounder	Echosounder

### Meteorology (HIMET)

Sensor	Serial number	Last calibration date	Deployment
Gill Wind sonic (Option 3)	064537	-	Port

Skye Instruments SKE510	28562	2009-04-29	Starboard until 2010-11-10
Skye Instruments SKE510	28560	2009-04-29	Starboard from 2010-11-10
Skye Instruments SKE510	28561	2009-04-29	Port
Kipp and Zonen Ltd CMB6	973135	2009-04-20	Starboard
Kipp and Zonen Ltd CMB6	973134	2009-04-20	Port
Vaisala PTB210	R0450005	2010-09-15	Port
Vaisala HMP45A	C1320001	2010-04-06	Port

## Surface hydrography (HIUWAY)

Sensor	Serial number	Last calibration date	Deployment
Sea-Bird SBE38	0416	2010-03-15	Hull inlet to non-toxic supply
Sea-Bird SBE45	0233	2010-03-18	CTD hanger non-toxic supply
Wetlabs C-Star	CST-1132PR	2010-06-04	CTD hanger non-toxic supply up to 2010-10-18 11:35 from 2010-10-20 11:35
Wetlabs C-Star	CST-1131PR	2008-07-15	CTD hanger non-toxic supply 2010-10-18 11:35 - 2010-10-20 11:35
Wetlabs WetStar	WS3S-246	2010-06-30	CTD hanger non-toxic supply

## Originator's Data Processing

### Navigation and bathymetry (HPPLAT)

During the cruise there was a dual logging system in place on the RRS James Cook. Data from the various instruments were logged to the RVS Level-C system and also as NetCDF (binary) through the Ifremer Techsas data logging system. In addition to the GPS systems the following instruments were logged during the cruise:

- 1) Chernikeef EM speed log (logged to RVS format as log\_chf)
- 2) Ships Gyrocompass (logged to RVS format as gyro)
- 3) Simrad EA600 Precision Echo Sounder (logged to RVS format as ea600m)

Processing was carried out using the RVS software suite. The following routines were run on the navigation and bathymetry data channels to produce files named after the routine that generated them:

RELMOV - Relmov is the relative motion file for this cruise. This was generated using the ships gyro and ships Chernikeef Log data to extract a movement in a given direction. This was then used by bestnav when and where necessary to calculate fixes if GPS fixes were not available.

BESTNAV - Bestnav uses all 3 GPS Systems logged and creates a best suite stream by providing an as complete account of the ships track as possible. This is done by reading all 3 GPS streams with gps\_g2 being primary, gps\_4000 as secondary and gps\_ash as tertiary. The system looks for gaps of a certain length in the primary and when it finds those gaps it requests that the next gps down fill in the gaps. If no GPS data is available it asks RELMOV to fill in until data is available again. Then the system calculates back over itself to ensure that the extrapolated positions are correct using the GPS data available around the

gap.

BESTDRF - Bestdrf is a product of bestnav. When run bestnav uses the relmov data which contains a predicted vn and ve based upon direction and speed through the water. The Bestdrf file is the accurate drift velocity of what actually occurred based on the GPS changes between each record.

Filename	Data type	Start Calendar Day	Start Time	Finish Calendar Day	Finish Time	Data Interval
bestnav	RVS Level-C processed	2010-10-12	10:40:50	2010-11-22	21:10:00	10 seconds
ea600m	RVS Level-C raw	2010-10-12	19:02:09	2010-11-22	21:10:09	1 second

## Meteorology (HPMET)

The meteorology component consisted of a suite of sensors mounted on the foremast at a height of approx 16.4m above the waterline. Parameters measured were wind speed and direction, air temperature, humidity and atmospheric pressure. There was also a pair of optical sensors mounted on gimbals on each side of the ship. These measured total irradiance (TIR) and photo-synthetically active radiation (PAR).

The data from the meteorological sensors were logged by the TECHSAS system during the cruise and combined in the RVS Level-C format to produce the file 'surfmet'. The following instruments were logged during the cruise:

- 1) Gill Wind sonic (Option 3)
- 2) Skye Instruments SKE510 (port and starboard)
- 3) Kipp and Zonen Ltd CMB6 (port and starboard)
- 4) Vaisala PTB100A
- 5) Vaisala HMP45A

No processing was carried out using the RVS software suite on meteorology channels.

Filename	Data type	Start Calendar Day	Start Time	Finish Calendar Day	Finish Time	Interval
surfmet	RVS Level-C raw	2010-10-12	07:50:36	2010-11-22	21:10:09	1 second

## Sea surface hydrography (HPUWAY)

The surface water component consisted of a flow through system with a pumped pickup at approx 5 m depth. TSG flow was approx 18 litres per minute whilst fluorometer and transmissometer flow is approx 1.5 litres per minute. Flow to instruments is degassed using a debubbler with 24 litres per minute inflow and 10 litres per minute waste flow. The non-toxic system ran throughout the cruise except when entering within 200 nautical miles of the Azores, Ascension Island, Falklands and Argentina.

The data from the non-toxic supply were logged by the TECHSAS system during the cruise and combined in RVS Level-C format to produce the files 'surfmet' and 'sbe45'. The following instruments were logged during the cruise:

- 1) Wetlabs C-star 25 cm pathlength transmissometer (logged to RVS format in surfmet)
- 2) Wetlabs WetStar fluorometer (logged to RVS format in surfmet)
- 3) Seabird SBE38 Temperature sensor (logged to RVS format in sbe45)
- 4) Seabird SBE45 MicroTSG (logged to RVS format in sbe45)

		Start Calendar	Start	Finish Calendar	Finish	

Filename	Data type	Day	Time	Day	Time	Interval
sbe45	RVS Level-C raw	2010-10-12	12:22:38	2010-11-22	21:10:09	1 second
surfmet	RVS Level-C raw	2010-10-12	07:50:36	2010-11-22	21:10:09	1 second

## BODC Data Processing

Navigation and bathymetry from processed RVS format files, along with meteorological and underway seawater data from the raw RVS files were transferred to BODC's NetCDF format (QXF) under the BODC Underway Data System (BUDS). This transfer involved reducing the data by averaging to 60 second intervals. Directional data were reduced by averaging using a unit circle.

### Navigation and bathymetry (HPPLAT)

The bestnav data were transferred as used as the source for cruise navigation data. A description of the channels present in the files, units, whether they were transferred, BODC parameter code and units, and if a unit conversion was applied during the transfer are detailed in the table below:

bestnav	Channels	Description	Units	BODC Parameter Code	Units	Conversion Factor
	lat	Latitude	Degrees +ve N	ALATGP01	Degrees +ve N	*1
	lon	Longitude	Degrees +ve E	ALONGP01	Degrees +ve E	*1
	vn	northwards velocity	knots	APNSGP01	cm s <sup>-1</sup>	*51.44
	ve	eastwards velocity	knots	APEWGP01	cm s <sup>-1</sup>	*51.44
	mode	mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix	-	not for transfer	-	-
	cmg	Course made good	Degrees True	APDAGP01	Degrees True	*1
	smg	Speed made good	knots	APSAGP01	m s <sup>-1</sup>	*0.514
	dist_run	Distance run	Nautical miles	DSRNCV01	km	*1.852
	Heading	Ship's heading	Degrees true	HEADCM01	Degrees true	*1
ea600m	Channels	Description	Units	BODC Parameter Code	Units	Conversion Factor

	depth	Bathymetric depth	m	MBANZZ01	m	*1
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Once the data in the RVS navigation file 'bestnav' were transferred to the BODC QXF format, a Matlab program ('navcheck') was run, which located any null values in the latitude and longitude channels and checked to ensure that the ship's speed did not exceed 15 knots. There were a few small gaps (<5 minutes) in the latitude and longitude channels, these were filled using the Matlab program 'navint' to interpolate data to fill the gaps. In addition the 'navcheck' routine checked the vessel's speed over the ground from the navigation data for values that are outside an expected range. There were no warnings indicated. The latitude and longitude channels were screened by plotting the course on to a map of the Atlantic Ocean. There was no further flagging required.

## Meteorology (HPMET) and Sea surface hydrography (HPUWAY)

The 'surfmet' and 'sbe45' files were used as the source data for transfer. A description of the channels present in the files, units, whether they were transferred, BODC parameter code and units, and if a unit conversion was applied during the transfer are detailed in the table below:

surfmet	Channels	Description	Units	BODC Parameter Code	Units	Conversion Factor
	temp_h	TSG housing temperature	-	not for transfer - channel null in file	-	-
	temp_m	Remote temperature at non-toxic inlet	-	not for transfer - channel null in file	-	-
	cond	TSG conductivity	-	not for transfer - channel null in file	-	-
	fluo	Raw fluorometer voltage	V	FVLTWS01	V	*1
	trans	Raw transmissometer voltage	V	TVLTDR01	V	*1
	press	Atmospheric pressure at measurement height - no sea level correction	1 hPa	CAPHTU01	1 mbar	*1
	ppar	Raw port PAR sensor voltage	10 <sup>-2</sup> mV	DVLTRPSD	V	*10 <sup>-5</sup>
	spar	Raw starboard PAR sensor voltage	10 <sup>-2</sup> mV	DVLTRSSD	V	*10 <sup>-5</sup>
	speed	Relative wind speed	m s <sup>-1</sup>	ERWSSS01	m s <sup>-1</sup>	*1
	direct	Relative wind direction	Degrees	ERWDSS01	Degrees	*1
	airtemp	Air temperature	Degrees Celsius	CDTASS01	Degrees Celsius	*1

	humid	Air humidity	Percent	CRELSS01	Percent	*1
	ptir	Raw port TIR sensor voltage	$10^{-2}$ mV	CVLTRP01	V	$*10^{-5}$
	stir	Raw starboard TIR sensor voltage	$10^{-2}$ mV	CVLTRS01	V	$*10^{-5}$
<b>sbe45</b>	<b>Channels</b>	<b>Description</b>	<b>Units</b>	<b>BODC Parameter Code</b>	<b>Units</b>	<b>Conversion Factor</b>
	temp_h	TSG housing temperature	Degrees Celsius	TMESSG01	Degrees Celsius	*1
	cond	TSG conductivity	$S m^{-1}$	CNDCSG01	$S m^{-1}$	*1
	salin	Salinity	PSU	PSALSU01	dimensionless	*1
	sndspeer	Velocity of sound in water	$m s^{-1}$	SVELSG01	$m s^{-1}$	*1
	temp_r	Remote temperature at non-toxic inlet	Degrees Celsius	TEMPHU01	Degrees Celsius	*1

### Wind channels - calculation of absolute values

The BODC Matlab procedure 'wincor' was run using relative wind speed and direction, the ship's north-south and east-west velocities with the vane set to 0 degrees at the bow to generate absolute wind speed (EWSASS01) and direction (EWDASS01).

### Irradiance channels (PAR and TIR) - conversion from voltages using manufacturer's calibrations

The voltages were converted to  $W m^{-2}$  using the coefficients on the calibration sheets provided. The maximum values from the two PAR sensors were merged to produce one channel.

### Transmissometer - conversion from voltage using manufacturer's calibrations

The coefficients from the calibration sheets provided for each transmissometer were used to generate the calibration equation to convert the raw voltage to transmittance and then to attenuation.

## Sample Calibrations

### Temperature

The hull temperature sensor data were calibrated against the CTD profile temperature. The data from the hull sensor at the CTD start time were compared with the temperature from the CTD averaged over the surface 5 decibars. The temperature offsets (CTD - Hull) were plotted against date/time and CTD sensor temperature and outliers identified and removed from the calibration dataset. The relationships in the offset between sensors were then compared to the date/time and the CTD sensor temperature in separate linear regressions. There was no significant relationship with CTD sensor temperature ( $R^2 = 0.003$ ;  $n = 74$ ;  $F = 0.184$ ;  $p = 0.669$ ). There was a significant regression of offset with date/time ( $R^2 = 0.117$ ;  $n = 74$ ;  $F = 9.502$ ;  $p = 0.003$ ).

Applying the significant regression equation the offset was generated at the date/time when the non-toxic underway system was switched on (13/10/2010 07:00 offset = -0.0012) and when switched off at the end of the cruise (22/11/2010 21:05 offset = -0.0087). The offset was applied for the period in-between by linear interpolation of these offsets through the BODC BUDS calibration routine (BODC ICALRF 6581).

## Salinity

The SBE45 salinity data were calibrated against bench salinometer data from samples collected from the underway system during the cruise. The data from the SBE45 TSG at the discrete sampling times were compared with the bench salinometer measurements. The salinity offsets (bench - TSG) were plotted against date/time and bench salinity and outliers identified. The relationships in the offset between TSG and bench salinometer were then compared to the date/time and the bench salinity in separate linear regressions. There was a significant relationship of offset with date/time ( $R^2 = 0.055$ ;  $n = 159$ ;  $F = 9.157$ ;  $p = 0.003$ ) but not bench salinity ( $R^2 = 0.006$ ;  $n = 159$ ;  $F = 0.950$ ;  $p = 0.331$ ).

Applying the significant equation from the date/time regression, the offset was generated at the date/time when the non-toxic underway system was switched on (13/10/2010 07:00 offset = 0.012) and when switched off at the end of the cruise (22/11/2010 21:05 offset = 0.003). The offset was applied for the period in-between by linear interpolation of these offsets through the BODC BUDS calibration routine (BODC ICALRF 6503).

## Fluorescence

The fluorometer voltage data were calibrated against extracted chlorophyll-a data from samples collected from the underway system during the cruise. Samples of seawater collected and extracted chlorophyll-a measurements made following Welschmeyer (1994). Each sample of 250 ml was filtered through a 47 mm 0.2  $\mu\text{m}$  polycarbonate filter. The filters were then placed in a vial with 10 ml 90% acetone and left in a freezer for 24 hours. The samples were then analysed on a pre-calibrated Turner Designs Trilogy fluorometer with a non-acidified chl module (CHL NA #046) fitted. The bench fluorometer calibration was checked against dilutions of pure chlorophyll stock during the cruise and no modifications to the calibration were necessary.

The raw voltage data from the fluorometer at the discrete sampling times were converted to nominal chl-a concentrations based on the manufacturer's calibration and these values were compared with the extracted chlorophyll-a measurements. The offsets (extracted chl-a - nominal chl-a) were plotted against date/time and extracted chlorophyll-a and outliers identified. Based on a preliminary calibration against extracted chl-a, which over stated the chlorophyll concentrations at the start of the cruise; it was decided to split the dataset for calibration. The calibration dataset was split into a number of sections to correct for different periods of drift in the sensor. These changes were related to different sections of the cruise where the non-toxic system had been turned off/on and/or cleaned.

Start	End	Calibration	N	R <sup>2</sup>	BODC ICALRF
13/10/2010 07:00	19/10/2010 21:22	CPHLUT01 = 0.1468 *CPHLUMTF + 0.0385	22	0.747	6514
19/10/2010 21:22	23/10/2010 15:00	Start offset = -0.3577 End offset = -0.1648	11	0.519	6516
23/10/2010 15:00	27/10/2010 00:55	Start offset = -0.1926 End offset = -0.3594	17	0.515	6517
27/10/2010 00:55	04/11/2010 10:00	Start offset = -0.1291 End offset = -0.3135	20	0.408	6518



04/11/2010 10:00	08/11/2010 07:30	Start offset = -0.1681 End offset = -0.5024	14	0.717	6519
08/11/2010 15:58	17/11/2010 19:00	Start offset = -0.0391 End offset = -0.1248	33	0.253	6520
17/11/2010 19:00	22/11/2010 21:05	CPHLUT01 = 0.4124 *CPHLUMTF - 0.2878	16	0.790	6515

## References

**Welschmeyer N.A., 1994.** Fluorometric analysis of chlorophyll-a in the presence of chlorophyll-b and phaeopigments. *Limnology and Oceanography*, 39:1985-1992.

## Screening

Each data channel was inspected on a graphics workstation using BODC screening software EDSERPLO and any spikes or periods of dubious data were flagged using BODC quality control flag system. Impossible values were checked carefully and flagged null only if believed to be genuine missing or bad data. EDSERPLO was used to carry out comparative screening checks between channels by overlaying data channels. A map of the cruise track was simultaneously displayed in order to take account of the oceanographic context.

## Data quality report

### Navigation and bathymetry (HQPLAT)

The navigation data have been through BODC quality control screening. The gaps of less than ten minutes have been filled by interpolation. Overall the navigation data for the cruise duration appear good.

The bathymetry channel has been flagged to remove the most obvious suspect data but for many periods the variation was large and frequent. The data became visibly noisier after 6th November 2010.

### Meteorology (HQMET)

The meteorology data have been through BODC quality control screening. Some intermittent flagging of data have been made. Overall the data for the cruise duration appear good. Additional notes are provided from the NMF technicians' report where anomalies in the data were apparent due to problems with the sensors during the cruise.

**Atmospheric pressure:** At 19:32 on 25th October there was a spike in the atmospheric pressure value and then an 8 millibar drop. There were further drops in the sensor's output during the day and at 21:27 on the same day the NMF technician noted the pressure sensor was reading 1001.2 millibar while the bridge's BATOS pressure sensor read 1009.2 millibar. Heavy rain prevented the met platform junction box from being opened for several days. When the rain stopped it was found that a connector above the pressure sensor had worked loose and rain water had dripped past the connector's gasket and onto the pressure sensor. The connector was tightened. The other pressure sensor was not on-board as it was being calibrated. Gradually the pressure sensor's reading approached a similar value to BATOS's but with high frequency noise of magnitude 0.3 to 0.4 millibar superimposed on it. There were also occasional steps away from the true value, e.g. between 13:55 and 15:10 on November 19th.

**Air temperature and humidity:** From 04:00 until 12:00 on 2nd November the temperature and humidity probe's data was incorrect. Heavy rain appeared to have got into the screen protecting the probe. After the rain had stopped, the probe quickly dried out and the data returned to normal. The met platform was

visited to check all of instruments between 13:20 and 13:35 on the same day resulting in spikes in the data. A repeat event happened between 03:42 and 06:20 on 21st November.

**Wind channels:** During the cruise the NMF technicians noted that for several days the processed true wind speed from the Surfmet and Level-C systems showed a decrease from the rest of the days' true wind speed when the ship was stopped on station. The met platform was visited and it was found that although the anemometer was situated above everything else on the met platform, when the wind came over the port bow, the search light and ocean colour monitoring experiment caused turbulence to the air flow that reduced the velocity of the wind passing through the anemometer. While the ship was steaming the wind came from a different angle and so the correct wind velocity was measured. At 10:55 on 29th October the anemometer was raised by 0.65 m in the hope that it would then be above the turbulence from other items on the met platform. No further drops in wind velocity were observed as the ship turned.

The relative wind speed and direction channels show natural variation and fluctuation but there were no values or trends that stood out as unrealistic. There were 'steps' in the channel but this is related to the vessel coming on to or leaving station. No additional flags were added. The absolute wind speed and direction channels were screened and a few spikes flagged suspect.

**Irradiance channels:** During the cruise the port and starboard PAR sensors were plotted with their calibration factors applied and there was a consistent difference between the two sensor values. On the 8th November the PAR sensors were swapped around with the spare sensor (sn 28560) for comparison. After applying each sensor's calibration factor it was found that sensor 28562 was under reading in comparison to the other 2 sensors by ~5%. At 11:05 on 10th November sensor 28560 replaced 28562 in the starboard PAR sensor position.

The data in the TIR and PAR channels did not require further flagging as it is unclear whether the variation is due to changing cloud cover etc.

## Sea surface hydrography (HQUWAY)

The underway log sheets were used as a guide to the times when the non-toxic flow was switched off, dropped low or was adjusted during the cruise. Where there was noise in the channel at these times the data were flagged suspect. If there was no noise or spiking the data remain unflagged.

The sample calibrations applied to the TSG salinity and hull sensor temperature channels appear reasonable and did not produce suspect data in the calibrated channels.

**Fluorometer:** During the cruise concern was raised at the fluorometer's lack of response to low magnitude changes that had been observed in the discrete surface underway samples as the track crossed the equatorial upwelling waters (voltage level ~ 0.11 volts in open ocean gyre waters and no increase through the upwelling waters where discrete sample concentrations increased from <0.1 mg m<sup>-3</sup> to 0.2-0.3 mg m<sup>-3</sup>). While data collection was stopped during the visit to Ascension Island on 8th November 2010, testing and cleaning of the transmissometer and fluorometer were carried out. Cleaning the fluorometer had little impact on the readings with MilliQ water (~0.14 volts before and after cleaning). At this stage it was noted that the fluorometer tubing was clear and possibly letting light into the sensor, affecting sensitivity for low level readings. Black tape was then added to the outlet tube of the fluorometer to prevent external light from entering the instrument. After the addition of the tape the voltage returned with MilliQ water passing through the sensor matched the calibration sheet value for MilliQ water (0.081 volts). All fluorometer data prior to this time may have been affected by this light pollution.

The calibrated fluorometer data exhibit large amounts of variability towards the end of the cruise in the southern Atlantic Ocean. The calibration in this area is not as closely matched to the sample data for this reason and for a few small periods the calibration results in values less than zero, which have been flagged suspect. Users should keep this in mind when using the sample calibrated fluorometer data.

**Attenuance and transmittance:** For the first few days there was noise in the transmissometer data that started whenever the ship stopped on station for a CTD cast. Initially there was concern that this was due

to a fault with the equipment and the transmissometer was stopped briefly at 11:35 on 18th October to replace instrument CST-1132PR with CST-1131PR. The problems continued and it was realized that bubbles were becoming trapped in the transmissometer. Logging was stopped again between 10:27 and 11:35 on 20th October; CST-1132PR was inserted again (since the calibration for sensor CST-1131PR was found to be out of date) and the plumbing set up was changed so that it remained mounted vertically but with water entering at the bottom of the transmission tube and leaving at the top, in the hope that any bubbles would travel out of the top of the transmission tube with the water exiting it. This was successful and noise was not seen again in the instrument.

## **Problem report**

### **Navigation and bathymetry**

Not applicable.

### **Meteorology**

Not applicable.

### **Sea surface hydrography**

Not applicable.