RRS Discovery

Cruise D376

Swansea to Southampton

FASTNEt Cruise to the Celtic Sea Shelf Edge

11th June to 1st July 2012

M.E. Inall et al.

A FASTNEt Cruise led by
The Scottish Association for Marine Science

Internal Report No. 277

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Summary

D376 was the first of two cruises under the NERC-funded Consortium grant FASTNEt (Fluxes A\wcross the Sloping Topography of the North East Atlantic). Sailing 11:00 BST on Monday 11th June 2012 from Swansea dry dock, D376 was a 19 day cruise to the Celtic Sea shelf edge, retuning to Southampton at 09:00 on Monday 2nd July 2012.

The scientific aims for D376 were three-fold: 1) A process study of the internal tide and its contribution to cross shelf exchange and vertical mixing, 2) An investigation of on-shelf intrusions of high-salinity water of oceanic origin, 3) deployment of long term platforms (Drifters and Gliders) for an investigation of the state of exchange at the shelf edge during the transition from summer-stratified to winter well-mixed conditions.

A series of summer storms tracked across the study area during the cruise. Despite this only about 48 hours were lost, and the cruise objectives were largely accomplished. Overall the cruise was a very good success.

1 Introduction

1.1 *Scientific Crew*

		Institution	Primary Activity
1	Mark Inall	SAMS	PS
2	Dmitry Aleynik	SAMS	Scanfish
3	Allan Audsley §	SAMS	Cruise Report
4	Estelle Dumont	SAMS	CTD
5	Colin Griffiths	SAMS	Moorings
6	Sam Jones *	SAMS	VMADCP
7	Marie Porter	SAMS	Drifters/LADCP
8	Joanne Hopkins	NOC	Moorings
9	Matthew Palmer	NOC	VMP/OMG
10	Terry Doyle	NOC	Landers
11	Juiliane Wihsgott §	NOC	OMG
12	Christopher Blafour	NOC	Gliders
13	Peter Hughes	Uni of Bangor	Moorings
14	Andrew Clegg ¤	Uni of Bangor	Moorings
15	Mattias Green	Uni of Bangor	VMP
16	Jess Mead ¤	Uni of Bangor	VMP
17	Holly Pelling	Uni of Bangor	VMP
18	Claire Mahaffey	Uni of Liverpool	Chemistry
19	Nealy Carr	Uni of Liverpool	Chemistry
20	*Hannah Whitby*	Uni of Liverpool	Chemistry
21	Mark Hebden	BODC	Data
22	Donal Griffin		Irish Observer

* PhD student, § Undergraduate student, ¤ MSc student

NMFSS Technicians

Martin Bridger	Robert Mclachlan
John Wynar	Thomas Roberts

Ship's Crew

Antonio Gatti	Master
Philip Gauld Chief	Officer
Alexander White	2nd Officer
Declan Marrow	3rd Officer
Ian Slater	Chief Engineer
Gordon Kincla	2nd Engineer
John Harnett	3rd Engineer
Edin Silajdzic	3rd Engineer
Emlyn Williams	ERPO
Stuart Cook	CPO (Deck)
Martin Harrison	CPO (Scientific)
Steve Duncan	PO
Mark Moore	Seaman
John Brodowski	Seaman
Steven Gallagher	Seaman
Richard Deal	Seaman
David Hartshorne	PCO
Peter Lynch	Chef
Dean Hope	Assistant Chef
Jacqueline Waterhouse	Steward

1.2 *Chronology*

Date	Julian Day		Location	Activity
11-Jun-12	162	Mon	Swansea	Under way
12-Jun-12	163	Tue	ST1	CTD/mooring
13-Jun-12	164	Wed	Line “A”	Moorings
14-Jun-12	165	Thu	Drifters	Run south
15-Jun-12	166	Fri		Poor weather
16-Jun-12	167	Sat	Line “A”	CTD/mooring
17-Jun-12	168	Sun	Jones Bank	Scanfish
18-Jun-12	169	Mon	ST3 / ST4	OMG / CTD
19-Jun-12	170	Tue	ST3 / ST4	Scanfish
20-Jun-12	171	Wed	ST3 / ST4	OMG / VMP
21-Jun-12	172	Thu	ST3 / ST4	VMP
22-Jun-12	173	Fri	LT1	Mooring/ CTD
23-Jun-12	174	Sat	LT1	Gliders/Scanfish
24-Jun-12	175	Sun	Line “C”	Gliders/CTD
25-Jun-12	176	Mon	Canyon	Gliders/Scanfish
26-Jun-12	177	Tue	ST3 / ST4	VMP
27-Jun-12	178	Wed	ST3 ST4	MSS/OMG
28-Jun-12	179	Thu	ST1, 2, 4	Moorings
29-Jun-12	180	Fri	ST5	Moorings
30-Jun-12	181	Sat	Jones Bank	Scanfish
01-Jul-12	182	Sun		Under way
02-Jul-12	183	Mon	Southampton	Dock

1.3 ***Cruise track***

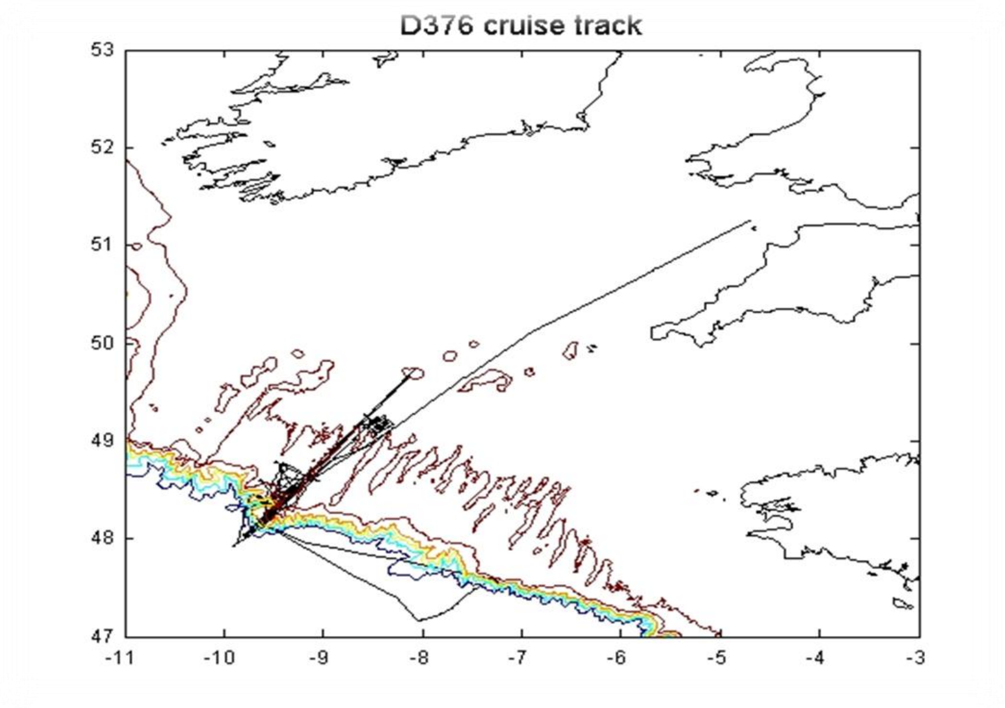

Figure 1.1 Cruise Track

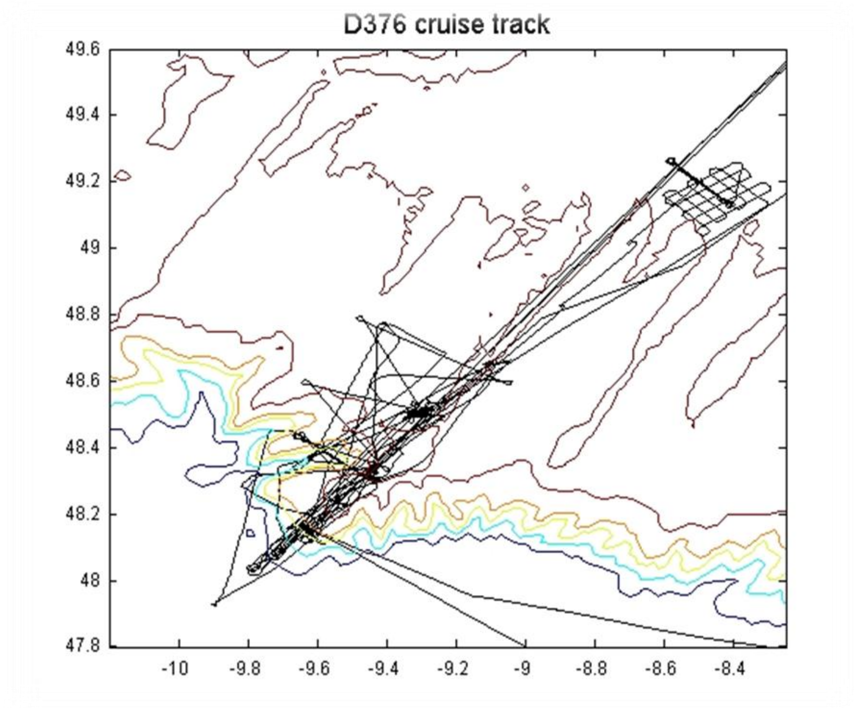

Figure 1.2 Cruise Track

1.4 *Sea surface temperature field*

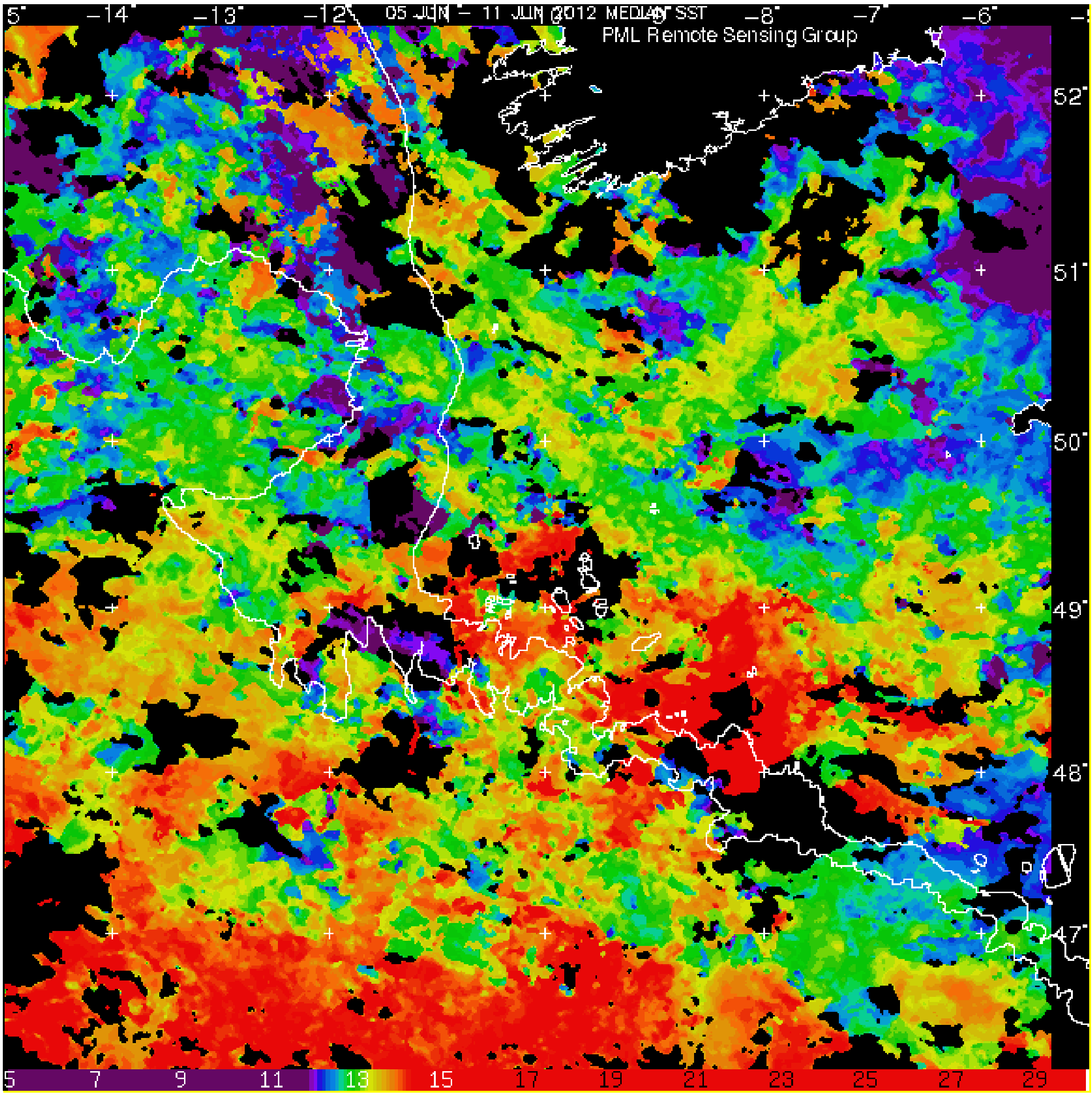

Figure 1.3: AVHRR image of the Celtic Sea showing a composite of sea surface temperature for the 7 day period to 11th June 2012. Satellite data were received and processed in near real time by the NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) at Dundee University and Plymouth Marine Laboratory (www.neodaas.ac.uk).

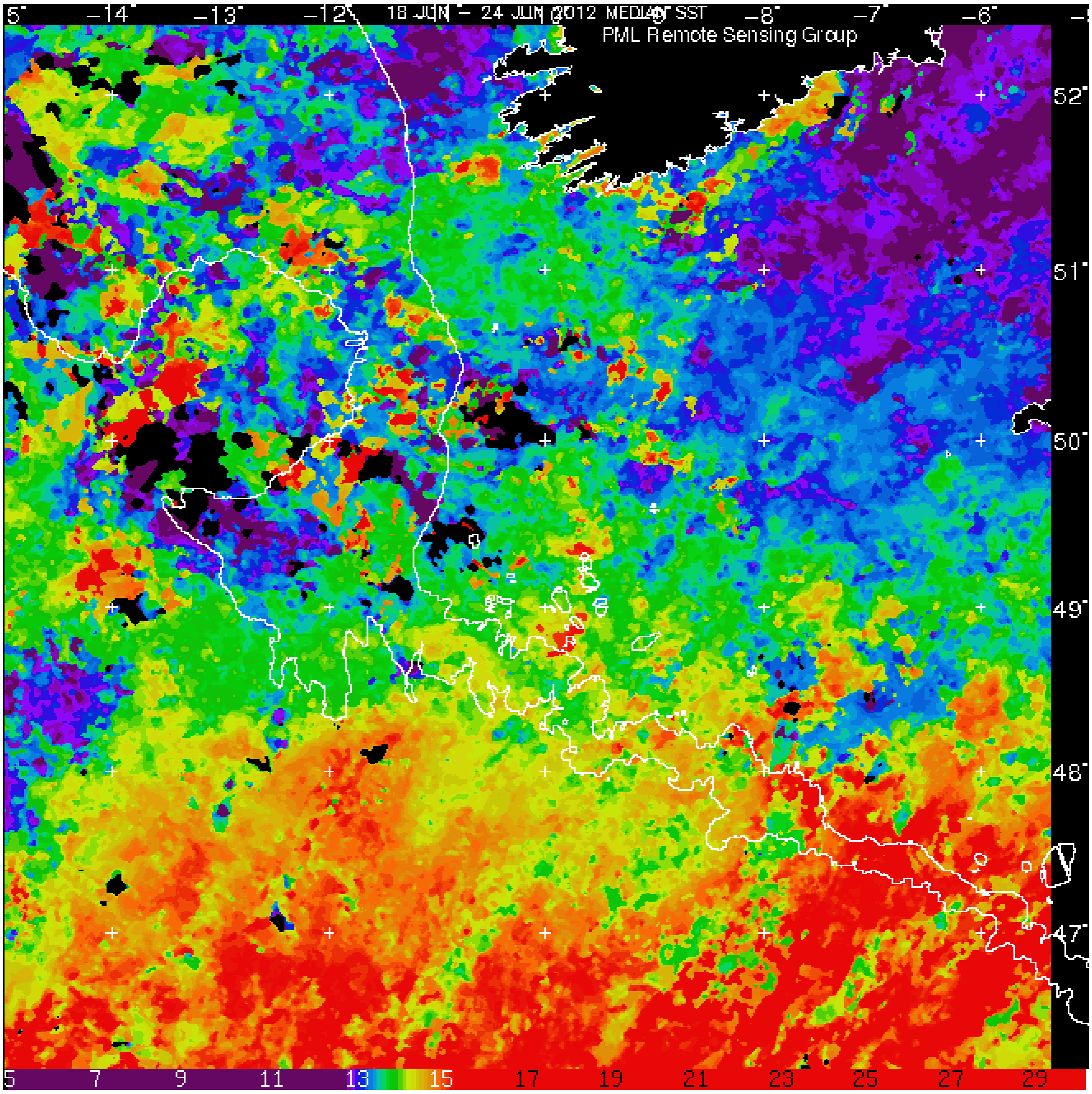

Figure 1.4: As for Figure 1.3, but for the seven day period to 24th June 20

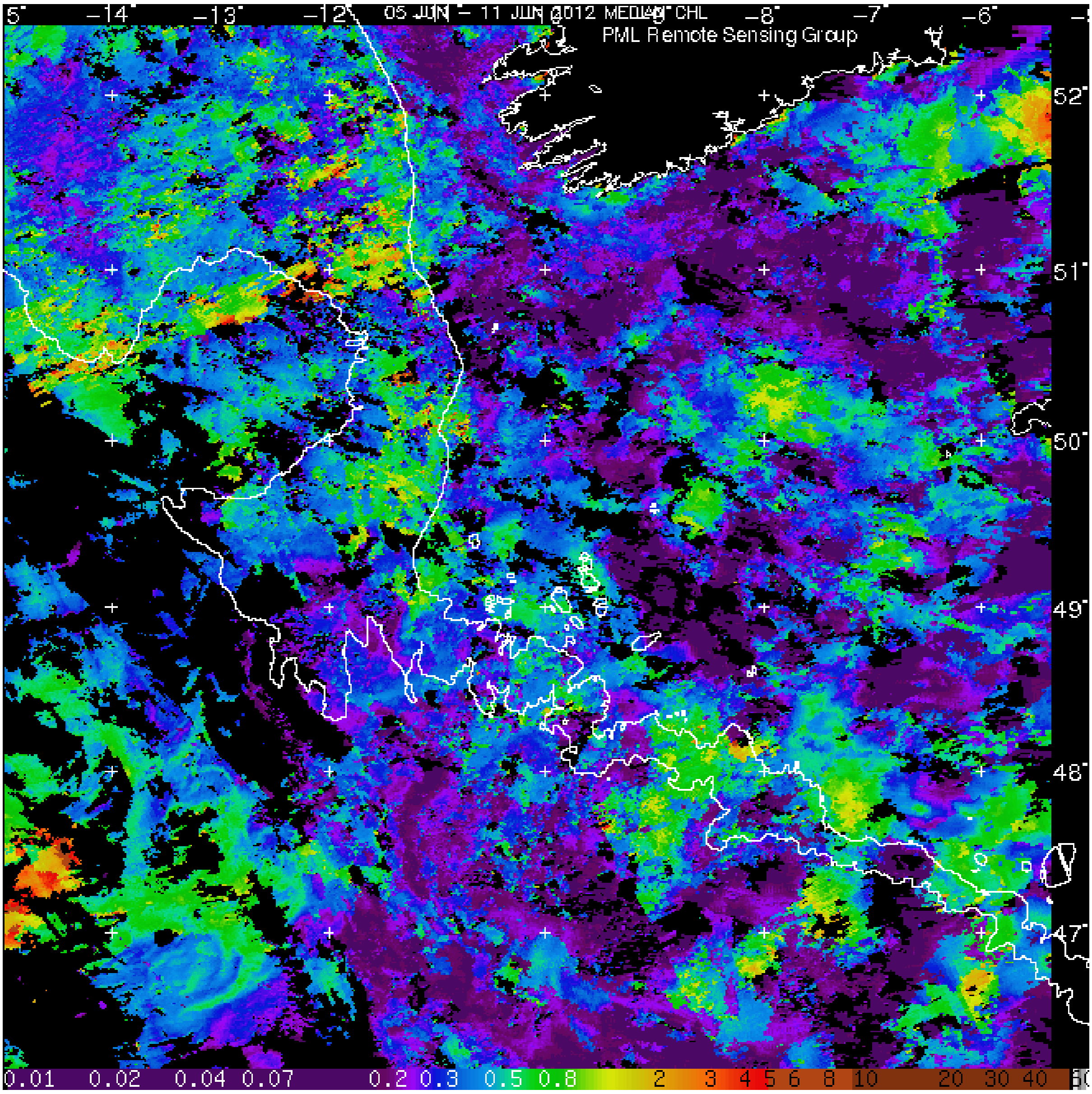

Figure 1.5: MODIS image of the Celtic Sea showing the sea surface chlorophyll *a* from a composite of the 7 day period to 11th June. Courtesy of PML Remote Sensing Group

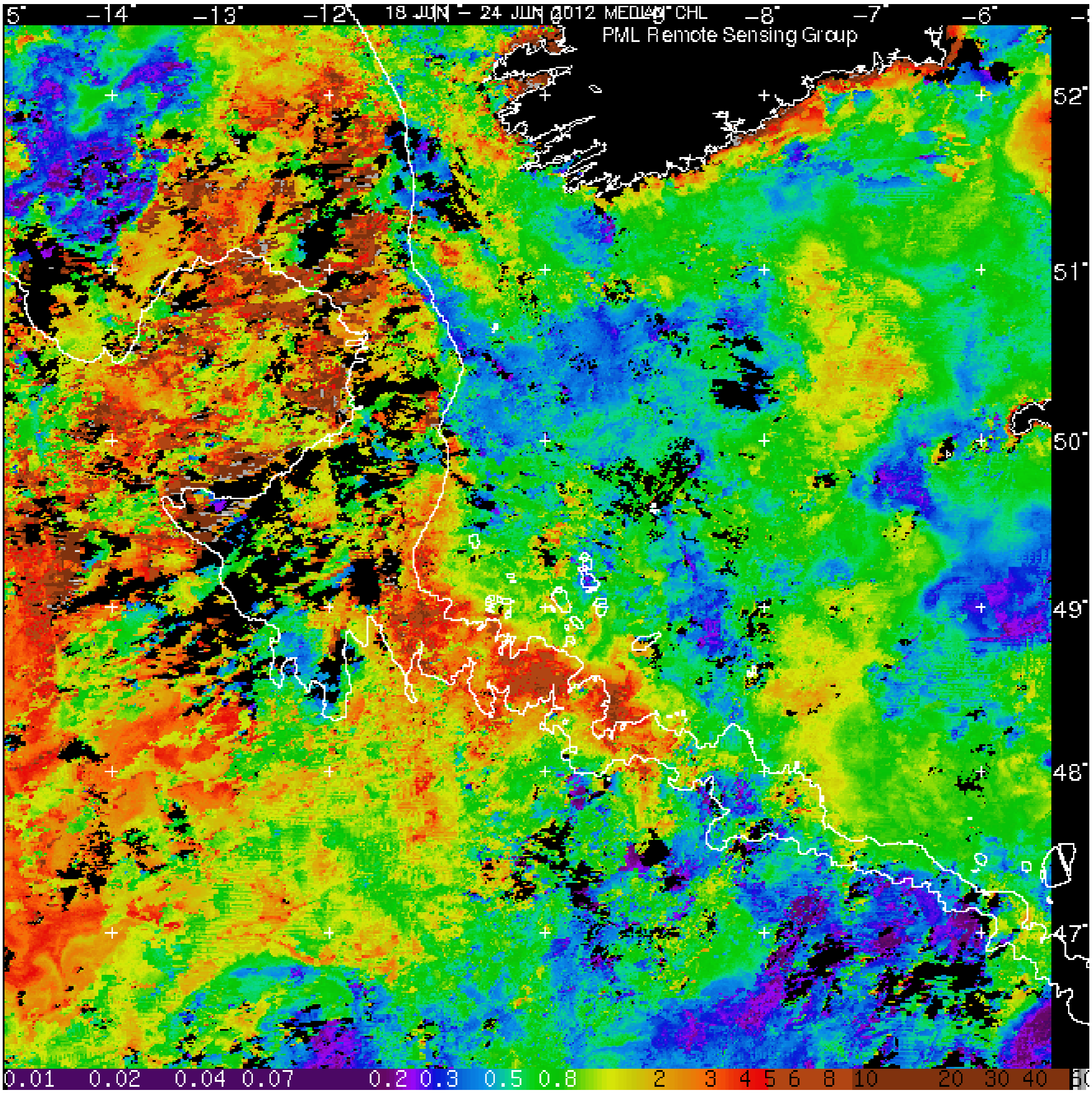

Figure 1.6: As for Figure 1.5, but for the seven day period to 24th June 2012

1.5 *Meteorological measurements*

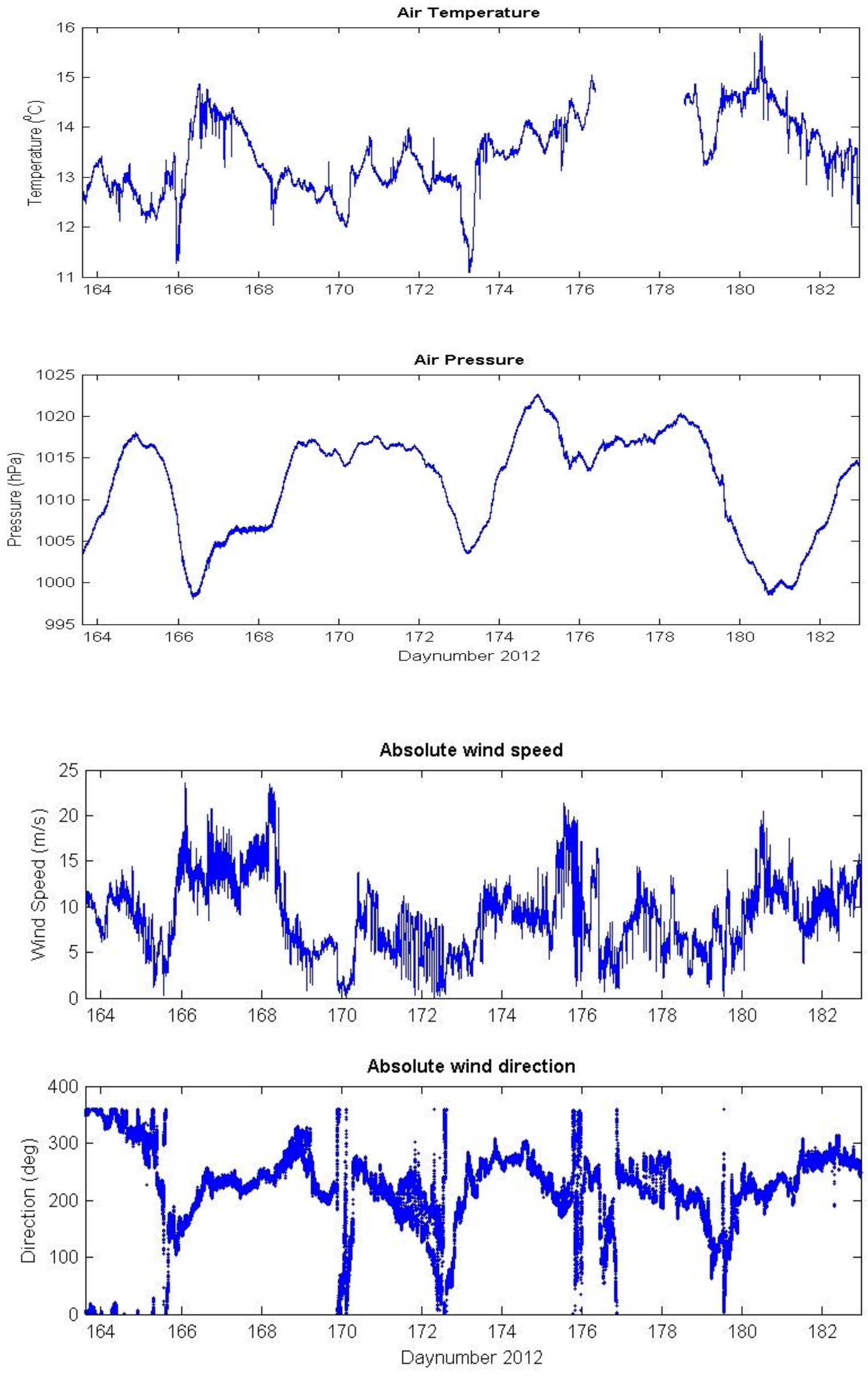

Figure 1.7 A summary of the meteorological measurements from the Surfmet logging system. For more details see section 14.

1.6 ***Sea surface observations***

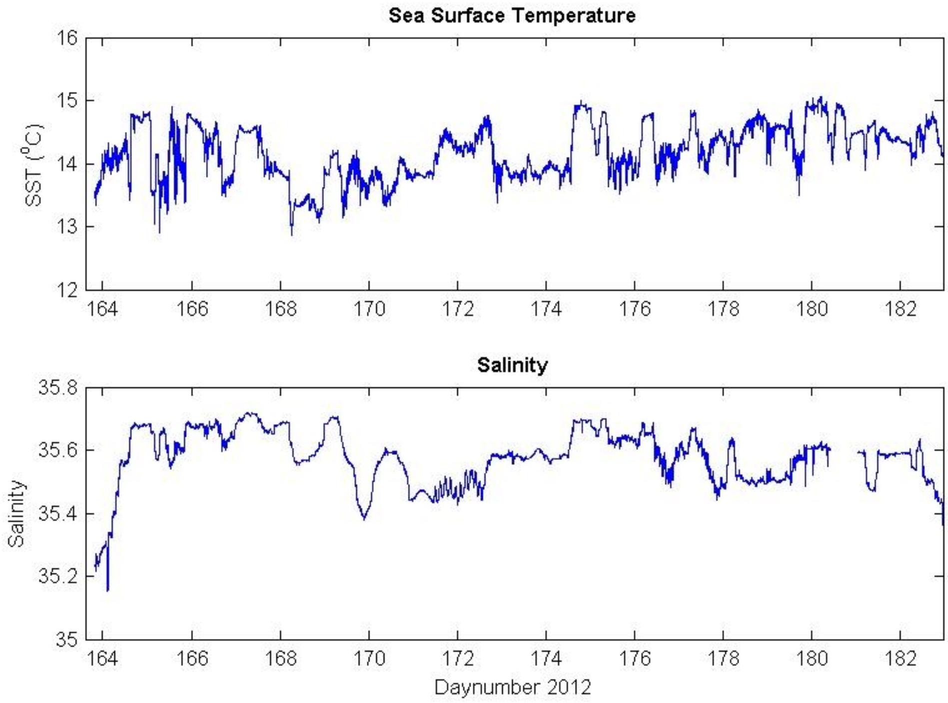

Figure 1.8. A summary of the oceanographic measurements from the Surfmet logging system. Gaps in the depth data are due to spike removal. For more details see section 14.

2 Narrative

Mark Inall, SAMS, PS

2.1 *Daily Diary*

All times in BST (UTC + 1)

Thursday 7th June:

Arrived Swansea 18:00, long drive round the docks to the Swansea Dry Dock Company. Discovery just refloated after steelwork repairs, and had to wait whilst she was secured and the gangway replaced. On board at 19:00. Light meal and an early night. Sea System guys arrived at ~21:00.

Friday 8th June:

Very strong winds tearing bits off the sheds beside Discovery over night! Certainly not summer. Setup office and stared to set up labs. NOCL contingent arrived mid-morning. Sea Systems and NOCL wagons unloaded. Not sure of sailing day/time yet. Provisional plan put out, but still many uncertainties. Forecast looking better for Monday/Tuesday! Last sea systems wagon loaded, ship re-supplied.

Saturday 9th June:

Mobbing all day. Sunny with wind dropping. Good day for laying concrete on the foredeck – which is exactly what happened.

Sunday 10th June:

Very busy day prepping all the mooring instruments. Everything looking good. Light rain, light winds. A few Scanfish questions resolved with a call to Liam Fernand (CEFAS); fluorimeter wired up and termination completed. Still some calibration issues outstanding.

Monday 11th June:

Depart Swansea dry dock 11:00, out of the gate and pilot off by 12:30 – on our way! 280nm to run to first station. Preparations continued during the day, making good progress at 12kn with the tide, slight swell. Underway sampling started, including VM Dopplers, and watches started at 12:00. Steaming through the night, wind increasing, long swell running with fresh wind-waves on top.

Tuesday 12th June:

Progress continuing at ~10kn to first station, ETA 16:00. Sea conditions slowly deteriorating, wind 4 to 5. Sounded over ST4, ST3 and ST2 en route to ST1 to give accurate depths for moorings. On station at 16:30. Started with a wire test to ~500m because the winches had not been used for several months. All OK. First CTD to 630m at ST1. Deck prepared for longest mooring at ST1 (target depth 693m), and successfully deployed before starting an overnight CTD section –Section “A”.

Wednesday 13th June:

Didn't manage to complete CTD Section "A" during the night, and had to break-off to be on site for a busy day of mooring deployments. First up was a single point mooring at ST2, then a steam to ST5 for a double deployment of ADCP lander and single point T/S mooring. Then back southeast to ST3 to deploy another ADCP lander, followed by the tricky WireWalker mooring, and attendant guard buoy (with Met sensors). Moorings all in by 20:45, and CTD section "A" resumed by 23:00 with the wind speed increasing steadily.

Thursday 14th June:

Wind touching 40 knots by 1am and the pressure still dropping. Had to break off after one CTD and run southeast away from the worst of the predicted severe gale. Headed for a position 100nm southeast of the study area, wind steady 40knots from the southwest all the way. By the evening we decided to deploy the drifter array at this SE location. All 20 drifters successfully deployed in the evening: each with a name on it, and the race, informed by realtime map display, was on! Seas remained too high to return to main study area.

Friday 15th June:

Very uncomfortable night for all on board. Awoke early to huge seas, but with wind dropping to 30 knots by breakfast. Started the long trek across the swell back to the northwest, in the hope of resuming science activities in the evening. Not looking too hopeful for the planned overnight CTD section though the medium to long term forecast looking nicely settled. No science done today.

Saturday 16th June:

Set off back to study into heavy seas, wind remained at 35knots most the way. Resumed science activities at after lunch with a CTD, then two mooring deployments - both wind and seas reduced. Picked up where we left off with CTD section "A" two days previously, managing to complete it by the small hours of Sunday.

Sunday 17th June:

Early start with Scanfish in much calmer and clearer conditions. Successful deployment at the start of a 26 hours line to Jones Bank and back. What a relief to be out of the stormy seas.

Monday 18th June:

Gliders – OMG (Ocean Mixing Glider). First ever deployment of turbulence-equipped Glider from a large vessel. All went pretty smoothly, although a freshening wind made keeping glider clear of the side of Discovery a little challenging. Incremental test dives all fault-free, and OMG sent on its way by mid-afternoon. Moved farther onto shelf with CTD stations hunting for salinity intrusions.

Tuesday 19th June:

Weather remaining calm and sunny. Repeat CTD profiling finished by midday, and Scanfish deployed for a marathon 28 hours of repeat sections followed directly by a lattice pattern. VMP and MSS preparations completed, ready for Wednesday. OMG Glider continued to operate well.

Wednesday 20th June:

Scanfish lattice pattern started in the small hours, continuing on until mid-afternoon. Weather – fresh breeze in the morning, then sunny spells with light winds. Text-book scanfish recovery, birthday cake for Estelle Dumont, and then off to the OMG site to start turbulence (VMP) profiling a couple of hours before mid-night.

Thursday 21st June:

VMP (vertical microstructure profiler) all day and all night. Weather conditions deteriorating during the day, but managed to continue profiling in the vicinity of the turbulence glider without need to recover the VMP. Excellent time series

Friday 22nd June:

Winds dropping through the morning, with even some glimpses of sunshine to greet tired workers at the end of the 38hour VMP time series at 1pm (BST). 32 nm steam to station LT1 to deploy the second of the long terms moorings – two 75kHz dopplers in 1500m water depth. Smooth deployment, followed by a repeat of CTD Section “A” with the first four stations occupied before breaking off to return to deep water for the first long term glider deployment.

Saturday 23rd June:

Civilised start with glider SN052 (“Bellamite”) launch after breakfast. Smooth handover from ship control to Southampton base station control after two shallow test dives. Steamed ‘up the line’ to ST3 from some Canyon hopping with Scanfish. Scanfish in the water and profiling on a 13hr repeat section across the top of a narrow gully at the top of Whittard canyon. As promised the weather duly deteriorated - gusting to force 9 at the time of writing this. Summer … what summer?

Sunday 24th June:

Scanfish recovered in the small hours in fairly poor conditions: conditions which were clearly too rough to deploy glider 052 at first light as planned. Plan B was pulled out again, and CTD Line “A” completed, and a new CTD Line “C” along the axis of the canyon then completed. Exhausted chemists sampled the whole lot!

Monday 25th:

Awoke to patchy fog, visibility about 100m, sometime less. Deployed glider 052 “Bellamite” without any problems. Fog not clearing, so no mooring recovery possible as planned (ST1 and ST2) – plan B again. This time a Scanfish zig zag from the canyon head, across the shelf passing close to all our shelf moorings. Fog remained all day, visibility varying from a few 10s to 100s of meters.

Tuesday 26th:

Awoke early to thick fog, less than 50m visibility. Again, for a second day, no mooring recoveries possible. Brought forward glider deployment, and start of second (neap tides) VMP session. Glider launch went without hitch. VMP stared at mid-day and programmed through until Wednesday early afternoon, after which we must begin mooring recovery, fog or no fog.

Wednesday 27th June:

A rude awakening for the PS at 3am with VMP termination problems, back-up MSS90 profiler system deployed and resumed the time series until shortly after midday. Good weather conditions persisted all day allowing us to recover the turbulence glider, with an improbably but highly successful net arrangement. We then managed to recover all three moorings at ST3 (Wirewalker, lander and Toroid) with some minor damage to the met sensors on the toroid. Two CTDs overnight brought us early to ST1 for a day of mooring recovery.

Thursday 28th June:

Single point mooring at in 700m ST1 recovered first, followed by a short steam (over breakfast) to ST2. Single point mooring recovered at ST2. Wind starting to strengthen as forecast during the 3 hour steam to ST4. Single point pellets in view on the surface, so recovered that one first. Winds rising to force 7 and seas becoming marginal for mooring recoveries, but lander frame recovered without problems. A busy day closed with a slow steam in heavy seas to the canyon station C3 to commence a 13 hours repeat CTD station. On arrival at C3 swell was too heavy to deploy the CTD, so activities were suspended.

Friday 29th June:

Slow and uncomfortable steam to ST5 through an awkward swell. Picked up a tangled ST5 single point mooring, losing one temperature logger during hauling. Lander/ADCP recovered directly afterwards, and steamed back to C3 with all moorings recovered and only one instrument lost in the whole operation – very successful!

2.2 ***Watch keepers***

A standard watch keeping system of 4h on, 8h off was maintained by the scientific staff throughout the cruise.

Watch	**CTD/Scanfish**	**VMP**
8 to 12	Colin Griffiths *	Mattias Green *
	Allan Audsley	Jess Mead
	Robert Mclachlan**	Peter Hughes
12 to 4	Estelle Dumont*	Holly Pelling *
	Terence Doyle	Joanne Hopkins
	Mark Hebden	Juliane Wihsgott
	Martin Bridger**	
4 to 8	Marie Porter *	Mathew Palmer*
	Dmitry Aleynik	Donal Griffin
	Sam Jones	Andrew Clegg
	John Wynar **	

* Watch leader   ** NMF Sea Systems

3 NMFSS Sensors and Moorings CTD Report

Estelle Dumont, SAMS, John Wynar, NOC

3.1 *CTD System Configuration*

The initial sensor configuration for the stainless steel (s/s) system was as follows:

- Sea-Bird 9*plus* underwater unit, s/n: 09P-1082
- Frequency 0 - Sea-Bird 3 Premium temperature sensor, s/n: 03P- 4116
- Frequency 1 - Sea-Bird 4 conductivity sensor, s/n: 04C-2841
- Frequency 2 - Digiquartz temperature compensated pressure sensor, s/n: 121341
- Frequency 3 - Sea-Bird 3 Premium temperature sensor, s/n: 03P - 4872
- Frequency 4 - Sea-Bird 4 conductivity sensor, s/n: 04C-3258
- V0 - Sea-Bird 43 dissolved oxygen sensor, s/n: 43-0709
- V2 - WETLabs turbidity sensor, s/n: BBRTD-167
- V3 - Benthos PSA-916T 7Hz altimeter, s/n: 874
- V6 - Chelsea Alphatracka MKII transmissometer, s/n: 161050
- V7 - Chelsea Aquatracka MKIII fluorometer, s/n: 088-2615

Ancillary instruments & components:

- Sea-Bird 11*plus* deck unit, s/n: 11P-34173-0676
- Sea-Bird 24-position Carousel, s/n: 32- 0518
- 24 x Ocean Test Equipment 10L water samplers, s/n: 1 through 24

3.2 *CTD Operations*

There were 61 CTD casts made in total. Casts 46 – 59 inclusive were part of a “yo-yo” time series (although the CTD was landed on deck after each cast while the ship re-positioned) without water samplers. Log sheets were scanned and included with the data from this cruise.

For the s/s system, the pressure sensor was located 30cm below the bottom and approximately 75cm below the center of the 10L water sampling bottles. The configuration file used was D376_NMEA.xmlcon for cast 1 only and D376_NMEA_1.xmlcon for all subsequent casts.

Sensor Failures

During the first cast a large discrepancy in measured values was noted between the two temperature sensors. On the basis that the secondary sensor mounted on the vane is more exposed and hence more likely to be damaged, it was that sensor which was replaced. This did in fact turn out to be the case as on the next cast the two temperature sensors were in close agreement. Therefore for the first cast only T2 s/n: 4872 was used; subsequently T2, s/n: 2919 replaced it from cast 2 onwards.

3.3 *Data Processing*

CTD cast data was post-processed routinely by a member of the scientific personnel in accordance with the guidelines and with the agreement of the BODC staff member on board.

3.4 *Salinity measurement*

A Guildline Autosal 8400B salinometer, s/n: 60839, was used for salinity measurements. The salinometer was situated in the Constant Temperature Lab, with the bath temperature set at 24°C, the ambient temperature being approximately 23°C. A bespoke program written in Labview called “Autosal” was used as the data recording program for salinity values.

In general, a scientist was given the responsibility of taking a salinity sample from each water sampler and making the measurements. Hence detailed results on salinity are given elsewhere in the cruise report.

3.5 *TRDI LADCP Configuration*

Initially the TRDI WHM 300kHz LADCP deployed was unit s/n: 4275 and installed in a downward-looking orientation on the s/s CTD frame. Analysis of each profile showed that beam 1 was weak and completely failed after cast 4. The unit was then replaced with another WHM 300kHz s/n: 12919.

Battery voltage could not be monitored as the cable was diode protected. The instrument was configured to ping as fast as possible, use 27 bins, a blanking distance of 1.76m and a bin size of 4m thus yielding a range of approximately 108m after the blanking distance. The ambiguity velocity was set to 175 cms^{-1} and pings per ensemble to 1.

Built-in pre-deployment tests *(PA, PC2 and PT200)* were run before each cast, and then the following command file sent *(F2)*:

Master command file:

```
>CR1
>CF11101
>EA00000
>EB00000
>ED00000
>ES35
>EX11111
>EZ0111111
>TE00:00:05.00
>TP00:00.00
>WM15
>LD111100000
>LF176
>LN27
>LP1
>LS400
>LV175
>LJ1
>LW1
>LZ30,220
>SM1
>SA001
>SI0
>SW0
>CK
>CS
```

3.6 ***Deployment Comments***

Each deployment BBtalk terminal session was logged to a file (*F3)* of the form: *D376_XX.txt*, where *XX* is the CTD cast number. Downloaded data files were re-named to be of the form: *D376_XXm.000*.
The real-time clock of the LADCP was checked prior to deployment *(TS?)* and re-synchronised with the ship's GPS clock if it was more than a few seconds in error. The time difference (if any) was written on the log sheet.

Paper log sheets were used for all casts (and scanned for electronic storage), the LADCP file number being defined by the CTD cast number.

3.6.1 Scanfish

The Scanfish used was a borrowed unit from CEFAS and was instrumented with a Hardt flurometer, a GMI CTD and a FSI CTD. No calibration information was provided at the time although it is hoped that a post-cruise calibration will be carried out in the near future. There were 5 Scanfish transects run in total, the instrument operating satisfactorily during each one.

The FSI CTD software was sometimes problematic, however. For instance, during the third tow no navigation data was recorded although terminal software showed that it was available at the serial port of the logging computer. A re-termination of the tow cable was necessary after the second transect due to water ingress.

4 CTD report

Estelle Dumont, SAMS ; John Wynar, NOCS.

Figure 4.1: SBE911+ CTD package by Colin Griffiths, SAMS.

4.1 *CTD System Configuration*

The initial sensor configuration for the stainless steel (s/s) system was as follows:

- Sea-Bird 9*plus* underwater unit, s/n: 09P-1082
- Frequency 0 - Sea-Bird 3 Premium temperature sensor, s/n: 03P- 4116
- Frequency 1 - Sea-Bird 4 conductivity sensor, s/n: 04C-2841

- Frequency 2 - Digiquartz temperature compensated pressure sensor, s/n: 121341
- Frequency 3 - Sea-Bird 3 Premium temperature sensor, s/n: 03P - 4872
- Frequency 4 - Sea-Bird 4 conductivity sensor, s/n: 04C-3258
- V0 - Sea-Bird 43 dissolved oxygen sensor, s/n: 43-0709
- V2 - WETLabs turbidity sensor, s/n: BBRTD-167
- V3 - Benthos PSA-916T 7Hz altimeter, s/n: 874
- V6 - Chelsea Alphatracka MKII transmissometer, s/n: 161050
- V7 - Chelsea Aquatracka MKIII fluorometer, s/n: 088-2615

Ancillary instruments & components:

- Sea-Bird 11*plus* deck unit, s/n: 11P-34173-0676
- Sea-Bird 24-position Carousel, s/n: 32- 0518
- 24 x Ocean Test Equipment 10L water samplers, s/n: 1 through 24

For the full configuration and sensors calibration information please see the CTD technical report in annex.

4.2 *CTD Operations*

There were 61 CTD casts made in total. Casts 46 – 59 inclusive were part of a “yo-yo” time series (although the CTD was landed on deck after each cast while the ship re-positioned) without water samplers.

The system was deployed from the CTD winch on the starboard side. The usual procedure was to first lower the CTD to around 10m deep for the pumps to switch on. The system was then brought back up to the surface before starting the cast. The Niskin bottles were fired on the way up, and the CTD package was stopped for at least 30 seconds before firing to allow the sensors to settle.

For the s/s system, the pressure sensor was located 30cm below the bottom and approximately 75cm below the center of the 10L water sampling bottles. The configuration file used was D376_NMEA.xmlcon (see section 18). for cast 1 only and D376_NMEA_1.xmlcon for all subsequent casts.

Sensor Failures

During the first cast a large discrepancy in measured values was noted between the two temperature sensors. On the basis that the secondary sensor mounted on the vane is more exposed and hence more likely to be damaged, it was that sensor which was replaced. This did in fact turn out to be the case as on the next cast the two temperature sensors were in close agreement. Therefore for the first cast only T2 s/n: 4872 was used; subsequently T2 s/n: 2919 replaced it from cast 2 onwards.

4.3 *Data processing*

The CTD data were processed according the standards described in the SAMS CTD data Processing Protocol (Dumont and Sherwin, 2008, SAMS internal report No 257), using Seabird Data Processing version 7.21f and Matlab R2012a. The processing steps were:

- Step 1(SBE Data Processing, batch processing): modules Data Conversion, Wild Edit, Align CTD, Cell Thermal Mass, Filter, Derive, Translate and Bottle Sum.
- Step 2 (Matlab): despiking of the 24Hz data
- Step 3 (SBE Data Processing, batch processing): modules Ascii In,, Bin Average (2db-bins) and Ascii Out
- Step 4 (Matlab): plot of the data
- Step 5 (Matlab): calibration of oxygen and salinity data on both 24Hz and 2db-bin averaged datasets (post-cruise).

4.4 *Raw data processing (SBEDataProcessing)*

Data Conversion converted raw data from engineering units to binary .cnv files and produced the .ros files. Variables exported were scan number, pump status, julian day, latitude, longitude, pressure [db], depth [m], temperature0 [ITS-90, deg C], conductivity0 [mS/cm], temperature1 [ITS-90, deg C], conductivity1 [mS/cm], oxygen [mg/l], altimeter [m], fluorescence [µg/l], beam transmission [%],beam attenuation [1/m] and turbidity [m^{-1}/sr].

Please note:
The primary TC sensors were labelled 0, secondary 1.
The depth exported here was only for indicative purposes in the bottle files. Accurate depth calculation was performed at the Derive stage, and this first depth removed in processed files.

Wild Edit detected and removed the major spikes in the data. Wild Edit's algorithm requires two passes through the data: the first pass removed data points over 2 standard deviations of a 100 scans average, while the second pass removed the data over 20 standard deviations of a 100 scans average.

AlignCTD was then run to compensate for sensor time-lag.
Both conductivities were automatically advanced by **0.073s** by the deck unit. Some negative spikes in the primary salinity data were observed indicating that the temperature lagged conductivity, i.e. either the conductivity has been advanced too much, either the temperature needed to be advanced. Given that the conductivity was aligned as recommended by Seabird it was assumed that the misalignment was probably due to a slow response form the primary temperature sensor. Several offsets were tested on a subset of the data, and a value of **+0.03s** gave the best results in correcting the problem. That offset was applied to the primary temperature on all casts.

The oxygen sensor response was advanced relative to pressure by **+4s**. This value was found to give the best results after testing several offsets on a subset of the data. This offset ensures that calculations of dissolved oxygen concentration are made using measurements from the same parcel of water.

In **Cell Thermal Mass**, a recursive filter was run to remove conductivity cell thermal mass effects from the measured conductivity. The constants used were the ones recommended by Seabird: thermal anomaly amplitude α=0.03 and thermal anomaly time constant 1/β=7.

Filter applied a low-pass filter (value of 0.2) on the pressure and depth data, which smoothed the high frequency (rapidly changing) data. To produce zero phase (no time shift), the filter was first run forward through the data and then run backward through the data. This removed any delays caused by the filter.

At the **Derive** stage, twin salinities (psu), twin densities sigma-theta (kg/m3) and depth (m) were calculated.

The data was converted from binary to ASCII format by the module **Translate**. The data had been kept in binary format up to this stage to avoid any loss in precision that could occur when converting to Ascii.

Finally, the module **BottleSum** created the ASCII bottle files (.btl) from the .ros files, for each bottle fired during a cast. These files contain mean, standard deviation, maximum and minimum values for all variables (average of 48 scans, i.e. 2s).

4.4.1 Despiking (Matlab)

The pressure, oxygen, temperature (primary and secondary) and salinity (primary and secondary) data were manually despiked. Any data recorded while the pumps were not on were deleted at this stage.

Notes on the despiking:
- When a spike occurred in the pressure, primary temperature or primary salinity data, making that/those point(s) flagged as bad, the whole corresponding scan has been deleted.
- When a spike occurred in the oxygen data, making that point flagged as bad, the erroneous value was set to NaN, and other variables of the scan (i.e. temperature, salinity, etc.) were kept in the dataset (if not flagged as bad themselves).
- When a spike occurred in the secondary temperature or secondary salinity data, making that/those point(s) flagged as bad, the secondary temperature, conductivity, salinity and density values were set to NaN, and other variables of the scan (i.e. primary temperature, primary salinity, etc.) were kept in the dataset (if not flagged as bad themselves).

4.4.2 Averaging (SBEDataProcessing)

After going through Matlab, the data files needed to be re-formatted to be recognised by SBE Data Processing. **ASCII In** added a header to the input .asc file and output a .cnv file (XXX_2.cnv).
The module **Bin Average** averaged the 24Hz data into 2db-bins, using the downcast data only.
Ascii Out output the bin-averaged data files as ASCII (with a simplified header).

4.4.3 Datafiles

The different types of files created are (example of cast no. 01):
d376_01_1.cnv : non-despiked, non-calibrated 24Hz data
d376_01_2.asc : despiked, non-calibrated 24Hz data
d376_01_2_2db.asc : despiked, non-calibrated 2db-bin averaged data
d376_01_3.asc : despiked 24Hz data, oxygen, primary and secondary salinities calibrated
d376_01.CTD: despiked 2db-bin averaged data (WOCE format conventions), oxygen and salinity calibrated
d376_01.btl : bottle data file, non-calibrated
d376_01.hdr : header file, detailing the data processing

4.5 *Data calibration*

4.5.1 Salinity calibration

Throughout the cruise the CTD was sampled for salinity measurements, in order to calibrate the conductivity sensors. Salinity was measured using a Guideline Autosal8400, s/n 60839 in a temperature-controlled room on-board the ship. The CTD data used for calibration comes from the .btl files (created by the Seabird software).

Due to the numerous operators and the varying degrees of experience using the salinometer, the Autosal was standardised only at the start of the cruise, and once in the middle of the cruise. For all the other runs a standard seawater sample was measured at the beginning and end of each crate (24 samples) and results recorded to allow for manual correction of the salinometer drift. The standard sweater ampoules used were from batch P153, with a double conductivity ratio of 1.999580. The readings (double conductivity ratio) and derived offsets for each crate are summarised in table 2. The calculated offsets (last column in Table 4.2) were then applied to each crate's Autosal data.

Table 4.2: Standard Seawater (SSW) measurements at the beginning and end of each crate. Readings marked in red appeared to be outliers (probably due to insufficient flushing of the cell prior to measurements) and were removed from the final offset calculation (last column).

Date	**Time**	**Crate**	Read 1	Read 2	Read 3	Raw average	**Despiked**	**Offset (SSW – avg**	**Avg offset for each**
27/06/12	12:05	Start 11	standardised - no readings recorded					0.000002	
27/06/12	13:09	End 11	1.999626	1.999625	1.999612	1.999621	**1.999621**	-0.000041	**-0.000020**
27/06/12	13:09	Start 17	1.999626	1.999625	1.999612	1.999621	**1.999621**	-0.000041	
27/06/12	14:15	End 17	1.999623	1.999626	1.999647	1.999632	**1.999632**	-0.000052	**-0.000047**
28/06/12	18:45	Start 901	1.999570	1.999590	1.999580	1.999580	**1.999580**	0.000000	
28/06/12	21:23	End 901	1.999596	1.999634	1.999561	1.999597	**1.999597**	-0.000017	**-0.000008**
29/06/12	05:28	Start 21	standardised - no readings recorded					0.000009	
29/06/12	06:39	End 21	1.999579	1.999614	1.999608	1.999600	**1.999600**	-0.000020	**-0.000006**
29/06/12	06:39	Start 19	1.999579	1.999614	1.999608	1.999600	**1.999600**	-0.000020	
29/06/12	08:01	End 19	1.999609	1.999602	1.999613	1.999608	**1.999608**	-0.000028	**-0.000024**
29/06/12	13:10	Start 12	1.999544	1.999603	1.999533	1.999560	**1.999560**	0.000020	
29/06/12	15:22	End 12	1.999627	1.999624	1.999625	1.999625	**1.999625**	-0.000045	**-0.000013**
29/06/12	21:45	Start 903	1.999590	1.999572	1.999586	1.999583	**1.999583**	-0.000003	
29/06/12	23:39	End 903	1.999606	1.999558	1.999552	1.999572	**1.999555**	0.000025	**0.000011**
30/06/12	16:14	Start 97-120	1.999617	1.999614	1.999604	1.999612	**1.999612**	-0.000032	
30/06/12	17:52	End 97-120	1.999612	1.999627	1.999594	1.999611	**1.999611**	-0.000031	**-0.000031**
30/06/12	18:26	Start 22	1.999547	1.999616	1.999635	1.999599	**1.999626**	-0.000046	
30/06/12	20:19	End 22	1.999605	1.999573	1.999578	1.999585	**1.999585**	-0.000005	**-0.000025**
02/07/12	12:02	Start 1	1.999511	1.999551	1.999552	1.999538	**1.999552**	0.000028	
02/07/12	13:21	End 1	1.999588	1.999594	1.999559	1.999580	**1.999580**	0.000000	**0.000014**
02/07/12	13:28	Start 18	1.999574	1.999580	1.999554	1.999569	**1.999569**	0.000011	
02/07/12	15:33	End 18	1.999581	1.999597	1.999619	1.999599	**1.999599**	-0.000019	**-0.000004**

A total of 167 salinity samples were collected and analysed, including a few duplicate samples. Six of these samples were taken on cast 001, which had a faulty secondary temperature sensor, and were not included in the calibration data for the secondary salinity. There was some uncertainty over one sample (unclear which bottle had been sample) and this point was removed from the dataset. The Autosal and the Seabird values were in very good agreement, there were no outliers removed. Calibration equations are shown in Figure 3 and 4.

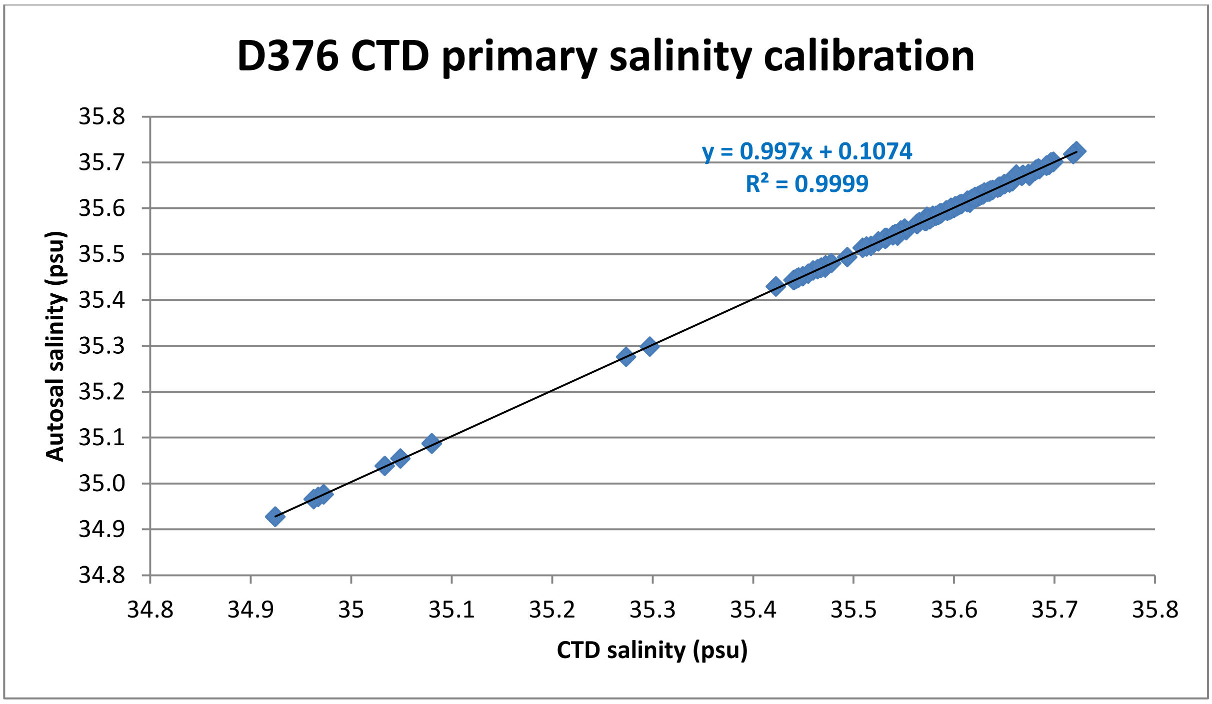

Figure 4.3: CTD primary salinity calibration data

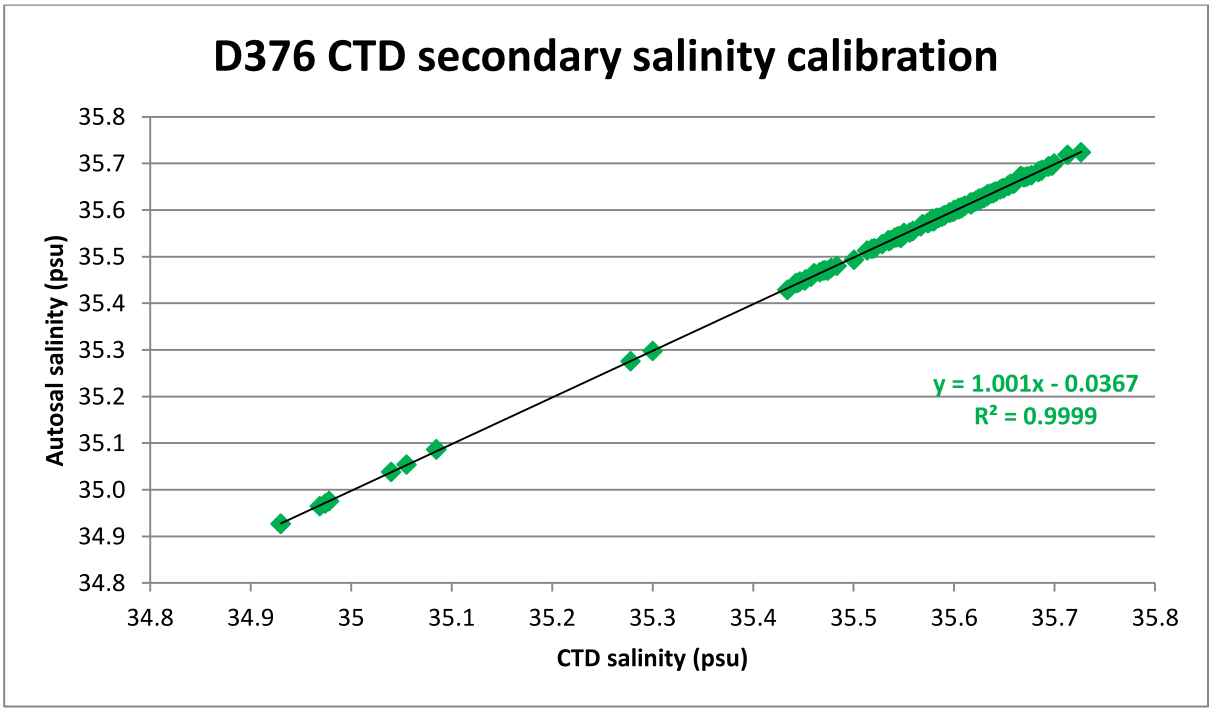

Figure 4.4: CTD secondary salinity calibration data

4.5.2 Dissolved Oxygen calibration

For the methodology refer to section 7.7.2.

In total, 149 samples were collected to calibrate the dissolved oxygen sensor on the CTD. Some of the discrete sampling data showed a large difference with the CTD readings (up to 3.1mg/l difference), and did not produce a satisfactory calibration. On three particular casts (3, 4 and 29) all of the samples showed very large differences to the CTD readings. The CTD oxygen profiles on those casts appear normal, which indicates that there may have been some issue during the sampling and / or titration of the samples for these particular casts. It was decided to remove all points with a difference over 0.5 mg/l (52 points), which for the most part (69%) belonged to the 3 casts mentioned above. The final calibration data is shown in Figure 4.5.

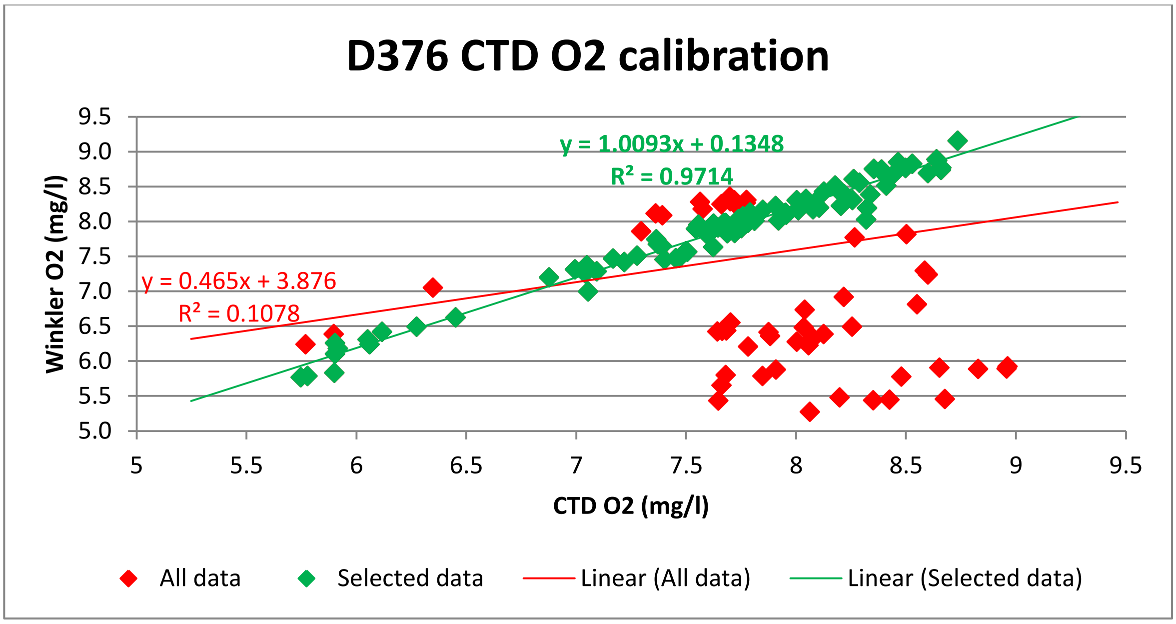

Figure 4.5: CTD O_2 calibration data and equation. Full dataset in red, selected data only in green. Final calibration data in green.

To follow WOCE data format conventions, the calibrated O_2 values in the final datafiles have been converted from mg/l to µmol/kg using the formula:
[µmol/Kg] = (([mg/L] / 1.42903) * 44660) / (sigma_theta + 1000)

4.5.3 Fluorometer calibration

Please note that the fluorescence data has not been calibrated in the final dataset. Users wishing to calibrate the data should refer to the chlorophyll discrete sampling data (see section 7.7.3).

4.5.4 Comments

Some large spikes were observed in the data from both CT sensors (and therefore in the salinity and density data), predominantly in the thermocline area. See example on figure 6 below. This issue has already been observed on previous cruises (e.g. CD173, D340, D352). A possible explanation was described in the D352 cruise report: “The spikes appear to be associated with a decrease in the decent rate of the CTD package and are therefore likely associated with inefficient flushing of the CTD package […]. As the veer rate on the winch slows ‘old’ water is pushed back passed the sensors out the base of the rosette. As the rate of decent increases again ‘new’ water is flushed back passed the sensors.”

The WildEdit and LoopEdit routines proved inefficient in removing those spikes, therefore they were removed manually in the Matlab despiking routine. This explains the sometimes irregular data interval observed on the 24Hz dataset. For the bin-averaged data, the Seabird software interpolates any missing values, and data users should therefore use caution when interpreting the data. For more details on the interpolating routine see SBE Data Processing manual (http://www.seabird.com/software/sbedataprocforwindowsdetails.htm).

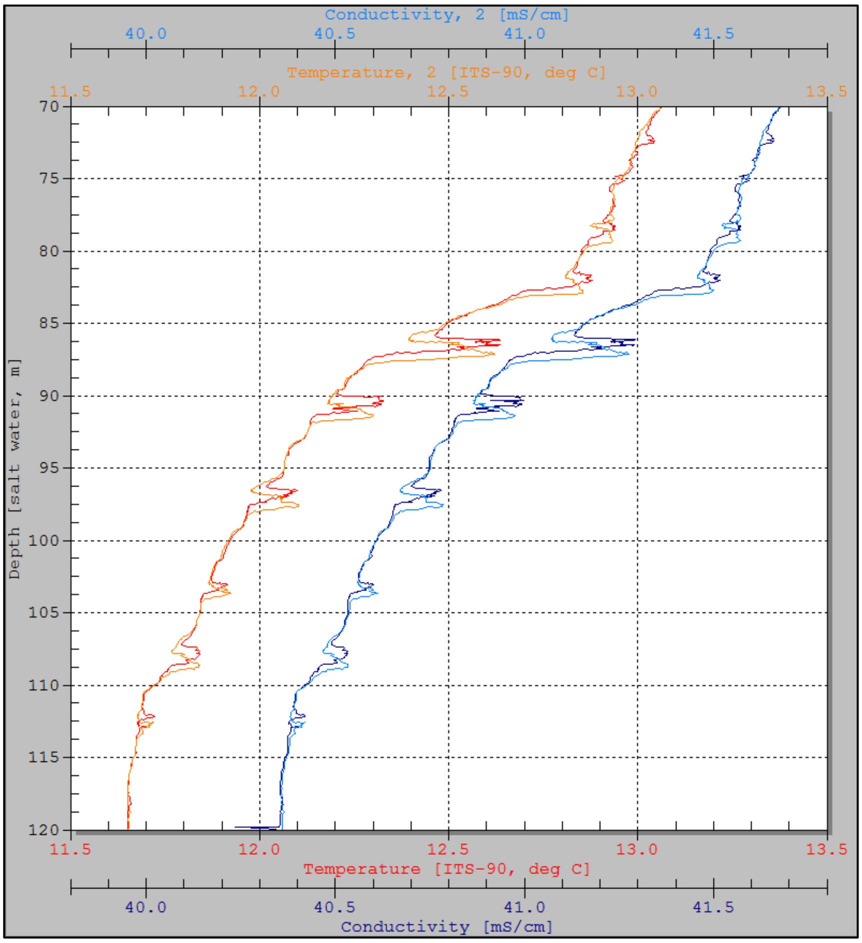

Figure 4.6: Typical spiking observed on CT sensors in the thermocline area (example from cast 8)

Additionally, the CT data on the upcast seemed particularly noisy and delayed in the thermocline and surface layers. The linear interpolation done by the Seabird bin-averaging routine, combined with the heavy data despiking described above results in some erroneous values in places. Data users are advised to use only the downcast data for CT readings and other related parameters (salinity, density, and oxygen). However, the sensors readings at the time of bottle firings should be acceptable as the CTD package was stopped in the water for at least 30 seconds before any firings, in order to allow sufficient time for the sensors to give stable readings.

5 Vessel Mounted ADCP (VMADCP) Processing using RDI OS75, OS150 & an Ashtech ADU5

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Adapted from D312, JR239, JR165 and JC29 cruise reports

5.1 *1. OS75 & OS150 configuration*

RRS Discovery is fitted with RD Instruments 75kHz & 150kHz Ocean Surveyor ADCP. Positional and attitude information is provided via an Ashtech ADU5 multi-receiver GPS attitude sensor. Ship's heading information from the vessel's Gyro, though streamed to and saved by the logging PC, was not used in the processing steps described here. The RDI proprietary software VMDAS (V1.42) was used to configure the ADCP and perform velocity mapping to the reference frame of the vessel. Bottom tracking was enabled where possible. A suite of MATLAB routines were used to perform data screening and transformation to absolute velocities in Earth coordinates: A summary of configuration and the processing steps is given below.

OS75 VMADCP Configuration

- No bins = 100
- Bin size = 8 m
- Blank after transmit = 8 m
- Transducer depth = 5.3 m
- Bottom track (when on) maximum depth 1100m
- Time between pings = as fast as possible (typically 5s)
- Low-resolution long-range processing mode

OS150 VMADCP Configuration

- No bins = 96
- Bin size = 4 m
- Blank after transmit = 4 m
- Transducer depth = 5.3 m
- Bottom track (when on) maximum depth 500m
- Time between pings = as fast as possible (typically 5s)
- Low-resolution long-range processing mode

5.2 *2. Output data format*

The filenames of the VmDas data are of the general structure CRUISE_xxx_yyyyyy.END where CRUISE is the name set in the data options recording tab of VmDas (see above), xxx is the number set in the same tab and changed before every restart of recording, and yyyyyy is a number automatically set by VmDas starting at 0 and increasing when the file size becomes larger than max size and a new file is created. END is the filename extension, denoting the different files that are created for each recording. The following list shows all the different file types that were created during D376 and their content.

- -.ENR: binary; raw ADCP data file.
- -.STA: binary; average ADCP data, using the short time period specified in VmDas Data Options.
- -.LTA: binary; average ADCP data, using the long time period specified in VmDas Data Options.
- -.ENS: binary; ADCP data after screening for RSSI and correlation, either by VmDas or adjusted by user, and navigation data from .NMS file.
- -.ENX: binary; : ADCP single-ping data and navigation data, after having been bin-mapped, transformed to Earth coordinates and screened for error velocity, vertical velocity and false targets.
- -.N1R: ASCII text; raw NMEA data, see section 3.
- -.N2R: ASCII text; raw NMEA data, see section 3.
- -.N3R: Cleaned version of .N2R, see section 3.
- -.NMS: binary; navigation data after screening and pre-averaging.
- -.VMO: ASCII text; option setting used for collection the data.
- -.LOG: ASCII text; all logging output and error messages. More options are available and information about the data files and their format is available in the various OS user guides. Here, a short overview about the structure of the binary data files is given. The structure varies slightly depending on whether only narrowband OR broadband mode are turned on or both are on.

- <u>-Header</u>: header ID, data source ID, number of data types (i.e. fixed leader, variable leader, etc.) and their offsets;

- <u>-Fixed leader data</u>: fixed leader ID, ADCP hardware configuration, number of beams, cells, and pings per ensemble, depth cell length, blank after transmit, signal processing mode (narrow- or broadband), output controls, amount of time between ping groups, coordinate transform parameters, heading alignment, heading bias, sensor source, sensors available, distance to middle of first depth bin, length of transmit pulse, distance between pulse repetitions;

- -Variable leader data: variable leader ID, ping ensemble number, date and time, speed of sound, transducer depth, heading, pitch and roll, salinity and temperature;

- -Variable data: velocity, correlation magnitude, echo intensity, and status data

- -Bottom track (BT): BT ID, BT number of pings, correlation magnitude, evaluation amplitude, BT mode, error velocity maximum, BT range, BT velocity, BT correlation magnitude, BT evaluation amplitude, BT maximum depth, receiver signal strength indicator, gain level for shallow water, most significant byte of the vertical range from the ADCP to the sea bottom;

- -Attitude: fixed and variable attitude data. Fixed attitude data includes the command settings and is the same for all pings. Variable attitude data changes with every ping and consists of heading, pitch and roll;

- -Navigation (ENS, ENX, STA, and LTA-files only): navigation ID, UTC date and time, PC clock offset, latitude and longitude received after the previous ADCP ping, UTC time of last fix, last latitude and longitude received prior to the current ADCP ping, average navigation speed, true navigational ship track direction and magnetic navigation ship track direction, speed made good, direction made good, flags, ADCP ensemble number, date and time, pitch, roll and heading, number of samples average since the previous ADCP ping for speed, true track, magnetic track, heading, pitch and roll;

- -Checksum**:** modulo 65536 checksum (sum of all bytes in the output buffer excluding the checksum). If data storing by VmDas is interrupted by e.g. a software crash and/or the data files are not closed properly by VmDas, the checksum can be incorrect and the check in the post processing can fail.

Note: The date recorded by VmDas is given as Julian day. VmDas takes 1st Jan to be day no. 0, different from the ship clock and the other data logging systems!

5.3 *Navigation data in the VmDas output files*

The navigation data is saved in two of the VmDas files: in .ENX the data is included in binary format. The .N2R-files contain the information in ASCII format and the following lines are utilised by the Matlab routines: $GPPAT, $PASHR, ATT, and $PADCP.

$GPPAT, time (UTC), deg latitude, south or north, deg longitude, west or east, quality indicator, number of satellites in view, various other parameters

$PASHR, ATT,????, heading, roll, pitch, various other parameters

$PADCP, ensemble number, date (yyyymmdd), time from PC clock

Note: On D376 the .N2R files are untidy, as for some reason the $PADCP line sometimes cuts the preceding line in half, and appears mid-line having failed to execute a carriage return. I therefore added clean_nmea_file.m to the suite of functions. It is called automatically in the early stages of processing and generates a rectified version with the extension .N3R. This is then used for all future operations.

5.4 *4. Processing in Matlab*

5.4.1 The Matlab routines

For the post-processing of the VmDas data, we used a set of Matlab routines. They were first obtained from IfM Kiel by Mark Inall and adapted for use on the RRS James Clark Ross by Deb Shoosmith. During JR165, Mark Brandon and Angelika Renner cleaned up large parts of the routines and added comments throughout. Since JR165, some further debugging and refinement have been done by Deb Shoosmith, Hugh Venables and Angelika Renner. The structure, general processing, and in- and output formats remain the same. The following description of the routines and the output data files are adapted from the JR235 cruise report with adaptions for D376.

5.4.2 Remarks and Glossary

Whenever it says 'run a routine/program/function', it means type in the function name in the Matlab command window and hit enter... A few terms should be clear:

-file sequence: all files for which in the filename CRUISE_xxx_yyyyyy.END the number at position xxx is the same. These files have been recorded without stopping the ADCP in between and the same setting was used.

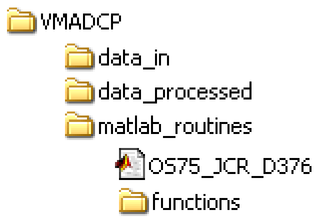
-amplitude, scaling factor, A: Throughout the routines the factor by which the ADCP data has to be scaled for calibration is called either amplitude, scaling factor or A.

-misalignment (angle), phi: synonyms for the angle by which the ADCP is misaligned in addition to the physical misalignment set in the command files.

-this document covers both the 75 and 150 kHz VMADCP. Unless stated otherwise, functions and variables are interchangeable, despite containing references to the 75kHz Doppler.

5.5 ***Quick'n'dirty***

5.5.1 How to get processed ADCP data



- Create a file structure as shown above.
- The master function (OS75_JCR_D376.m) lives in 'matlab_routines', all others go in the subfolder 'functions'.
-There are a few things that have to be set for each cruise in file OS75_JCR_D376.m. These are:

1. Add the correct path to the 'functions' subfolder (line ~54).
2. Point Matlab variable '*RAWPATH*' to 'data_in' and '*PATH*' to 'data_processed' (Remember the 'forward slash' character!). Lines ~62 – 70.
3. The expected VMDAS output: '*filename*'. Line ~73. Note that both the length and the position of file numbers has to be correct or the program will not get very far! If file length/numbering are different, there's also a bit of tinkering to be done at line ~274…
4. The cruise name: variable *'cruise'*. The name is used when reading in raw data and saving processed data, and appears in the plots. Line ~74.
5. The file sequences: variable '*files*'. This determines which of the file sequences are processed. 'Files' can be a single number or a vector containing the numbers of several file sequences. Line ~99
6. The averaging interval: variable '*superaverage'. 'superaverage'* sets the interval over which ping ensembles will be averaged. Unit is seconds. **Leave as is if unsure.** Line ~108.
7. The year: variable '*YYYY*'.
8. A switch for which lat/lon fix to be used (see 5.1): variable '*which_prdid_fix'*. Options are a) 1 to use the fix directly after the previous ADCP ping, or b) any other number to use the fix directly before the current ADCP ping. **Set it to 1 if you don't want to bother, it works.**
9. The upper and lower limit of the reference layer: variables '*ref_uplim'* and *'ref_lowlim'*. Those are needed for calculation of a reference velocity which is used when doing calibration by water tracking. Unit is meters. **Leave as is if unsure**.
10. The misalignment angle and the scaling factor: variables '*misalignment_nb'* and '*amplitude_nb'. nb = narrowband, (see note*

below) **When running *OS75_JCR_D376.m* the first time, set the misalignment to 0 and amplitude to 1. (Currently Line ~ 183).** After the first run, to correct for the angle and the scaling, set the variables to the mean, median, mode or whichever value is preferred, and run OS75_JCR_D376.m again. The Mean, median, and standard deviation are displayed in the plot *adcp_calib_calc.ps.* (The commented out values used on D376 should give a ballpark value for Discovery). To keep track of which values were used, it is a good idea to note down, which file sequences require which correction factors. *Deb Shoosmith modified this bit so that only 'misalignment_nb' and 'amplitude_nb' are used. On JR235/6/9, almost all data are in narrowband mode so that we just use the changed version. It is possible though to return to the previous version. The description below therefore still includes this option.*

That is all that should be set. All that needs to be done then is:

1. Put raw files into 'data_in' folder. Note the program only requires .N2R and .ENX files to run, just make sure you get the whole file sequence (on D376 max file size was set at 20 Mb after which a new file was started by the VMDAS).
2. Run OS75_JCR_D376.m.
3. Check which values for misalignment angle and scaling factor are derived.
4. Set 'misalignment_nb' and 'amplitude_nb' in OS75_JCR_D376.m to these values. Note: setting these values other than 1 and 0 invokes some additional statistical routines which triple the processing time… (You have been warned!)
5. Run OS75_JCR_D376.m again.

5.5.2 Existence of files in 'data_processed' and 'data_in' folders

If the program encounters files or plots of the current working name in the 'data_processed' folder, it skips much of the processing, assuming them to be completed. Therefore until you are happy with the outputs it is best to regularly delete the contents of the 'data_processed' folder, or at least move them elsewhere.

Similarly with .N3R files: these are cleaned versions of .N2R files, generated as part of the program run and used for subsequent operations. The program checks for their existence and skips new file generation if an .N3R file of the correct name already exists to save processing time. This is fine if you are happy with the .N3R format.

5.5.3 What's it doing? (In brief)

The misalignment angle of the transducer relative to the vessel (α) and the velocity amplitude correction factor (A) are determined as follows. A reference layer velocity between 100 and 300m is calculated from the super-ensembles (u and v), and the ship velocity calculated for the corresponding super ensembles (su and sv). First differences are taken (du, dv, dsu, and dsv) between all possible pairs of super ensembles, then differences selected for when the ship speed exceeds 3 ms^{-1} over the ground between ensembles not more than 5000m or 3600s apart in space or time. Then the following function is minimised for α and A using the Matlab function FMINSEARCH.m (a multidimensional minimization method).

$$f(A,\alpha) = \left(Adu\cos\alpha - Adv\sin\alpha + dsu\right)^2 + \left(Adu\sin\alpha + Adv\cos\alpha + dsv\right)^2$$

An initial guess at (A) and (α) is made in order to perform the minimisation on the super-ensembles outlined above. The whole processing procedure is then repeated for the newly determined values for (A) and (α) to give the final absolute velocities.

5.5.4 Brief description of Matlab processing steps

1. RDI binary file with extension ENX (single-ping ADCP ship referenced data from VMDAS) and extension N2R (ascii NMEA output from ADU5 saved by VMDAS) read into MATLAB environment. NB: The N2R file consists of ADCP single ping time stamps ($PADCP string) and ADU5 pitch, roll and heading information ($PRDID string). The latter NMEA string is created from the raw ADU5 string ($PASHR,ATT) by a splitter box on board RSS Discovery. The reason for this is that early versions of VMDAS were unable to directly interpret the $PASHR,ATT NMEA string.)
2. Ensembles with no ADCP data removed
3. Ensembles with bad or missing ADU5 GPS heading data identified and adjusted GYRO heading substituted
4. Attitude information time-merged with single ping data
5. Heading data used to rotate single ping ADCP velocities from vessel centreline reference to True North reference
6. Transducer mis-alignment error corrected for (derived from the mis-alignment determination – see text below)
7. Ship velocity derived from ADU5 positional information
8. Further data screening performed:
   i) Max heading change between pings (10 degrees per ping)
   ii) Max ship velocity change between pings (>2ms^{-1}pingrate^{-1})
   iii) Error velocity greater than twice Stdev of error velocities of single ping profile
9. All data averaged into 600-second super-ensembles (user selectable)
10. Determine absolute water velocities from either bottom track derived ship velocity or ADU5 GPS derived ship velocity. ADU5 derived velocity was favoured during D312

5.6 ***Detailed description of the processing functions***

5.6.1 The master function: OS75_JCR_D376.m

The main function for the processing is OS75_JCR_D376.m. In there, the environment and variables are set, and the subfunctions are called. Fig.5.1 gives an overview of the processing routines, their order and the output. In the first part the work environment is defined: the paths to the processing routines are added to the Matlab search path, the directory with the raw data and the directory for the processed data are declared, the file- and cruise names are defined, and the vector containing the numbers of the file sequences that are to be processed is created. Several choices can be made for the processing: the variable *superaverage* is used to define the interval over which pings will be averaged in time, unit is seconds; which $PASHR, ATT string sets, i.e. the first $PASHR, ATT fix after the previous $PADCP string or the last one before the current $PADCP string; this will make sense later! The values for *ref_uplim* and *ref_lowlim* give the upper and lower limits of the reference layer of which a velocity is calculated and used as reference velocity. This is of importance mostly for water track calibration in cases where no bottom track data is available or the bottom track calibration is not satisfactory.

Then, during the first run through OS75_JCR_D376.m, where no data is processed yet and no calibration data is available, the correction values for the misalignment angle (*misalignment_xb*) and the scaling factor (*amplitude_xb*) are set to 0 and 1 respectively (x=n for narrowband mode, x=b for broadband mode). For the second run, when values for *misalignment_xb* and *amplitude_xb* have been calculated, they should be set to the median, mean, mode or whichever value works best (i.e. gives the smallest angle and amplitude after the second run). To keep a record of the settings used to process a set of ADCP data, the settings and the text displayed on screen during the processing are written to a diary called *adcp_proc_log_runX.txt.* X will be 1 for the first run (when *misalignment_xb* and *amplitude_xb* are equal to 0 and 1, resp.) and 2 for the second run *(misalignment_xb* and *amplitude_xb* unequal 0 and 1, resp.).

After this introductory part, the processing starts. Arrays are declared for later use when calling some of the subroutines, and the file containing calibration point data is deleted if it exists in the processed data directory. Then, the loop through all file sequences specified above starts. First, the filename is set. Its general structure is *CRUISE_xxx_yyyyyy.* At this point, *xxx* is set to the file sequence number that is the current in the loop and *yyyyyy* is 000000. After the initialisations, the run through the subroutines begins! This includes all routines described in 5.6.2 to 5.6.11. Once all files have been passed through these routines and the loop is finished, the functions described in 5.6.12 to 5.6.16 are called. After that, all data is processed and saved in the specified directory. The last thing in the main function is a plot of velocities: cross sections of the zonal and meridional velocities against time are produced and the plots are saved in *adcp_vel_contours.ps.*

5.6.2 read_os.m

In this routine, the raw binary data from VmDas are read. In case of D376, we used the .ENX files, which contain ADCP single-ping and navigation data. The ADCP single-ping data has already been bin-mapped, transformed to Earth coordinates, and screened for error velocity, vertical velocity and false targets (see VmDas User's Guide).

read_os.m is called with the file name variable and optional arguments. The latter define which part of the raw data is read:

- -'ends': ???
- -'ens list': list of ensemble numbers
- -'yearbase': start year
- -'second set': read narrow band mode data when both broad and narrow band are collected.
- -'vel': read velocity.
- -'cor': read correlation magnitude.
- -'amp': read echo intensity.
- -'pg': read percent good.
- -'ts': read pitch, roll, and heading.
- -'bt': read bottom track data.
- -'nav': read navigation data
- -'all': includes vel, cor, amp, ts, bt, and pg.

More than one argument can be passed on to read_os.m. Arguments can also be numbers. After the switches are set, the subroutine os_id, which is within read_os.m, is called with the argument *id_arg*. The value of *id_arg* depends on the offset of the positions of the data. If both narrowband and broadband data are collected in broadband mode, this also decides which data are read. If *id_arg*=1, the narrowband data is extracted. os_id returns the structure id with the positions/identifiers of the data fields in the binary data files. The next step is the first call to the subroutine read_buf, also within read_os.m.

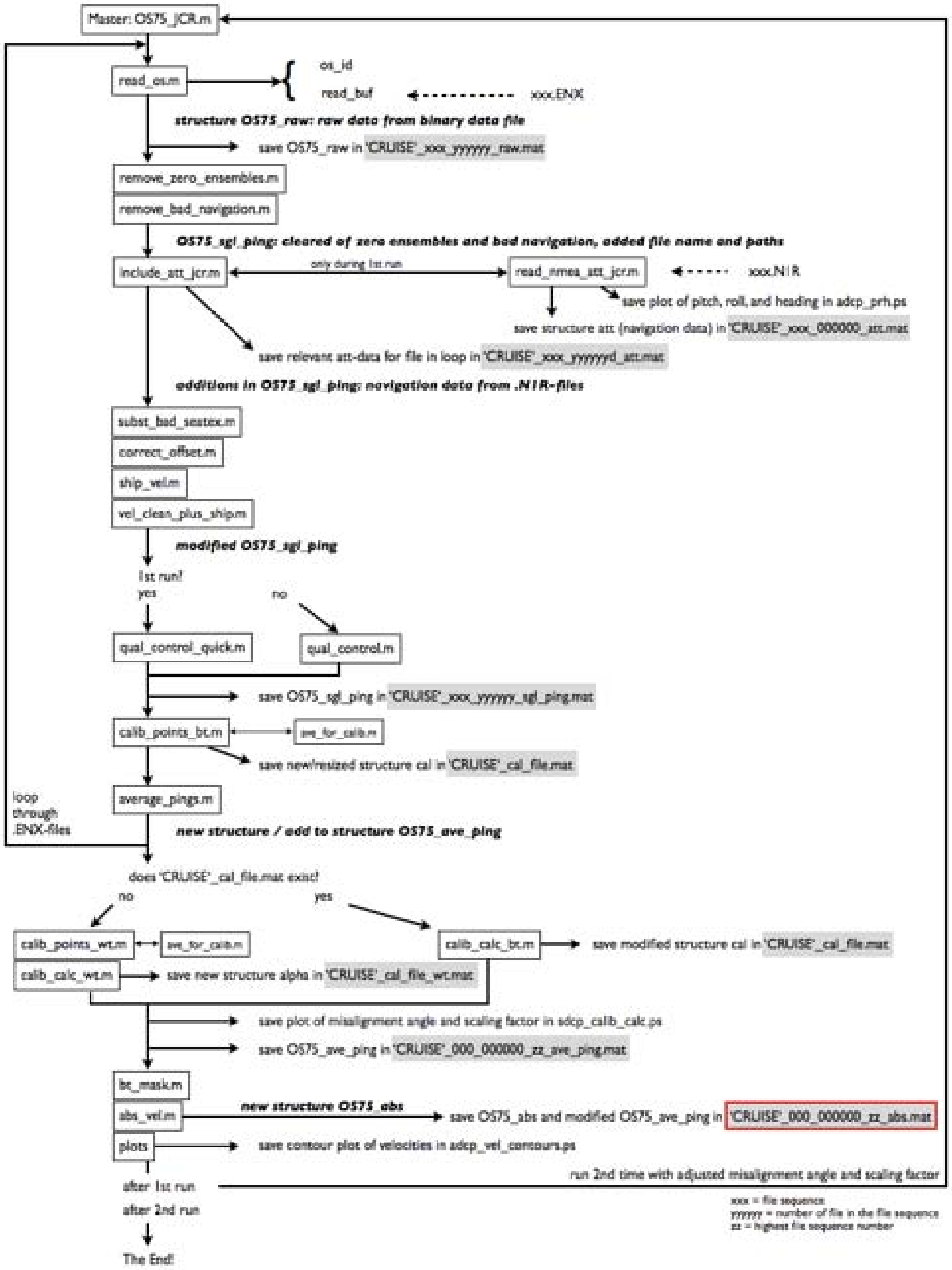


Figure 5.1. The master for D376 is OS75_JCR_D376.m

read_buf This is the part where the binary data is read. During the first call with only one argument, the configuration of the OS75 ADCP is extracted from the fixed leader data and stored in the structure config. If one of the checks on number of bytes, header or data source ID or checksum fails, an error message will be returned to read_os.m. Otherwise, information about ADCP hardware and setup that remains the same for all pings is read. After that and during the second call (with two arguments), the variable, bottom track, attitude, and navigation data is extracted. After the first call to read_buf, the configuration data is used to set up the variables and the reading loop. During the second call, the data requested by using the various switches is stored. Before returning to the main routine, variables are adjusted for negative numbers or NaNs. All raw data read in is stored in the structure OS75_raw and returned to the main function and written to the file *CRUISE_xxx_yyyyyy_raw.mat.*

5.6.3 patch_heading_data.m (Presently commented out).

This was written during D376 as an attempted fix for a couple of periods were heading input to the .ENX file failed, resulting in a heading of zero and nonsensical velocities. The routine patches in the heading data from the ascii .N3R file and adjusts for the quoted misalignment angle. The fix works but on completing I realised that velocities in the ENX file must have already been rotated based on the bad heading. There may be a way to recover these by transforming vectors but it is beyond the scope of my time on the cruise. Therefore this is a work in progress.

5.6.4 remove_zero_ensembles.m

The structure OS75_raw is handed over to remove_zero_ensembles.m. A search for all ensembles whose ensemble number (OS75_raw.ens_num) is not zero is done and only those are kept and handed back to the main routine as *OS75_sgl_ping*.

5.6.5 remove_bad_navigation.m

Depending on *which_prdid_fix*, *OS75_sgl_ping.nav.txy1* or *2* is checked for time (first row), longitude (second row) and latitude (third row) duplicates. The number of rejected data cycles is printed on screen and saved as bad and good (=number of data cycles - number of rejected cycles) in the file *CRUISE_bad_nav.mat.* The rejected data cycles are then removed from *OS75_sgl_ping* and the structure handed back to the main routine.

5.6.6 include_att_jcr.m .

Arguments passed on to this routine are *OS75_sgl_ping*, *add_to_ensnum* (for the correction of ensemble numbers; see below) and *which_prdid_fix*. If no file *CRUISE_xxx_000000_att.mat* exists yet in the processed data directory (i.e. the navigation data in the .N3R-files has not been read yet), *OS75_sgl_ping* is passed on to Clean_nmea_file.m, then read_nmea_att_disc.m which is called to read the .N3R-files.

Clean_nmea_file.m A D376 addition due to the poor quality of .N2R files being produced. Main problem is tendency of *$PADCP* line to cut the previous line in half in (various modes of failure). This function scans through the N2R file, compiling a clean version as it goes. This is then saved with file extension .N3R, and used on all subsequent processing steps. If the .N3R file in question is already present in the 'data in' folder, this function is skipped.

read_nmea_att_disc.m. The routine goes through all .N3R-files in a file sequence. The number of lines to be read in one goes is limited to a maximum of 160000, the loop will go on until all lines are read. The text in the .N3R-file is read into a matrix. Then lines containing the $PADCP or the

$PASHR, ATT string are extracted. If two $PADCP-lines are consecutive, the first of them is discharged (no attitude data available for this ping ensemble!). From the $PASHR, ATT-lines the one following the $PADCP-line are extracted, the others discharged. Pitch, roll and heading are read from the remaining $PASHR, ATT-lines and stored. If heading is missing (=999), pitch and roll are set to 999 as well. From $PADCP-lines, the ping ensemble number and the PC time of the ping ensembles (converted to decimal Julian days) are extracted. After all files are read, the ping ensemble number is checked and corrected for duplicates, which can appear due to the splitting of the files after the maximum number of lines is read. The data is stored in the structure *att* which is written to *CRUISE_xxx_000000_att.mat*. Pitch, roll and heading are plotted and the figures saved to *adcp_prh.eps*. (Figures need to be improved!) After that, return to include_att_jcr.m.

The file *CRUISE_xxx_000000_att.mat* with the att-structure is loaded in. If the structure contains data, the following is done: For further processing the ping ensemble number has to be increasing. When the ADCP times out while waiting for a response and resets, the ensemble number goes back to 1. Here, the ensemble numbers are modified so that they increase throughout the file (for *att*) and throughout the files of a file ensemble in O*S75_sgl_ping.ens_num*. *(There has been a bug here which was corrected during JR235/6/9.)* There is already attitude data in the structure *OS75_sgl_ping* which comes from the .ENX-file. To extract pitch, roll, heading, and PC clock offset which are relevant for the current .ENX-file, a vector is created for each variable of the length max (highest ensemble number in *att*, highest ensemble number from the .ENX attitude data) and filled with NaNs. Then, the attitude information from *att* is written into the vector and on the data points corresponding to the ensemble numbers from the .ENX-file are stored. If *att* is empty, heading, pitch, roll, and PC clock offset are set to NaN.

The extracted attitude data is written to *OS75_sgl_ping.att.* The attitude data relevant to the current .ENX- file is also saved in the new structure *att* in *CRUISE_xxx_yyyyyyd_att.mat.* The modified OS75_sgl_ping is returned to the main routine.

5.6.7 subst_bad_seatex.m

The arguments *OS75_sgl_ping.att,* and *sea_file* are handed over. In *sea_file* the number of accepted and rejected (due to bad Seatex data) data points will be stored. A search on *OS75_sgl_ping.att* data is done for ensembles where:

- -heading = 0;
- -heading = 999;
- -pitch and roll = 0;
- -the second differential of heading = 0.

The total number of those ensembles is printed on screen and saved as bad in '*CRUISE'_bad_heading.mat.* *OS75_sgl_ping* contains two headings:

OS75_sgl_ping.heading which comes from the .ENX-file and *OS75_sgl_ping.att.heading* from the .N3R-file. Both are from the same instrument (Seapath Seatex), but maybe slightly different due to a (very) small time difference in when they are recorded. Therefore, the velocities in OS75_sgl_ping are rotated by the difference. To get bottom track velocities in the correct orientation, *OS75_sgl_ping.bt.vel* is multiplied by -1. *OS75_sgl_ping* with the modified values is returned to the main routine.

5.6.8 correct_offset.m

Using the helper routine *uvrot.m*, this routine scales the water and bottom track velocities and corrects them for misalignment. From the main routine, the arguments *OS75_sgl_ping, misalignment_xb* and *amplitude_xb* are passed on, x=n or b depending on whether the current file ensemble is in narrow- or broadband mode. The horizontal velocities are multiplied by the scaling factor *amplitude_xb* and rotated by the specified misalignment angle *misalignment_xb.* The heading is adjusted by subtracting the misalignment angle. The modified structure *OS75_sgl_ping* is returned to the main routine.

5.6.9 ship_vel.m

The routine is called with the arguments *OS75_sgl_ping* and *which_prdid_fix.* The latter decides which navigation fix is used for the calculation of the ship velocity: either *txy1* or *txy2.* With the help of the routine *sw_dist.m* from the CSIRO Seawater toolbox, the distance and the direction between the fixes is calculated and then converted to distance in east- and northward direction in meters and time difference in seconds. Dividing distance by time difference results in ship velocity in m/s, which is written to *OS75_sgl_ping.ship_velocity.* If bottom tracking was on, the horizontal bottom track velocities *OS75_sgl_ping.bt.vel(1:2,:)* should contain values other than NaN. If that is the case, the ship velocity is set to *OS75_sgl_ping.bt.vel(1:2,:).* The structure *OS75_sgl_ping* is then handed back to the main routine.

5.6.10 vel_clean_ship_vel.m

This routine was added by Hugh Venables during JR218 to filter out spikes in the GPS data. It is called with the arguments *OS75_sgl_ping* and *which_prdid_fix* and returns the modified structure *OS75_sgl_ping.*

5.6.11 qual_control.m

Several criteria are used in this routine for further quality control. Therefore, the arguments *OS75_sgl_ping, beam, heading_change* and *ship_velocity_change* are included in the call. *Beam* is the number of beams of the ADCP instrument, *heading_change* is the maximum change in heading allowed at any one time step, and *ship_velocity_change* is the maximum change in ship velocity allowed at any one time step. Large changes lead to less reliable ADCP data. The values used during D376 are 10° per ping for the heading change and 0.5514 m per ping for the ship velocity change.

The first step of quality control uses the error velocity provided through the fourth beam *(vel(:,4,:)).* A variable *err_vel* is set to 2 times standard deviation of the error velocity, and the velocities of all ping ensembles where the absolute value of this velocity exceeds *err_vel* are set to NaN.

Then, if *beam* = 0, a check using *percent good* is performed: velocities of ping ensembles with percentage of good four beam solutions equal to zero are set to NaN.

The two following steps look at the heading changes. First, a smoothed version of the heading change *(diff(heading)),* created using a Hamming-window based, second order filter is checked for values exceeding heading change, and the velocities of affected ping ensembles (i.e. the two ensembles in between which the change is large) are set to NaN. The same is done for the unfiltered heading change.

NOTE: for mfilter.m and the therein used Matlab function filtfilt.m, the data needs to have a minimum length of 3 times the filter order! **This means that files with less than 5 minutes of data cannot be used.**

Velocities are set to NaN if the change in ship speed exceeds ship velocity change.

A last control is done on absolute horizontal velocities in a reference layer: The eastward and northward velocities in the ninth depth bin are chosen and the ship velocity is added to obtain absolute velocities. Then, velocities of ping ensembles between which the change of either of these reference velocities is larger than 2m/s are set to NaN.

The structure with the modified velocity array is returned to the main routine.

Hugh Venables modified the call to the quality control routine such that in the first run, a quicker, less thorough quality check is done using the routine qual_control_quick.m to allow faster processing for quick data checks. During the second run, the above quality control is done.

5.6.12 calib_points_bt.m

In this routine, calibration points are extracted using 2-minute averages of ADCP data and various criteria these points have to fulfill. It is called with the arguments *OS75_sgl_ping*, *cal_file, which_prdid_fix, ref_*uplim and *ref_lowlim. cal_file* specifies where the data for calibration extracted here will be written to, *which_prdid_fix* does the same as in ship_vel.m.

To average the ADCP data over 2 minutes, the routine ave_for_calib.m is called with the arguments *OS75_sgl_ping, av_time* (set to 120 seconds), *ref_uplim, ref_lowlim,* and *which_prdid_fix.*

ave_for_calib.m This routine is a reduced version of average_pings.m (see 5.6.13), including only variables required by calib_points_bt.m. The possibility of missing out ping ensembles in the averaging process when several .ENX-files exist in a file sequence is ignored here (for more about that issue see 5.6.13). After the averaging, a check is done whether bottom track velocities are available or not. If all bottom velocities are NaNs, the routine stops and returns to the main program.

The principle used is based on a comparison of ADCP bottom track data and GPS tracks. The bottom velocity recorded by the ADCP should be the same as the GPS derived ship velocity. Therefore, the value GPS ship speed/ADCP bottom track speed gives the scaling factor to adjust ADCP velocities, and −(GPS ship heading − ADCP bottom track heading) is the misalignment angle. As velocities from bottom tracking are crucial for the calibration, ping ensembles with NaNs in either zonal or meridional bottom velocity are discharged. The ship velocity is derived from navigation data in *OS75_sgl_ping.nav* and *which_prdid_fix* sets which fix is used. Ship velocity is then calculated as in ship_vel.m as distance in east- and northward direction divided by time difference. The criteria potential calibration points have to fulfill are:

- the change in ship heading is small;
- the change in ship speed is small;
- the ship speed is within the interval average ship speed ± standard deviation;
- the ship heading is within the interval average ship heading ± standard deviation;
- the bottom speed is larger than a specified minimum speed;
- there are a minimum number of possible calibration points in a row that fulfill the criteria.

Relevant data at the calibration points are extracted and saved in the structure cal. This includes bottom velocity, speed, heading and range, ADCP velocities and heading, ship speed and heading, and the navigation data. The scaling factor at the calibration points is calculated as is the misalignment angle. To enable quality control of the intervals of calibration points (interval=row of successive calibration points) and possible filtering by hand after the processing, some statistics are done and included in the structure: average and standard deviations of ship velocity and heading, bottom velocity and heading, scaling factor and misalignment angle, and the number of 2-minute averages in the interval. If the cal_file does not exist yet, it is created, otherwise, the data is added to the existing file.

5.6.13 average_pings.m

The routine is called with the arguments *OS75_sgl_ping*, *d_missed, OS75_ave_ping, superaverage, ref_uplim, ref_lowlim,* and *which_prdid_fix.*

The time in seconds over which the ping ensembles are averaged is given by *superaverage.* As the ping ensembles in a file of a file sequence are not necessarily divisible into the specified time intervals without remainder, the structure d_missed is used to carry on the surplus ensembles and add them to the ping ensembles of the next file in the same file sequence. If there are ping ensembles left at the end of a file sequence, they will not be included in the averaging.

At first, a check is done whether any ping ensembles from the previous file were carried forward. If that is the case, and the bin depth is the same in both files, they are added to the current file in the loop. bA depth range for the reference layer velocity is set as is the maximum number of depth bins.

Pings are averaged in intervals determined by *superaverage* and using the time stamps in *OS75_sgl_ping.nav.txyX* where *X* is either 1 or 2 depending on *which_prdid_fix.*

Throughout the routine, there are various occasions where (usually) three dimensional arrays are split up into several 2d-arrays. This is done using the reshape-command and the size of the velocity fields. To avoid problems when the original velocity field is 2d instead of 3d, a check is introduced and the variable containing the size of the field is adjusted.

Several variables are extracted and derived: the reference layer velocity (zonal and meridional) as mean of the horizontal velocities in the depth range specified by *ref_uplim* and *ref_lowlim*; absolute velocities by adding the ship velocity to the horizontal velocities; percent good from the fourth beam; a value for bottom range for each ping ensemble with the condition that it is between 50 and 1200 m depth and using the median of the four beams; the difference between the headings from the .ENX- and from the .N3R-file (set to NaN if the .ENX-heading does not change for two successive ping ensembles); pitch and roll (set to NaN if data is missing, i.e. > 998); the PC clock offset; the echo intensity as mean over all beams.

The navigation data is set to NaN for ping ensembles where there is no velocity data in any of the beams and any of the depth bins. For the averaging, the heading is broken up into components (-cos and sin) and reconverted to angles in degrees afterwards.

Of the extracted variables, the ones included in the averaging are: absolute velocity (all three directions), reference velocity, heading, difference in .ENX- and .N3R-heading, PC clock offset, echo intensity, percent good, and bottom range. Additionally, ship velocity and navigation data (time, longitude, latitude) are averaged. For pitch and roll, the standard deviation is calculated.

The data from ping ensembles that were remainders after the averaging is written to *d_missed* and returned to the main routine. The averaged absolute velocity is converted back to velocity relative to the ship by subtracting the averaged ship velocity. The reference layer velocity is then recalculated from the resulting averaged (relative) velocity. The averaged variables are added to the structure *OS75_ave_ping* as are the variables depth and *ref.bins* (=numbers of the bins in the reference layer). The structure is then returned to the main routine.

average_pings.m is the last routine called within the loops through all files in a file sequence and through all file sequences specified. At the end of the loops, the structure *OS75_ave_ping* contains averaged data for all files included in the processing. Before the loops are left, the array *bindepth* containing bin depths for each of the averaged velocity profiles is created. Next steps are the final part of the calibration, blanking the bottom, and removing the ship velocity from the ADCP velocity data.

5.6.14 calib_points_wt.m

If there is no bottom track data available, the calibration is done using water track. Again, the search for possible calibration points is done using 2 minute averages produced by ave_for_calib.m. First differences are calculated from the average data for the reference velocities (i.e. the water velocities in the reference layer specified by *ref_uplim* and *ref_lowlim*) du and dv, and the ship velocities dsu and dsv. Of those, only differences were considered for when ship speed exceeded 3 m/s between ensembles not more than 5000 m or 3600 s apart. Using the Matlab function fminsearch.m, the following function was minimized for phi and (A):

$$f(A,\alpha) = \left(Adu\cos\alpha - Adv\sin\alpha + dsu\right)^2 + \left(Adu\sin\alpha + Adv\cos\alpha + dsv\right)^2$$

Values for (A) and phi are written to the array alpha together with relevant heading, navigation, and velocity data, and alpha is handed back to the main routine.

5.6.15 calib_calc_wt.m

After alpha has been created in calib_points_wt.m, it is passed on to this subroutine. Here, average, median, and standard deviation for phi and (A) are calculated and written to *cal_file_wt.* The average or the median should then be used during the second run of OS75_JCR_D376.m for misalignment and amplitude correction. Several plots of the misalignment and the scaling are also produced and stored in *adcp_correction_stats.ps.*

5.6.16 calib_calc_bt.m

During the first run of OS75_JCR_D376.m, the misalignment angle and the scaling factor which are to be used for the second run are calculated here. In the second run, the results for phi and (A) should be closer to zero and one, respectively, than before.

The arguments handed over are *cal_file*, which specifies the file with the calibration point data, cruise, *misalignment_xb* and *amplitude_xb*, which are used for the plots created in this routine. After *cal_file* is read in, scaling factors and misalignment angles outside the interval average ± standard deviation are sorted out.

From the remaining points, the average, the median and the standard deviation for (A) and phi are calculated and added to the structure *cal*. The median is less affected by outliers which might have survived the screening in calib_points_bt.m and calib_calc_bt.m and should therefore be used as correction value in the second run.

Before returning to the main routine, a plot showing the distribution of the misalignment angles and thescaling factors and their temporal evolution is produced. (After returning to the main program, the plot is written to the file *adcp_calib_calc.ps*.)

5.6.17 bt_mask.m

OS75_ave_ping and *bindepth* are passed on to this routine. Here, a mask is created using the bottom range *bt.range*. With this mask, velocity data below 86% of the bottom range (= water depth) is set to NaN. The structure containing the modified velocity fields is returned to the main routine.

5.6.18 abs_vel.m

OS75_ave_ping and *bindepth* are handed over from the main routine. In order to derive absolute water velocities independent of the ship movement, the east- and northward ship velocity is added to the horizontal water velocity (*OS75_ave_ping.vel*). The same is done for the velocity in the reference layer (*OS75_ave_ping.ref.vel*). The resulting absolute velocities, the navigation data and the depth array (set to *bindepth*) are handed back to the main routine within the structure *OS75_abs*.

5.6.19 Helper routines: julian.m, sw_dist.m, uvrot.m, rot_fun_1.m, mfilter.m

These routines are called on various occasions during the processing. sw_dist.m is part of the CSIRO Seawater toolbox.

5.7 Overview of output files

5.7.1 CRUISE_xxx_yyyyyy_raw.mat

The structure *OS75_raw* in this file contains the raw, unedited data from the .ENX-file as read in in include_att_jcr.m and read_nmea_att_jcr.m. For JR235/6/9 the structure consists of:

- vel, cor, amp, pg (arrays of size [number of bins x number of beams x number of ensembles]): velocity, correlation magnitude, echo intensity and percent good for the four beams.

- heading, pitch, roll as [1 x number of ensembles]-array.
- temperature, soundspeed: [1 x number of ensembles]-array. The temperature here is the temperature of the water at the transducer head. It is either set manually or measured. The soundspeed is calculated or set manually.
- dday, ens_num,num pings: [1 x number of ensembles-]array. dday is decimal day, ens_num the ensemble number of the pings, and num ping the number of pings in each ensemble.
- bt: structure containing the bottom track data:
- vel, range, cor, amp, rssi (arrays of size [4 x number of ensembles]): bottom track velocity, range, correlation magnitude, echo intensity and receiver signal strength indicator for the four beams
- nav: structure containing navigation data:
- sec pc minus utc: [number of ensembles x 1]-array containing the PC clock offset in seconds;
- txy1, txy2: [3 x number of ensembles]-arrays; first row: time in decimal Julian days, second row: longitude, third row: latitude. txy1 is data from the first $PASHR.ATT-fix after the previous ADCP ping, txy2 is
    - from the last $PASHR.ATT-fix before the actual ADCP ping.
- config: structure containing the setup information about the OS75 and VmDas
- depth: [1 x number of bins] array. The array contains the depth of the bins in the configuration used for the actual file sequence.
- error: if reading of data fails, an error message will be stored here, otherwise it should be empty. There is one such file for each .ENX-file in a file sequence.

5.7.2 CRUISE_xxx_000000_att.mat

In this file, the structure *att* contains the attitude information from all .N3R-files of a file sequence, read during read_nmea_att_jcr.m. This includes the following [1 x number of ensembles]-arrays:

- heading, pitch, roll;
- pc_time: time from the ADCP PC clock;
- pc_time_offset: offset of the ADCP PC clock from UTC in seconds;
- ens_num: the ping ensemble number.
-

Per file sequence, one file CRUISE_xxx_000000_att.mat is produced.

5.7.3 CRUISE_xxx_yyyyyyd_att.mat

For each file in a file sequence, attitude data is extracted and saved in CRUISE_xxx_yyyyyyd_att.mat. It contains a structure *att* which consists of the following arrays of size [1 x number of ensembles] per .ENX-file:

- att_heading, att_pitch, att_roll: heading, pitch and roll from the .N3R-files for the ping ensembles in the corresponding .ENX-file;
- heading_orig: heading from the .ENX-file;

- ens_num: the ping ensemble number;
- lat: latitude of the ping ensemble.
-

The difference between att_heading and heading_orig should be small and therefore negligible. In the case of JR235/6/9, they both come from the SeaPath Seatex, but there is a small time lapse between the writing of data to the .ENX- and the .N2R-files.

5.7.4 CRUISE_xxx_yyyyyy_sgl_ping.mat

Again, one file with single ping data is produced for each .ENX-file. In the structure *OS75_sgl_ping*, after several steps of quality control, filtering and correcting for misalignment and scaling (after final processing), data from the four beams, bottom track data, navigation data, configuration data and information about the processing environment are stored:

- all variables that exist in *OS75_raw* in the file CRUISE_xxx_yyyyyy_raw.mat are included;
- additional variables:
- filename: CRUISE_xxx_000000;
- path, rawpath: paths to the directories where the processed data is written to (path) and where the raw data files are stored (rawpath);
- att: structure containing heading, pitch, roll, and PC clock offset;
- heading_orig: [number of ping ensembles x 1]-array, heading from the .ENX-file;
- ship velocity: [2 x number of ping ensembles]-array, containing the eastward (first row) and the northward (second row) ship velocity.

5.7.5 CRUISE_cal_points.mat

In this file, all information at bottom track calibration points needed for the calculation of misalignment angle and scaling factor are stored. This includes:

- bt: structure with bottom track data: arrays vel ([2 x number of calibration points]), speed, heading, and range ([1 x number of calibration points]);
- vel: [number of bins x 2 x number of calibration points]-array of east- and northward velocity heading: [1 x number of cal. points]-array; heading from .N1R-data; nav: structure containing txy1 data at the calibration points;
- ship speed, ship heading: [1 x number of cal points]-arrays;
- scaling, phi: scaling factor and misalignment angle at each calibration point; [1 x number of cal. points]-array;
- intervals: stats for each interval of successive calibration points; see description of routine calib_points_bt.m;
- mode: [1 x number of cal points]-array. 1 or 10 for each calibration point depending on broadband or narrowband mode.
- which file: [number of cal points x 16]-character array with file name of the file the calibration point is from.

- stat: structure with values for the scaling factor (a) and the misalignment angle (phi) as calculated in the routine calib_calc_bt.m; the values stored here after the first run of the main routine OS75_JCR_D376.m are the ones that should be used for the second run!
-

Only one file for all file sequences processed in a run is created.

5.7.6 CRUISE_cal_points_wt.mat

If no bottom track data is available, calibration is done using water track. For this, the array alpha is created. From data in alpha, the misalignment angle phi and the scaling factor scaling are derived and alpha, phi, and scaling are stored in this file.

5.7.7 CRUISE_000_000000_zz_ave_ping.mat

(zz=highest file ensemble number included in the processing).

The structure *OS75_ave_ping* contains data after averaging over a chosen time interval (xyz = number of velocity profiles after averaging):

- vel: [number of bins x 3 x xyz]-array of average velocity (zonal, meridional and vertical);
- amp, pg: [number of bins x xyz]-arrays; echo intensity and percent good;
- ship velocity: [2 x xyz]-array of zonal and meridional ship velocity; if bottom track velocity is available, then the ship velocity equals the bottom track velocity;
- heading: [1 x xyz]-array;
- nav: structure containing txy1: [3 x xyz]-array of time (decimal Julian days), longitude and latitude;
- att: structure containing:
- heading difference: [1 x xyz]-array of the difference between heading from .ENX and .N3R (hope- fully equal to zero);
- pitch, roll, pc time: [1 x xyz]-arrays;
- ref: structure with velocity ([2 x xyz]-array): average over the reference layer, and bins: vector containing the depth bins that lie within the reference layer;
- bt: structure containing range: [1 x xyz]-array of bottom track range;
- depth: [1 x number of bins]-array (bin depths of the setting of the last file sequence processed).

5.7.8 CRUISE_000_000000_zz_abs.mat

(zz=highest file ensemble number included in the processing)

In this file, both *OS75_abs* and *OS75_ave_ping* are saved. The latter contains the same fields as in
CRUISE_000_000000_zz_ave_ping.mat, where only the values in the velocity field are changed.

Additionally, the variable bindepth is included as well.
OS75_abs includes (xyz = number of velocity profiles after averaging):

- vel: [number of bins x 3 x xyz]-array of absolute velocity (zonal, meridional and vertical), i.e. horizontal velocities are corrected for ship velocity;
- nav: structure containing txy1: [3 x xyz]-array of time (decimal Julian days), longitude and latitude;
- ref: structure with velocity ([2 x xyz]-array): average over the reference layer, and bins: vector containing the depth bins that lie within the reference layer;
- depth: [number of bins x xyz]-array (bin depths corresponding to the settings used for the velocity profiles).
-

5.8 *D376 specifics*

Changes made to the Matlab suite on D376 were mostly due to the poor quality of the text output (.N2R files). An example of the file contents is shown below:

```
$PASHR,POS,0,8,055154.00,4800.99428,N,00946.78804,W,00063.40,????,162.94,000.18,+
000.31,02.0,01.0,01.7,01.2,AG02*3A
$PASHR,ATT,21130.0000,254.8519,-0.9548,-0.4495,0.0010,0.0125,0*25
$GPPAT,055155.00,4800.99417,N,00946.78794,W,00063.66,254.8519,-000.95,-
000.45,0.0010,0.0125,0*6D
$PASHR,POS,0,8,055155.00,4800.99417,N,00946.78794,W,00063.66,????,151.92,000.68,+
000.16,02.0,01.0,01.7,01.2,AG02*31
$GPPAT,055156.$PADCP,3,20120617,055154.54
00,4800.99400,N,00946.78784,W,00063.67,255.0623,-000.89,-000.81,0.0009,0.0090,0*69
$PASHR,POS,0,8,055156.00,4800.99400,N,00946.78784,W,00063.67,????,162.49,000.62,-
000.16,02.0,01.0,01.7,01.2,AG02*3E
$PASHR,ATT,21132.0000,255.2339,-0.6224,-0.9767,0.0007,0.0031,0*2B
$GPPAT,055157.00,4800.99390,N,00946.78782,W,00063.35,255.2339,-000.62,-
000.98,0.0007,0.0031,0*63
$PASHR,POS,0,8,055157.00,4800.99390,N,00946.78782,W,00063.35,????,194.66,000.18,-
000.43,02.0,01.0,01.7,01.2,AG02*39
```

Information from the ADCP (blue) is inserted into the GPS output (red), cutting lines in half.

The routine ‘Clean_nmea_file.m’ was written to tidy this and other glitches up, writing to a new file designated ‘.N3R’, which is stored in data_in and used for all future operations. All raw files are preserved but this should be considered the ‘clean’ file for most future processing.

5.8.1 Other tweaks:

Line headers from the ship navigation (‘PASHR,ATT’, ‘GPPAT’ etc) had to be changed for D376. Only the ADCP header (PADCP) remained unchanged.

File names were a slightly different length to those expected by OS75_JCR_D376. Input file number creation relies on counting backwards from the end of the file name, so this must be correct.

No Matlab stats package available on this cruise so a couple of modifications to take this into account.

5.9 *Calibration and processing*

The instruments (ADCP and Ashtech ADU5) both functioned reasonably well during the cruise. Brief (<1 sec) cutouts from the GPS kept a constant stream of errors writing to the data log, these didn't seem to compromise the data but may have been responsible for the messy output in the merged .N2R file. Longer failures occasionally affected the ADCP output, worrying as they were impossible to detect until the data had been downloaded and tested. However stopping and starting file generation seemed to fix the problem, so with the exception of continuous section monitoring, a new file was generated daily.

Due to the rough weather and consequent frequent presence of air bubbles under the hull and across the transducer face, water profiles were often quite poor (less than 50% good at depth as shallow as 180m). An example figure of processed data is shown in figure 8.

Raw data files in RDI format and processed data files in MATLAB format will be logged with BODC after the cruise, the approximate total quantity of data will be 6GB. Raw RDI data are divided into 16 series (series D376_OS150001_000000 to D376_OS150016_000000). Within each series files are subdivided into files of maximum 20MB in size. Series number is incremented each time VMDAS is stopped and restarted; the number of sub-files per series is therefore variable.

D376 operated both on and off the shelf, so bottom tracking was possible on some program runs. The following alignment and amplitude corrections were used for file generation:

OS150

Files 2-6:
misalignment_nb = 0.7324
amplitude_nb = 1.006998
Files 7-11:
misalignment_nb = 0.6319
amplitude_nb = 1.007483
Files 12-16:
misalignment_nb = 0.6601
amplitude_nb = 1.007250

OS75

Files 2-6:
misalignment_nb = -3.2881
amplitude_nb = 0.996432
Files 7-11:
misalignment_nb = -3.2512
amplitude_nb = 0.995536
Files 12-16:
misalignment_nb = -3.3509
amplitude_nb = 0.996260

5.10 File sequences during D376

Date	Time	Filename	File open/closed	Comments
11/06/2012	18:47	D376_OS150001_000000	closed	
11/06/2012	18.47	D376_OS150002_000000	opened	Closed/opened to enable test processing
13/06/2012	14:48	D376_OS150002_000000	closed	
13/06/2012	14.48	D376_OS150003_000000	opened	Closed/opened to enable test processing
15/06/2012	09:40	D376_OS150003_000000	closed	
15/06/2012	09:41	D376_OS150004_000000	opened	Daily file generation
15/06/2012	20:10	D376_OS150004_000000	closed	Suspect section at end of file 3; closed to allow inspection
15/06/2012	20:10	D376_OS150005_000000	opened	
16/06/2012	11:53	D376_OS150005_000000	closed	
16/06/2012	11:53	D376_OS150006_000000	opened	Daily file generation
17/06/2012	05:52	D376_OS150006_000000	closed	
17/06/2012	05:52	D376_OS150007_000000	opened	Commence file to cover Scanfish track 1
18/06/2012	10:06	D376_OS150007_000000	closed	End file to cover scanfish track 1
18/06/2012	10:06	D376_OS150008_000000	opened	
19/06/2012	10:27	D376_OS150008_000000	closed	
19/06/2012	10:27	D376_OS150009_000000	opened	Commence file to cover Scanfish track 2
20/06/2012	15:10	D376_OS150009_000000	closed	End file to cover scanfish track 2
20/06/2012	15:10	D376_OS150010_000000	opened	
21/06/2012	13:04	D376_OS150010_000000	closed	
21/06/2012	13:04	D376_OS150011_000000	opened	Daily file generation
22/06/2012	13:53	D376_OS150011_000000	closed	
22/06/2012	13:53	D376_OS150012_000000	opened	Daily file generation (includes Scanfish track 3)
24/06/2012	05:27	D376_OS150012_000000	closed	
24/06/2012	05:27	D376_OS150013_000000	opened	Scanfish track 4 (zigzag)
26/06/2012	06:16	D376_OS150013_000000	closed	
26/06/2012	06:16	D376_OS150014_000000	opened	Daily file generation
27/06/2012	18:08	D376_OS150014_000000	closed	
27/06/2012	18:08	D376_OS150015_000000	opened	Daily file generation
29/06/2012	13:11	D376_OS150015_000000	closed	
29/06/2012	13:11	D376_OS150016_000000	opened	Daily file generation
01/07/2012	09:47	D376_OS150016_000000	closed	End of science work

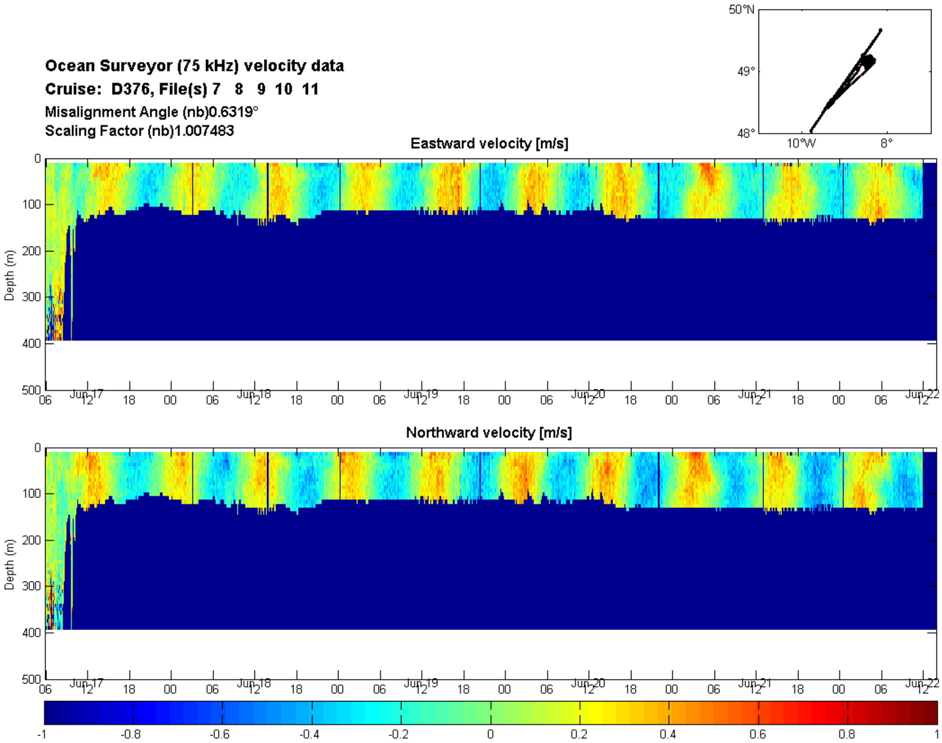
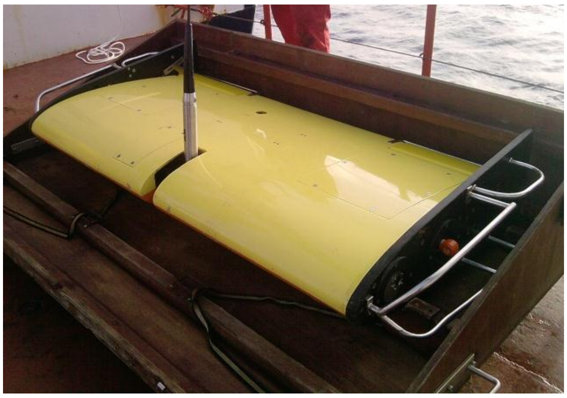


Figure 5.2
Example processed OS75 VMADCP data covering several days and tidal cycles on the shelf

6 Scanfish Processing

Dr Dmitry Aleynik , SAMS

6.1 *Introduction*

Scanfish CTD data were obtained from the FSI CTD unit, Haardt Fluorometer and AANDERAA CTD sensors all borrowed from the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) along with the Scanfish frame and body. The main pressure temperature sensors and conductivity cell were sited on right side of the Scanfish body, while the Fluorometer and the secondary CTD (AANDERAA) unit were on its left side. The specification details of the Scanfish are given in the manual technical report, this section describes data acquisition and processing. All scanfish CTD profiles were acquired with CTDAcq-DT application version 3.56 and have been processed during the cruise with Citadel CTDPost Processing version 3.57 software; both from Teledyne RD Instruments updated in 2010. The original CTD data was combined with ship navigation data to provide accurate information on vertical distribution of the water parameters, and to calculate its position in the water using the ship as a reference.

6.2 *Acquisition*

Before data acquisition begins two deck units are started – for Scanfish flying operations and the other one for data from FSI CTD. Software setup includes several sequential steps described below:

1. Establish communication to FSI CTD using [File] menu and [configure instrument] panel, which invoke instrument setup data with Direct-DT, baud rate 300, com-port 3. And select additional channels (DC6,7,8 for Flourometer). Scan rate was defined at 25 scans (per second).
2. In Calibration setup pressure correction value for slope B=0.01666 should be applied.
3. Enable communication with Navigation input (com port 3) at baud rate 4800 and select PC or GPS time stamps to be recorded.
4. Pressing [Start up cast] acquisition allows define the output filename and folder.

5. Close the file using the [End up-cast] button, which allow software to finalise all the files and write correct settings in the header and calibration files.

6.3 *Processing*

Raw Scanfish CTD data was processed following standard way used in hydrographic cruises. After each series of tow-yo Scanfish CTD casts were completed. The data was saved to the deck unit PC and transferred over the ship network to the Unix data disk.

The CTDAcq_DT writes 5 files per each series of tow-yo: *"Test_n01_01"* with the following extensions: *.raw* (raw data file), *.c00* (data configuration file), and *.hdr* (a header file) as well as supplementary files: *.btl*, for bottles fired, *.ltg* with station listing information, and *.EDT* with binary data (a copy of. *raw* data file edited).

Calibration data for FSI has been invoked from the instrument CTD-ES-R firmware version 3.6 and S/N 1366I and dated to 05 Nov 2005. Calibration parameters from *.C00* files for each sensor are in the Tables.9-11**.** Data from fluorometer (channels DC6, 7, 8) was stored in counts units.

Table 6.1 Temperature Sensor calibration parameters

TEMPERATURE STANDARD TEMPERATURE S/N	ATB-1250
SPRT SENSOR S/N	
DATE LAST STANDARD CALIBRATION	**05/11/05**
PLATINUM TEMPERATURE SENSOR S/N	
P,T,C INTERFACE S/N	
DATE LAST TEMPERATURE CALIBRATION	
A	0.0
B	0.0
C	0.0
D	0.0005
E	0.0
LAG	0.150
LAG'	0.0

Table 6.2 Pressure Sensor calibration parameters

DATE LAST STANDARD CALIBRATION	**05/11/05**
PRESSURE SENSOR S/N	
P,T,C, INTERFACE S/N	
DATE LAST PRESSURE CALIBRATION	
A	0.0
B	0.0
C	0.0
D	0.016666
E	0.0

LAG	0.0
LAG'	0.0

Table 6.3. Conductivity Sensor calibration parameters

CONDUCTIVITY	
CONDUCTIVITY STANDARD S/N	ATB-1250
CONDUCTIVITY INTERFACE S/N	CSA-1250
CONDUCTIVITY SENSOR S/N	
DATE LAST STANDARD CALIBRATION	05/11/05
CONDUCTIVITY SENSOR S/N	
P,T,C,INTERFACE S/N	
DATE LAST CONDUCTIVITY CALIBRATION	
A	0.0
B	0.0
C	0.0
D	0.001
E	0.0
LAG	0.0
LAG'	0.0
ALPHA	-6.5E-6
BETA	1.5E-8
T0	2.8
P0	3000.0

6.4 *Scanfish FSI Data processing routine descriptions*

Raw binary data from the FSI instrument were stored at folders:
Z:\SCANFISH\FSI_DATA\tests\test_n01\ … test_n31
Z:\SCANFISH\FSI_DATA\canyon
Z:\SCANFISH\FSI_DATA\line_no01
Z:\SCANFISH\FSI_DATA\repeat_no1
Z:\SCANFISH\FSI_DATA\zigzag

Raw ascii Conductivity, Temperature, Pressure and engineering data from the AANDERAA scanfish instrument were stored in the files *ScanfishYYYYMMDD_hhmmss_C.NPD '* at folders:

Z:\SCANFISH\NPD_DATA\170612\
Z:\SCANFISH\NPD_DATA\190612\
Z:\SCANFISH\NPD_DATA\230612\
Z:\SCANFISH\NPD_DATA\250612\

Ascii files were produced with **CTD Post v3.57** post-processing software using [File] – [Data] - [Save data] menu and stored at Z:\SCANFISH\raw_data\raw_data.zip. The *.txt* files are in the separate subfolders for each experiment respectively:

Z:\D376\SCANFISH\raw_data\L\line_no1_03.txt
Z:\D376\SCANFISH\raw_data\L\line_no1_04.txt

Z:\D376\SCANFISH\raw_data\R\repeat_no1_01.txt
Z:\D376\SCANFISH\raw_data\R\repeat_no1_02.txt
Z:\D376\SCANFISH\raw_data\R\repeat_no1_03.txt
Z:\D376\SCANFISH\raw_data\R\repeat_no1_04.txt

Z:\D376\SCANFISH\raw_data\C\canyon_no1.txt
Z:\D376\SCANFISH\raw_data\C\canyon_no2.txt
Z:\D376\SCANFISH\raw_data\C\canyon_no3.txt

Z:\D376\SCANFISH\raw_data\Z\zigzag_no1.txt

These ascii files have been de-spiked against main outliers using sorting for pressure, temperature and conductivity columns and resorted again using scan number column data.

Time series of EA500 Echo-Sounder data and the best-navigation underway data has been collected by Jo Hopkins at 1s rate and aligned with the ship GPS navigation data to produce the bottom relief profiles during the scan-fish tow-yo transects. The echo-sounder data have huge gaps, but the accuracy of Navigation data allowed recover the scanfish position on Zigzag tow-yo section. In all the rest of the experiments data from GPS has been stored in FSI raw data.

6.5 *Scanfish Conductivity / Temperature data alignment.*

For alignment between platinum temperature sensor and conductivity cell data there are two approaches which have been developed for FSI and for AANDERAA data respectively: We performed tests for maximum correlation between two data rows (FSI, AANDERA) and for minimum variance (AANDERA) of conductivity C_i when it is aligned with temperature records using formulae:

$$C = C_i \cdot R + (1 - R) \cdot C_{i-1};$$

Where *i* is the index of the current data point (scan number for FSI), and R is the delay coefficient. We found for AANDERAA that the minimum variance was obtained when conductivity was delayed from temperature with R=0.717 (M. Inall script *NPD_align_1.m*) and the maximum correlation achieved with *R*=0.65. For FSI the maximum correlation was obtained with *R*=0.4 at 99% correlation confidence interval using *cor_sig.m* matlab script written by A.Shaw.

Slightly different value Rwo= exp(–1/25·0.15)=0.7659 was used previously in the FSI post-processing Fortran code provided by CEFAS *CE0708_040_prs.for.* For conversion of the fluorometer counts from DC6 channel into µg/L we applied the SEPA recommended values for nominal range 1 - 5 v:

FIC = 20*(DC6/16383), and for range 2 – 5 v. FIC = 100*(DC6/16383)

6.6 *Scanfish ASCII data post-processing*

In the D376 cruise Scanfish was generally 'flown' at a tow speed of 7.5 - 8.0 knots, on a cable wire in 550m behind the ship from 1-5m below the surface to the depth 100-120m in the deeper areas and within 10m above the sea bed in the shallower parts of the transects. Cycling every 2 minutes gives an effective horizontal resolution of approximately 400 -500m. Data from Scanfish presented in this report have been gridded onto tz- and xz-planes using linear:

a) time weighting, with Δt=120/86400 seconds, Δz=2 m and a search radius defined by sx=300/86400seconds and sz=2 m. and / or
b) distance along the transect weighting, with Δx=500 m, Δz=2m and a search radius defined by sx=3*Δx and sz=2 m.

For post-processing of the Scanfish data several Matlab scripts have been developed, adjusted and stored at c*:\D376\SCANFISH\code*

R1_get_fsi_mtm.m – to read ascii input data and store it in mat arrays.
R2_mk_combined_tgrid_FSI_L1.m – *g*ridding along transects time or distance array
R4_plot_combined_dist.m – plotting of the combined grid for each tow.
R5_plot_segments_gridit.m – plotting of the segments.

6.7 *Results from the Shelf Break – Jones Bank Line*

(Figures. 6.1 - 6.5)

The first transect was performed between 17-Jun-2012 06:44:51 and 21:38:51 GMT in coordinates 48 02.00' N, 9 48.00'W and 49 40.00' N, 8 08.00'W. (*Fig. 6.1*) from depth 3000m to ~100m. The second transect we started on 17-Jun-2012 21:50:48 and finished on 18-Jun-2012 09:20:22 GMT, in coordinates 49 39.00' N, 8 10.20'W and 48 24.00' N, 9 23.50'W, ¾ of the way of the 1st one. (*Fig. 6.5*).

The transect line was approximately perpendicular to the Shelf Break isobaths. At the beginning of deployment, after the 3rd dive, when the instrument approached depth 30m the data flow from the FSI instrument became unstable as we found out only after instrument recovery and data files were finalised. A failure in communication/wiring was identified and secondary instrument servicing along with cable termination maintenance was performed afterward and before the next (Repeat) survey. Sparse data from FSI on the first transect line allows the capture main features of thermo-haline structure over the area shown on fig. 11. At the deepest part of the transect, the high saline (>35.4 psu) waters occupied all observed depth range (0-120m), while the coastward section of the transect was filled with low saline waters (<34.2). In the central part of the transect at depth 40-55m two discrete lenses of anomalously high-salinity and high temperature water was found. These objects were similar in horizontal scale (~ 5-10km) to the features pronounced as the density spikes at the distance range 75-150km from shelf break to Jones Bank transect TR1 fulfilled on 25-26th July 2008 in JC25 cruise [Inall, Aleynik et al, 2011]. Multiple lens presence recently has been detected in same area in [Hopkins, et al 2012], who give the estimates of its transport velocity, which match well with the magnitude of measured residual currents, and the hypothesis of its generation mechanism as the result of breaking internal wave packets at the shelf edge, leading to increasing of intra-thermocline mixing.

The data from Anderaa instrument were available with 1s resolution, but with the significant offsets in compare to FSI data. The offset for Temperature was defined as – 0.15ºC, and for conductivity ratio = –0.0806. The vertical distributions of the Temperature, Salinity and Potential Density along the two lines according to AANDERAA are shown at Fig. 5.4a-c for the Shelf-Break to Bank transect and on Fig. 6.5a-c for the Bank to Shelf Break transect.

6.8 ***Repeat survey and lattice grid***

(Figures. 6.6 - 6.7)

The 3rd survey was fulfilled between 19 Jun-2012 10:37 and 20 Jun-2012 14:23 GMT in two parts: repeat transects between site A (49 08.88' N, 8 26.02'W) and B (49 15.12' N, 8 33.98'W) (*Fig. 6.3*) at the shallow central part of the Celtic Sea with depth 100-200m. When the location of the higher salinity lens at mid-depths was identified closer to the southern edge of the repeat survey, the lattice of scanfish tracks were designed and started at 19-Jun-2012 20:22:30 to capture its 3D dynamics in spatial-temporal continuum.

The data obtained on this scanfish experiment revealed high quality and the gridded (dx=2 minutes, dy=2 m) overall 'combined' transects of temperature salinity, density and fluorescence are shown on Fig. 6.6 (a-d). Further analysis would expect application of the "moving frame" platform coordinate system centred at certain time (central time of the survey, assigned to fixed tidal phase) to the positions of all data points.

Zone of higher salinity (probably one of the lenses) was crossed by scanfish lines at least 17 times of 19 transects. Upper layer 0-40m contains low saline waters (35.2 - 35.25) on the northern segments, and >35.3 waters on south-eastern part of segments. In the layers 45-90m salinity varies in smaller range (35.30 - 35.42 psu). Temperature of upper layer varied between 14.5 and 13.5 ºC, and below sharp thermocline the temperature was 11 - 12 ºC. Highest fluorescence was observed between 10 and 25m.

6.9 ***Canyon Scanfish Survey***

(Figures. 6.8a-d)

The 4th scanfish survey was performed in the area where the tide met the shelf edge. The continental slope in the study area has quite corrugated bathymetry – multiple Celtic Deep Sea Fan systems consisting of several deep channels delivering debris and other materials from the Celtic Margin and Celtic sand banks down to the foot step of the continental slope through two main (Whittard and Shamrock) systems [Drozet al 2003]. The eastern branch of Whittard channel system - the Petite Sole Canyon - was chosen to perform the next experiment in attempts to estimate and quantify the presence of tidal energy flux upward along the canyon axis, established in a typical Monterrey Canyon survey [Kunze et al 2002] and how its altered by narrowing of the bottom and side wall topography and by variations in the sea water property distribution.

For this purpose two sequential surveys were designed – Canyon and Zigzag. The first survey took place in the upper part across the canyon, with depths 180m on SE side, 900m in the central trench and ~400m on its NW wall, Fig 6.1b-3. During 15 hours (1 and ¼ of dominant M_2 tidal cycle) we performed 8 transects between 10:17 23rd June and 01:27 24th June 2012.

In temperature field we observed deepening (with a pick up to 70m in central part of the canyon on low tide phase, 14:37 - 16:07 GMT) and narrowing (~20m, high tide at 19:38 - 21:38 GMT) of the upper warm layer (14 - 13.2ºC), which was well consistent with tidal cycle (Fig. 6.8a panel 4, 6). The snapshots of vertical distribution of salinity across the transect reveal two-pattern systems: higher salinity (>35.44) feature on the NW side of the canyon and low saline (<35.43) on its SE side. The absolute difference was tiny, but well recognisable with a given instrument. According to the data, shown on Fig. 6.8b, vertical movements of the high saline feature were also well correlated with tidal phase. We can detect vertical displacement only for layer 0-110m limited by the maximum depth of the instrument deployment. The conclusion can be derived that the south eastern side provide the outflow for less saline (shelf) waters downward the canyon especially on an ebb phase. In an opposite the north western wall of the canyon can work as channel for delivery of higher saline (oceanic) waters toward the shallow part of the Celtic sea during the flow tidal phase. With some other preferable conditions (i.e. spring tide, favourite winds or/and strong enough internal wave packet arrival) the along canyon axis flow pattern could breaks and form individual lenses separately mowing (with residual current speed) toward the central part of the shelf. The highest fluorescence values were observed on low tide (ebb) phase when outflow from shelf dominates.

6.10 *Zigzag Scanfish Survey*

(Figures. 6.9a-d)
To detect such an event the Zigzag scanfish survey was designed and performed (Fig 6.1b-4) between 11:13 25th June and 04:38 26th June 2012 within coordinates 48 05.00’ N, 9 39.00’W and 48 48.00’ N, 9 02.0’W.

On the first line of the zigzag transect higher salinity waters were detected over the Canyon, extended very close to surface, and one small salty blob at depth 15 - 30m, which just start its separation from a main saltier body survey (1st panel, Fig 6.9b). This process developed later into completely separated and still higher salinity lens, which has been detected on approach to the shelf break zone near the entrance to the canyon around 3:00 GMT 26th June 2012 during the last backward transect of the ZigZag survey (last panel, Fig 6.9b). This signal also well represented in temperature (slightly colder waters), and in potential density fields. A small consistent signal was also detected in the vertical transects of the velocity data from vessel-mounted ADCP from both 75 and 150 kHz instruments (ref. to VM-ADCP section of this cruise D376 Report). Lower values of fluorescence distribution also were detected within this lens (Fig 6.9d).

The main result of the Canyon-Zigzag scanfish surveys can be summarised as the recognition and localisation of *canyon salt canon* which is able to pump in certain conditions (spring/neap tidal cycle and phase, favorable wind) the small scale salt lenses toward central part of Celtic Sea shelf.

6.11 *Long Line 2 from the Shef Break to Jones Bank*

(Figures. 6.10a-d)

The last Long Line 2 transect was performed between 30th June 2012 10:10 and 23:53 GMT in coordinates 48 07.61' N, 9 48.00'W and 49 45.00' N, 8 04.00'W from depth 800m to ~80m south of Jones Bank (*Fig. 6.1-10*).

The aim of the survey was to detect a presence of small and meso-scale features along the line extended from the shelf-break zone to the central part of wide shelf sea in the context of ocean-shelf exchange process, internal wave propagation and energy fluxes. The result of measurements is shown on Fig.5.10a-d.

6.12 *References*

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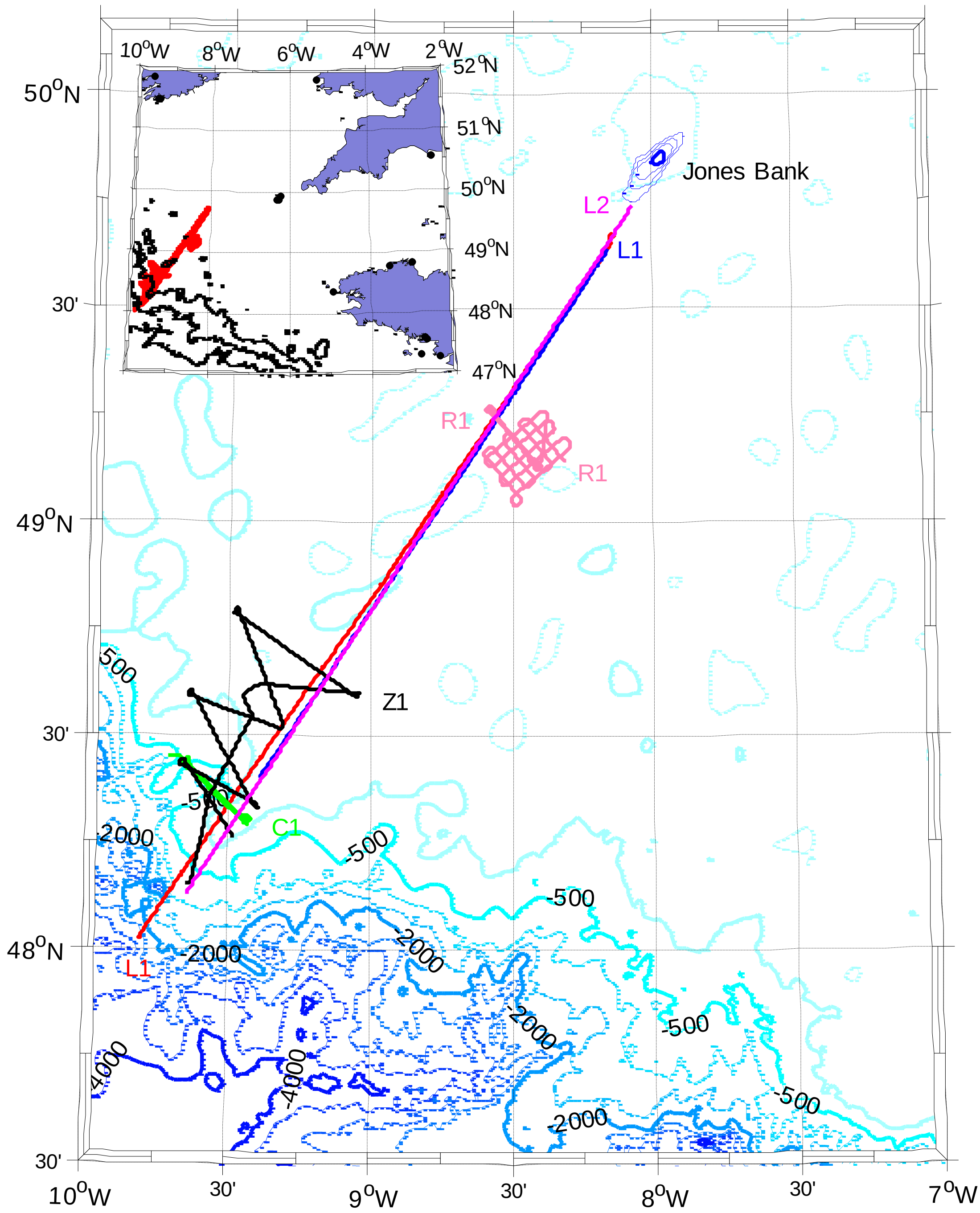


Figure 6.1a. Position of the Scanfish surveys, June 2012, D376 cruise: 1-2, 6. along the long Line form the Shelf Break to Jones Bank and return (L1, L2) and ETOPO-1 bathymetry of Celtic Sea and shelf break area.

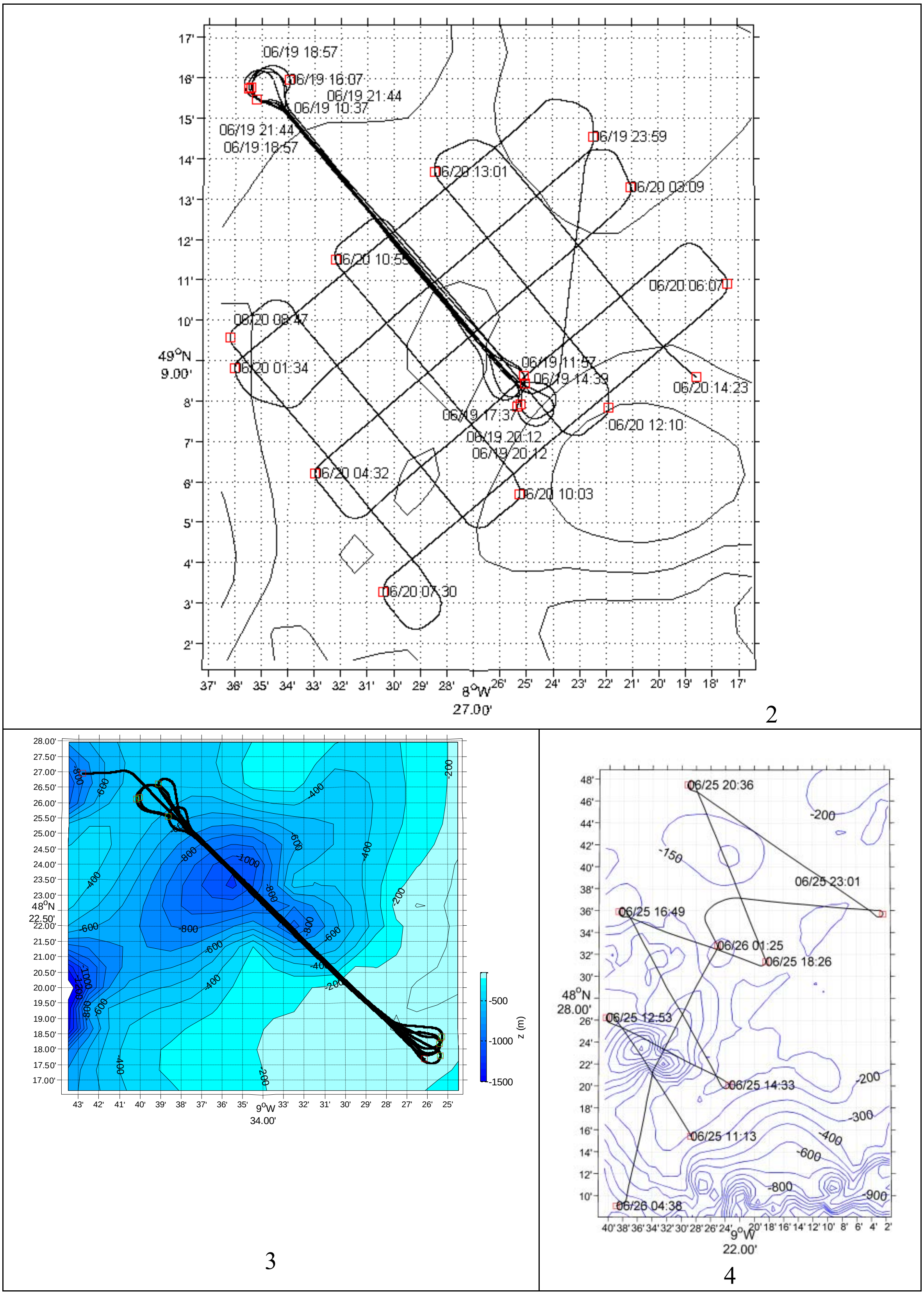


Figure 6.1b. Position of the Scanfish surveys, June 2012, D376 cruise:

2. Repeat survey over central part of Celtic Sea shelf (R),
3. Survey over the upper part of the Petit Sole Canyon (C),
4. Zygzag survey from Canyon to the central part of Celtic Sea Shelf (Z),

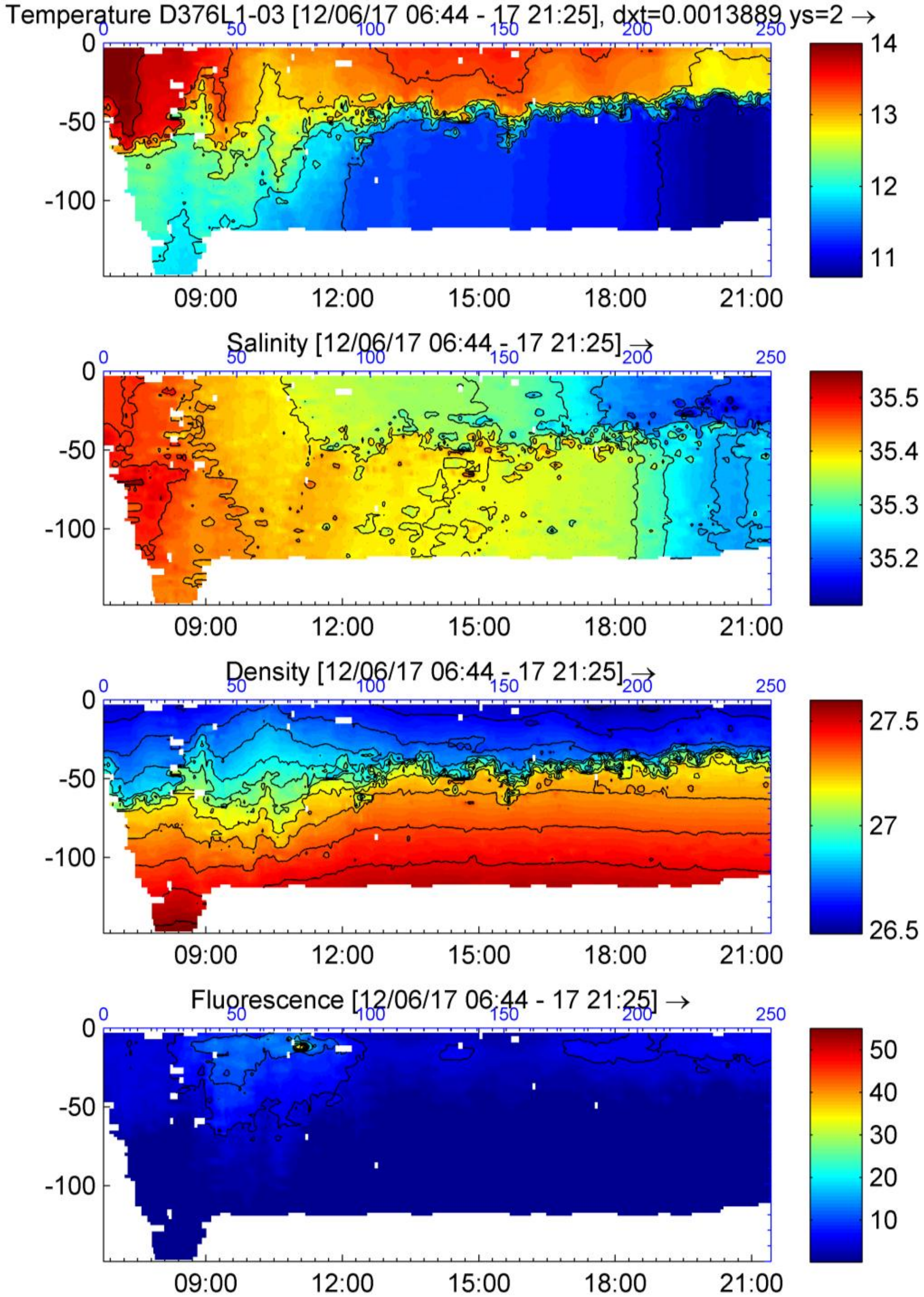


Figure 6.2. Vertical distribution of temperature, salinity, potential density and Fluorescence along the FSI Scanfish transect form Shelf Break to Jones Bank, Leg 1 from SW to NE, 17th June 2012.

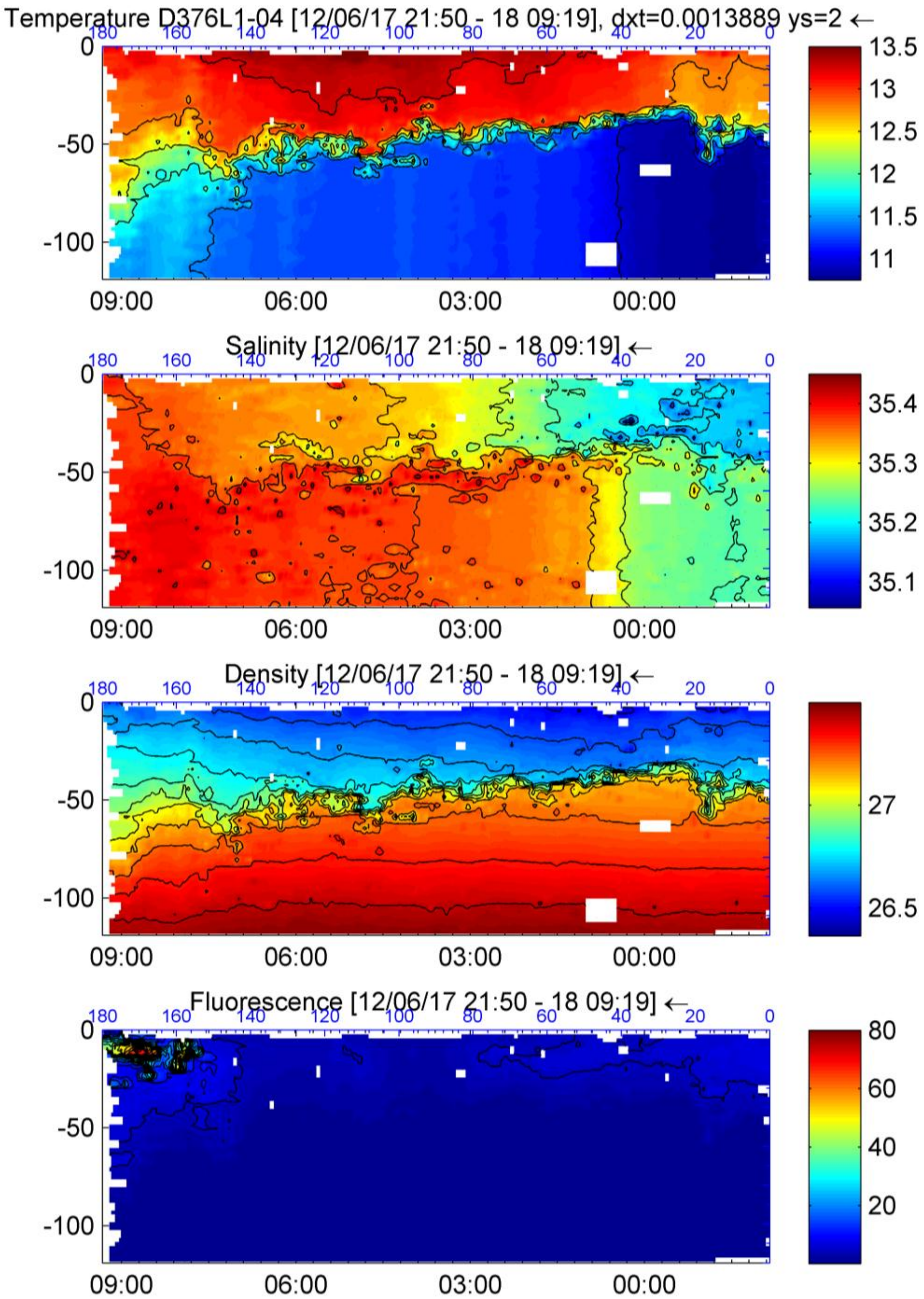


Figure 6.3. Vertical distribution of temperature, salinity, potential density and Fluorescence along the FSI Scanfish transect form Jones Bank to Shelf Break, Leg 2 from NE to SW, 17th & 18th June 2012.

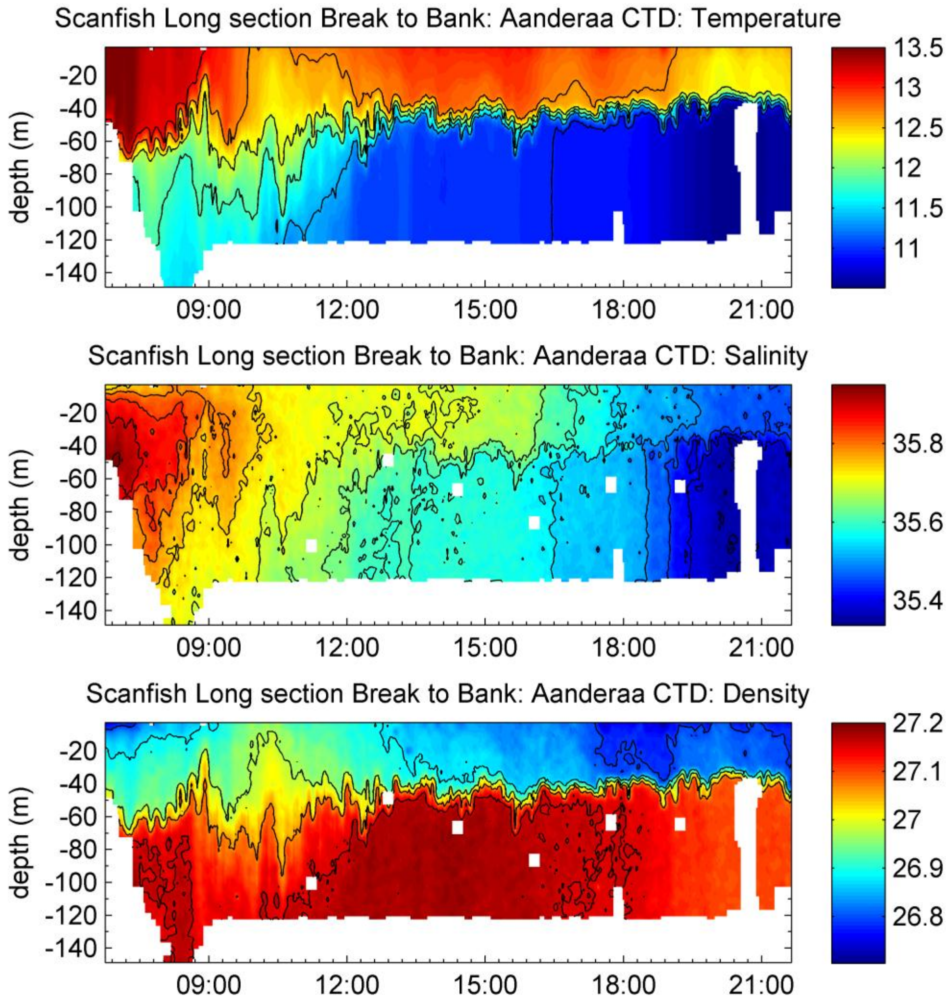


Figure 6.4. Vertical distributions of temperature, salinity, potential density along the AANDERAA Scanfish transect form Shelf Break to Jones Bank, Leg 1 from SW to NE, 17th June 2012.

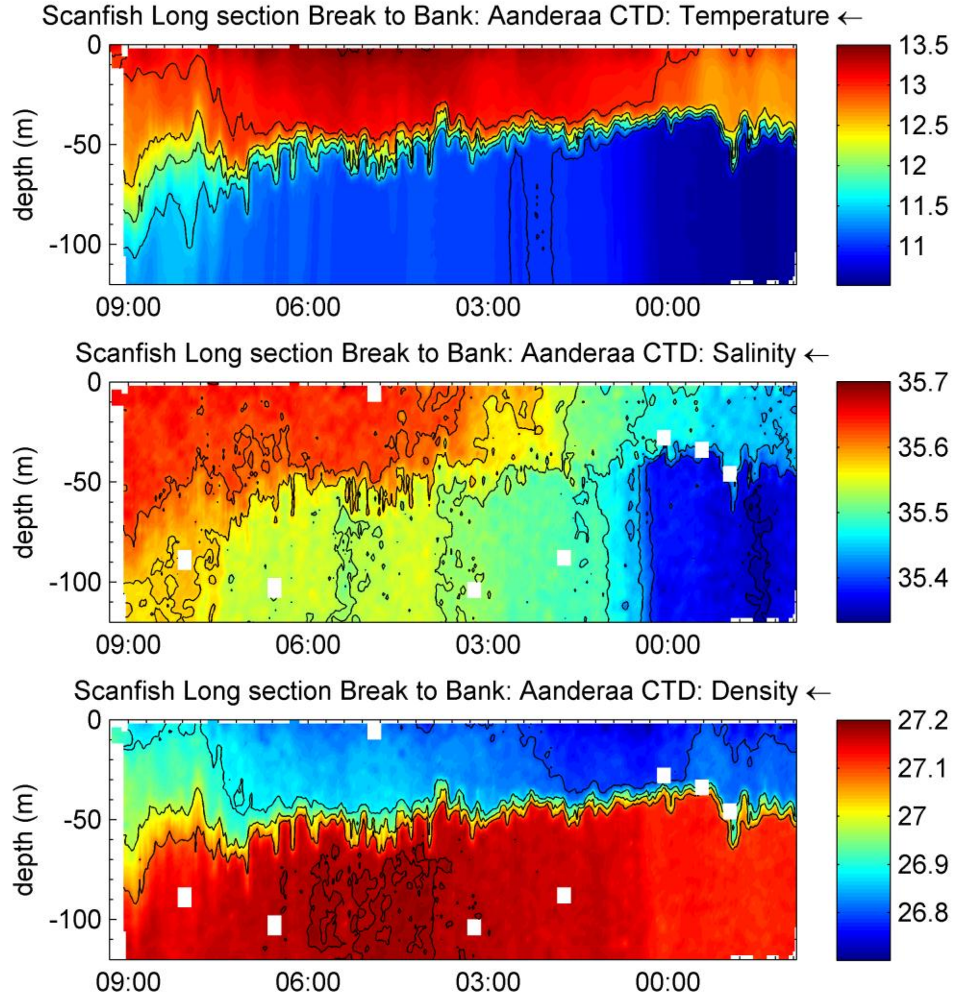


Figure 6.5. Vertical distributions of temperature, salinity, potential density along the AANDERAA Scanfish transect form Jones Bank to Shelf Break, Leg 2 from NE to SW, 17th - 18th June 2012.

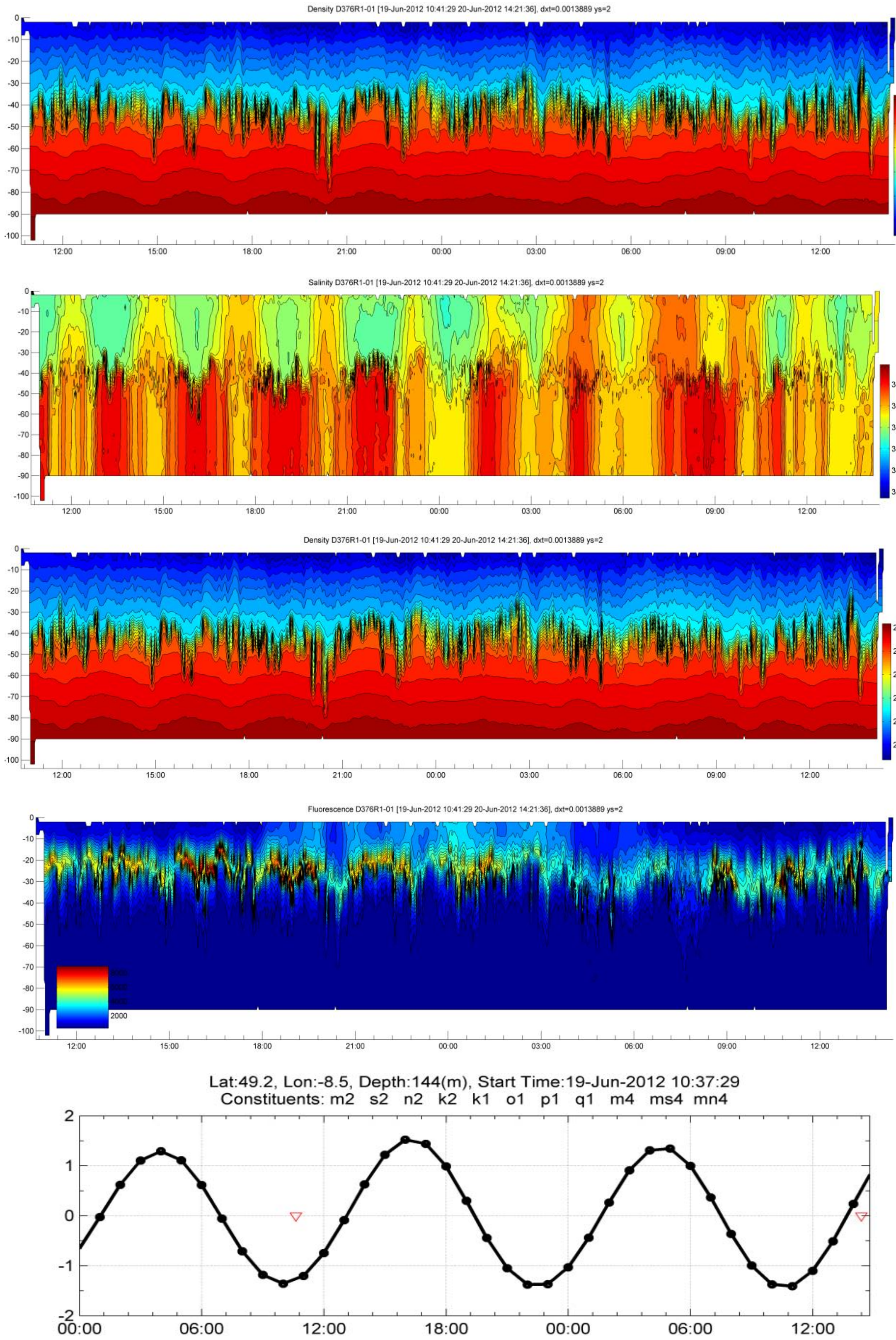


Figure 6.6 a-d Vertical distributions of temperature, salinity, potential density and fluorescence (counts) along the FSI Scanfish Repeat transects 19th - 20th June 2012. Tidal sea surface elevation, the survey time is marked with red triangles calculated with TMD2.03.

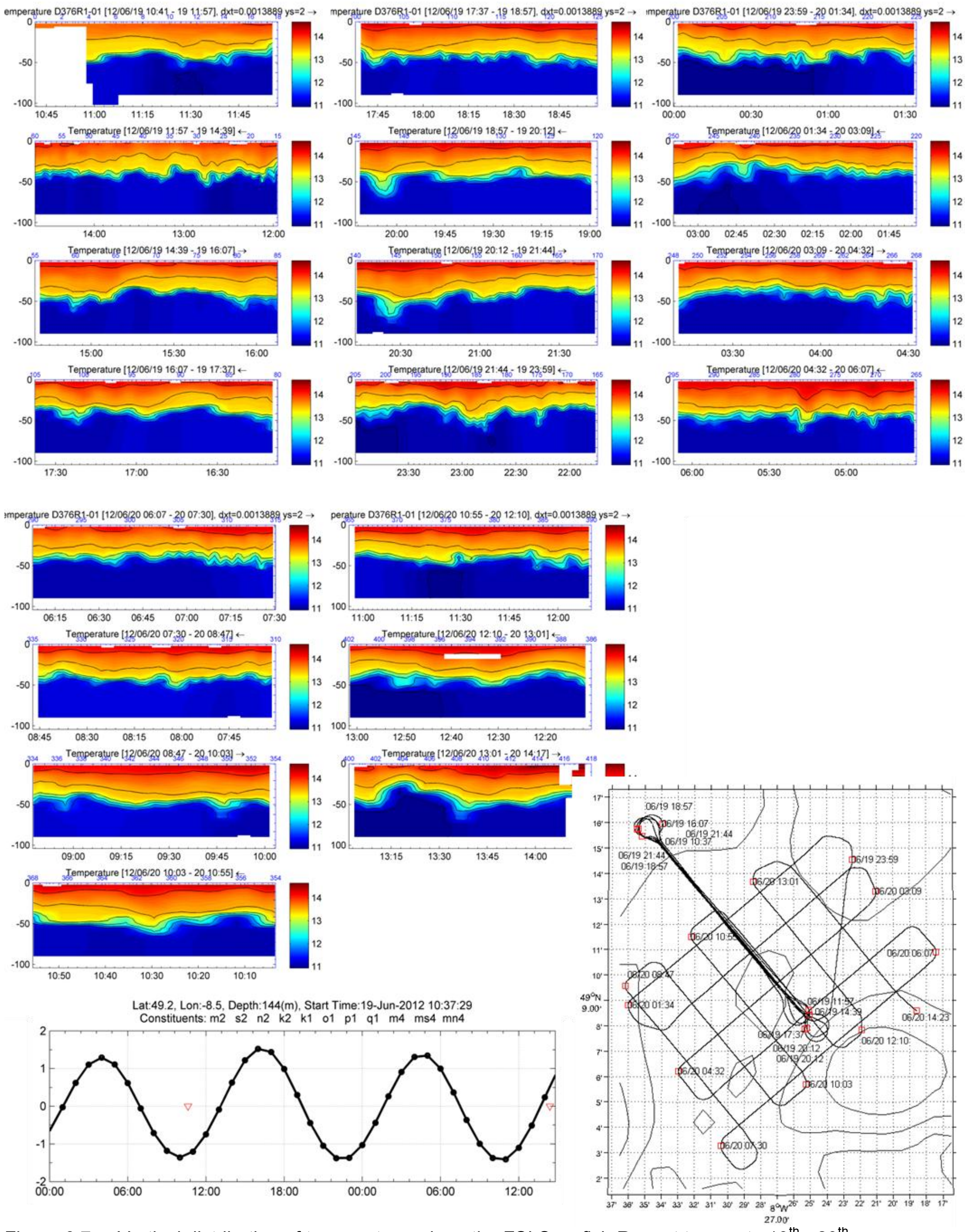


Figure 6.7 a. Vertical distribution of temperature, along the FSI Scanfish Repeat transects 19th - 20th June 2012. Tidal sea surface elevation, the survey time is marked with red triangles. Location of the transects is shown on a map with time stamps.

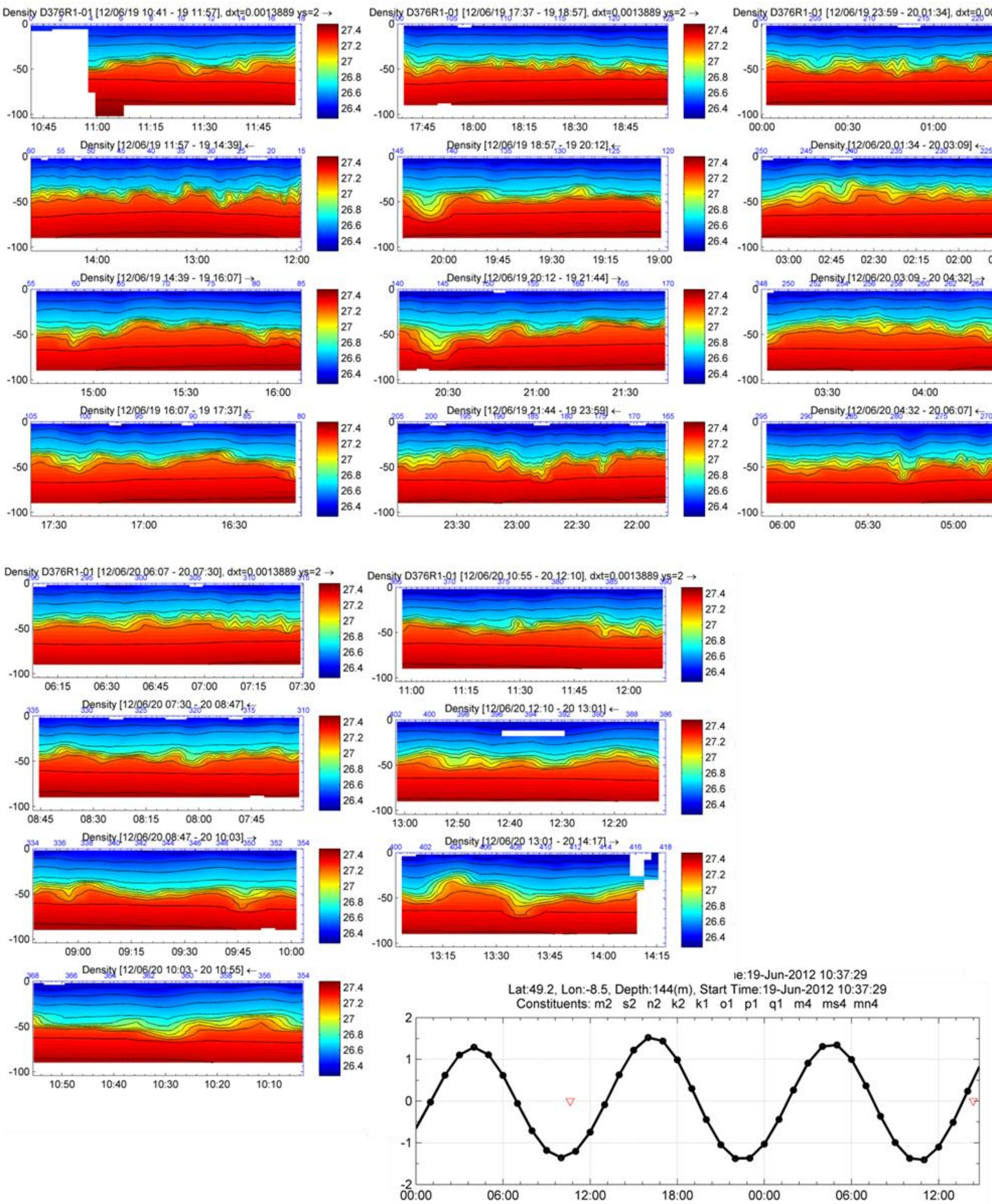


Figure 6.7 b. Vertical distributions of salinity (psu) along the FSI Scanfish Repeat transects 19th - 20th June 2012.

Figure 6.7 c Vertical distributions of potential density (kg m^{-3}) along the FSI Scanfish Repeat transects 19th - 20th June 2012.

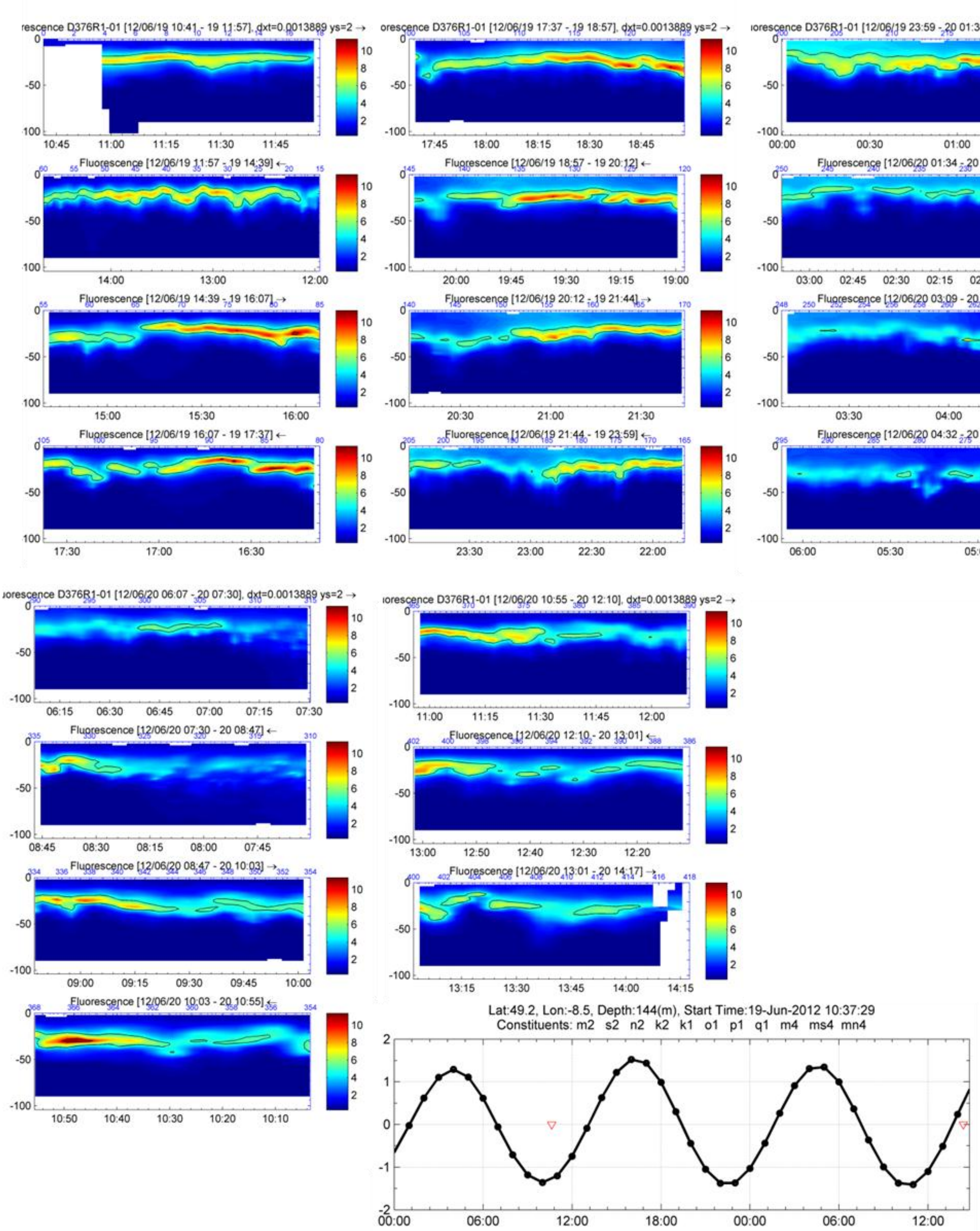


Figure 6.7d. Vertical distributions of fluorescence (μg L^{-1}) along the FSI Scanfish Repeat transects 19th - 20th June 2012

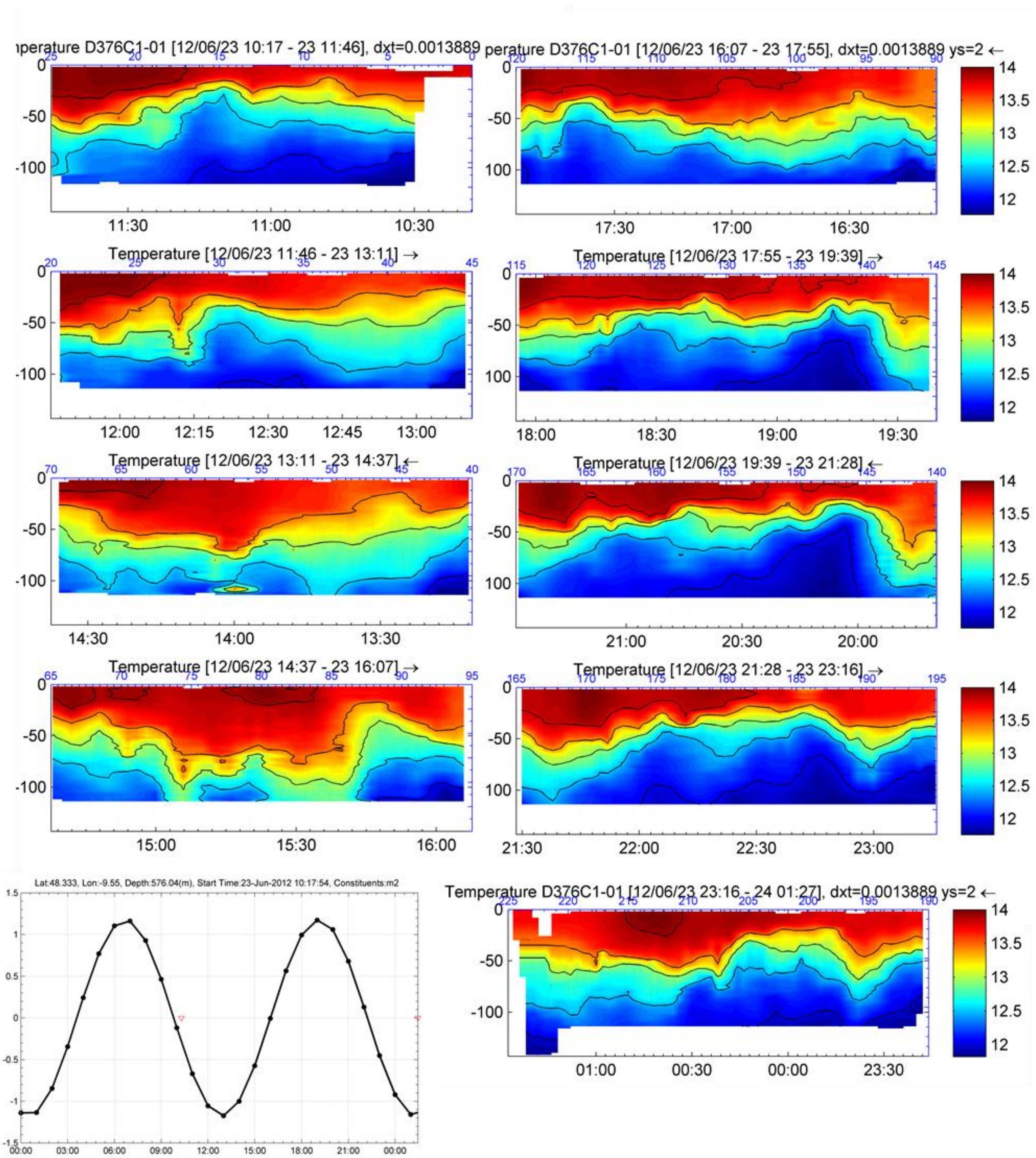


Figure 6.8a. Vertical distributions of temperature (a), salinity (b), potential density (c) and fluorescence (µg L^{-1}) (d) along the FSI Scanfish Canyon transects 23rd - 24th June 2012

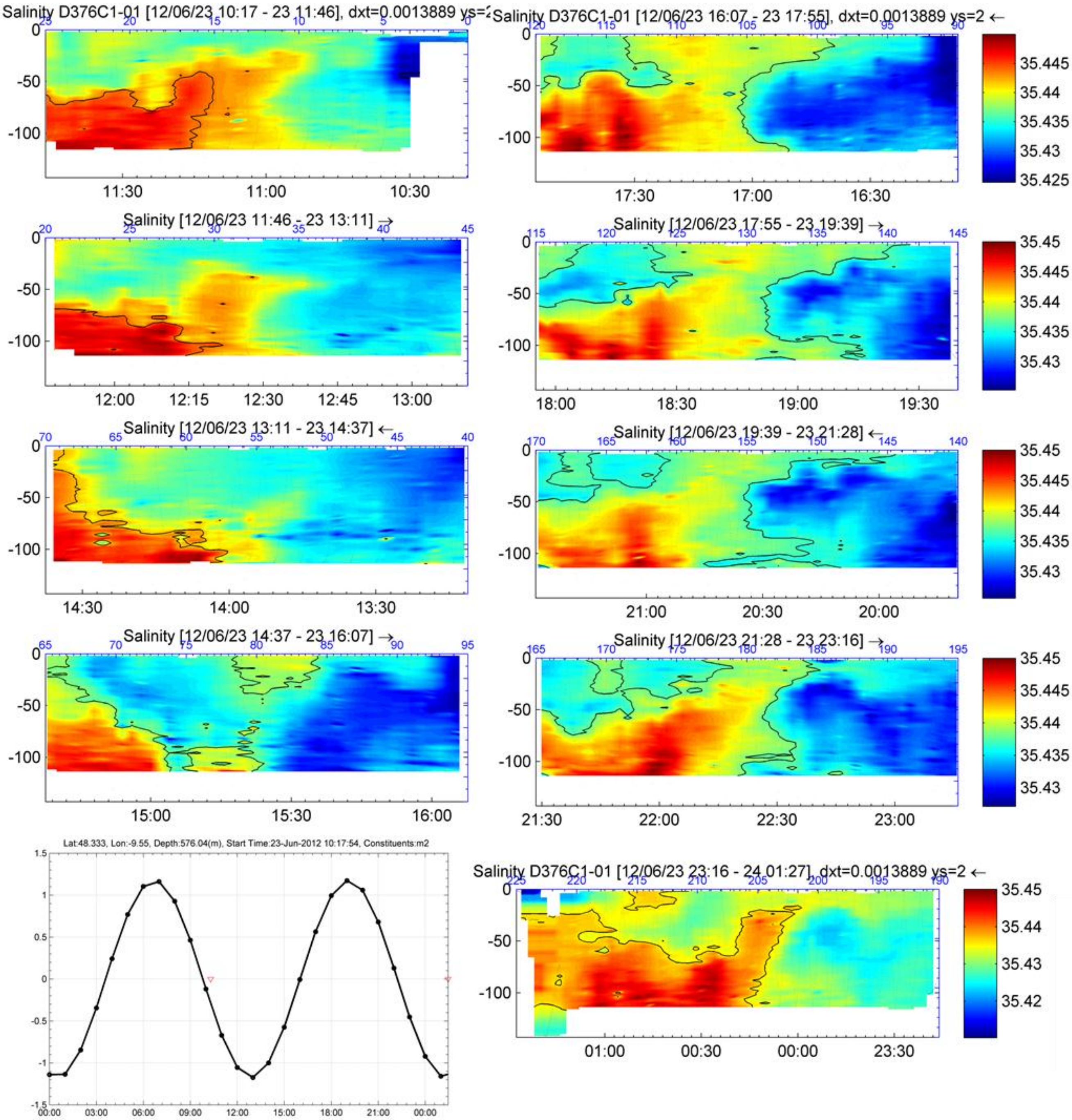


Figure 6.8b. Vertical distributions of salinity along the FSI Scanfish Canyon transects 23rd - 24th June 2012

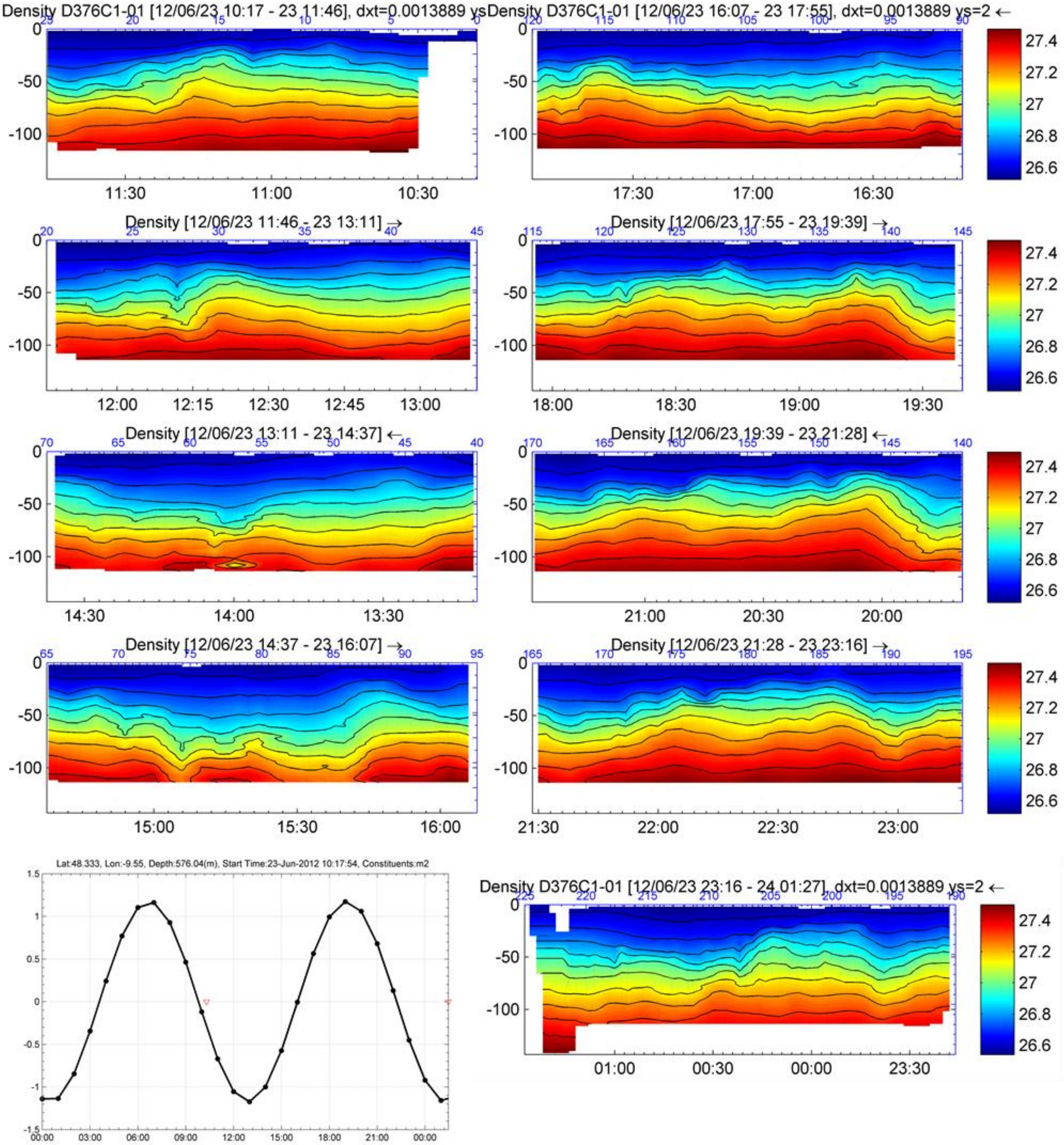


Figure 6.8c. Vertical distributions of potential density along the FSI Scanfish Canyon transects 23rd - 24th June 2012

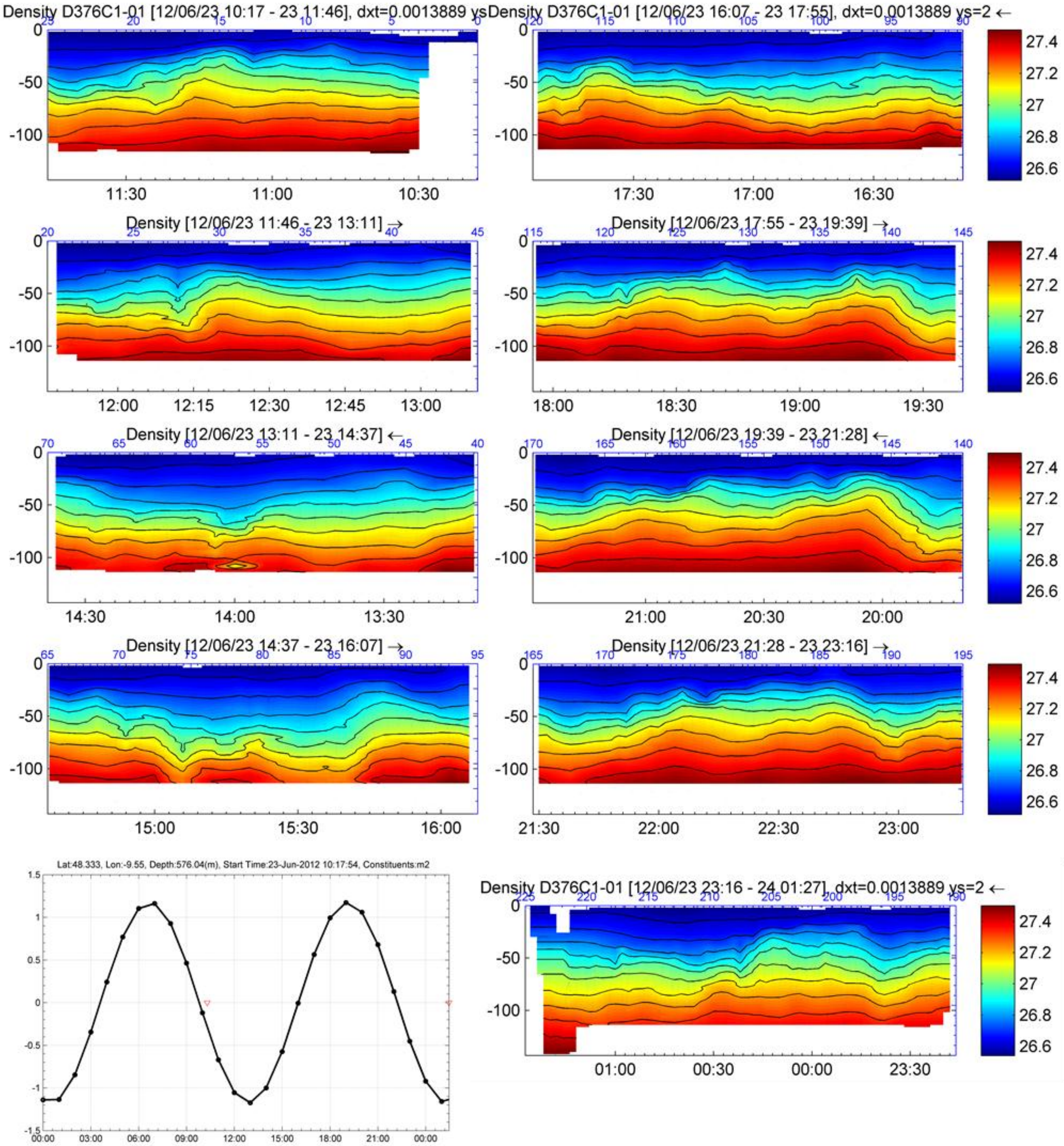


Figure 6.8d. Vertical distributions of fluorescence (μg L^{-1}) along the FSI Scanfish Canyon transects 23rd - 24th June 2012

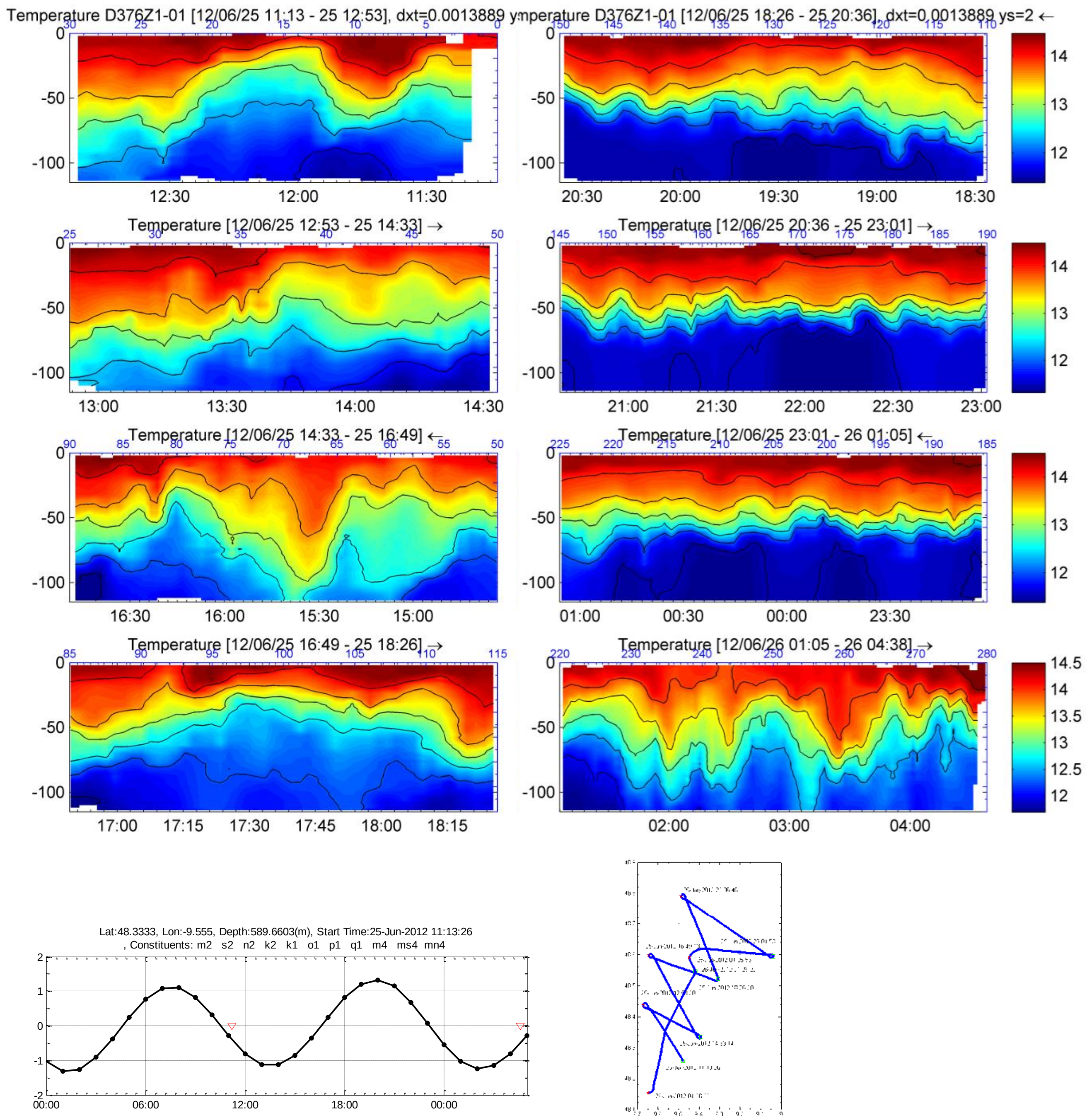


Figure 6.9a. Vertical distributions of temperature (a), salinity (b), potential density (c) and fluorescence (µg L^{-1}) (d) along the FSI Scanfish Zigzag transects 25h - 26th June 2012.

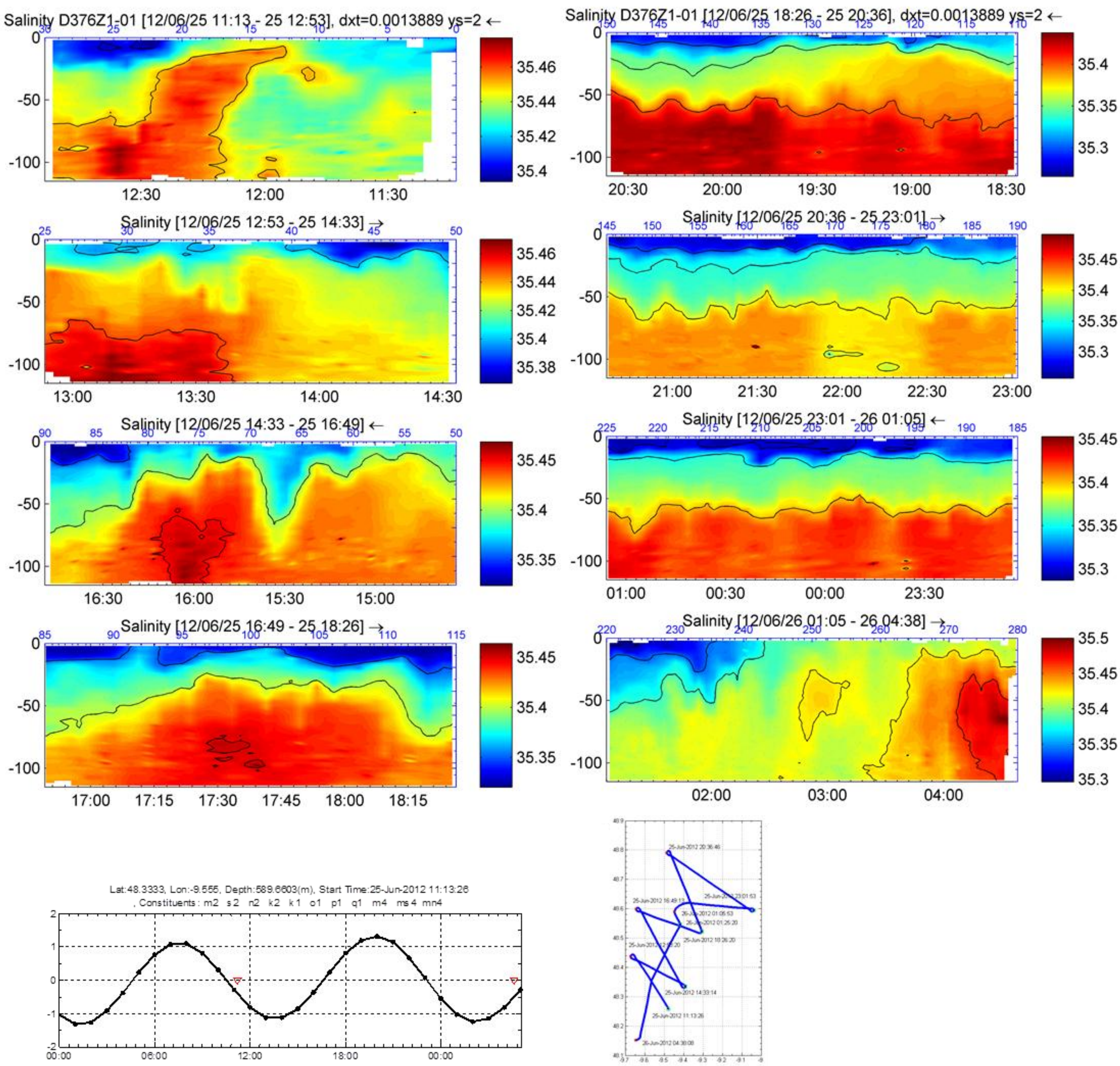


Figure 6.9b. Vertical distributions of salinity along the FSI Scanfish Zigzag transects 25th - 26th June 2012.

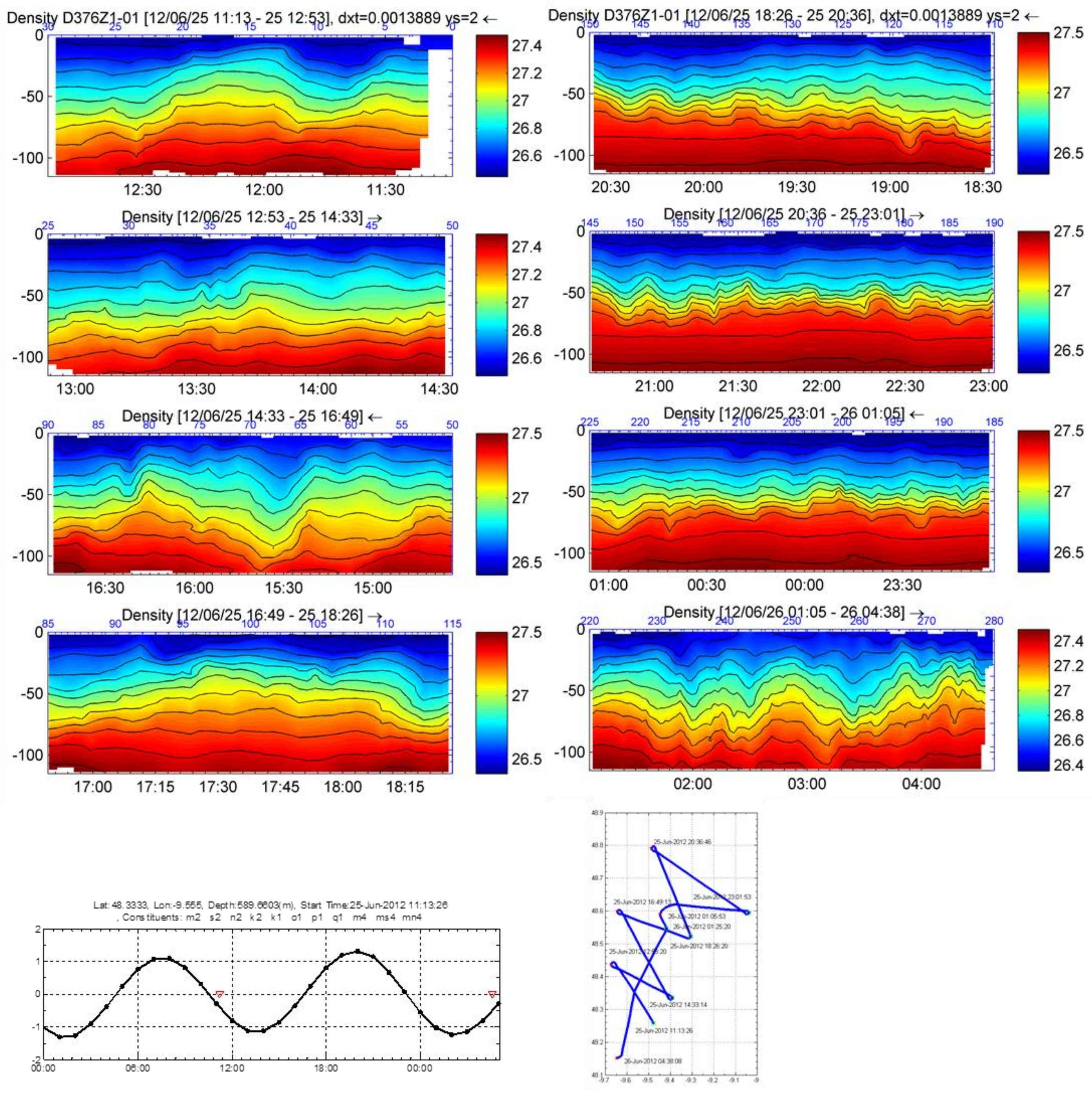


Figure 6.9c. Vertical distributions of potential density along the FSI Scanfish Zigzag transects 25th - 26th June 2012.

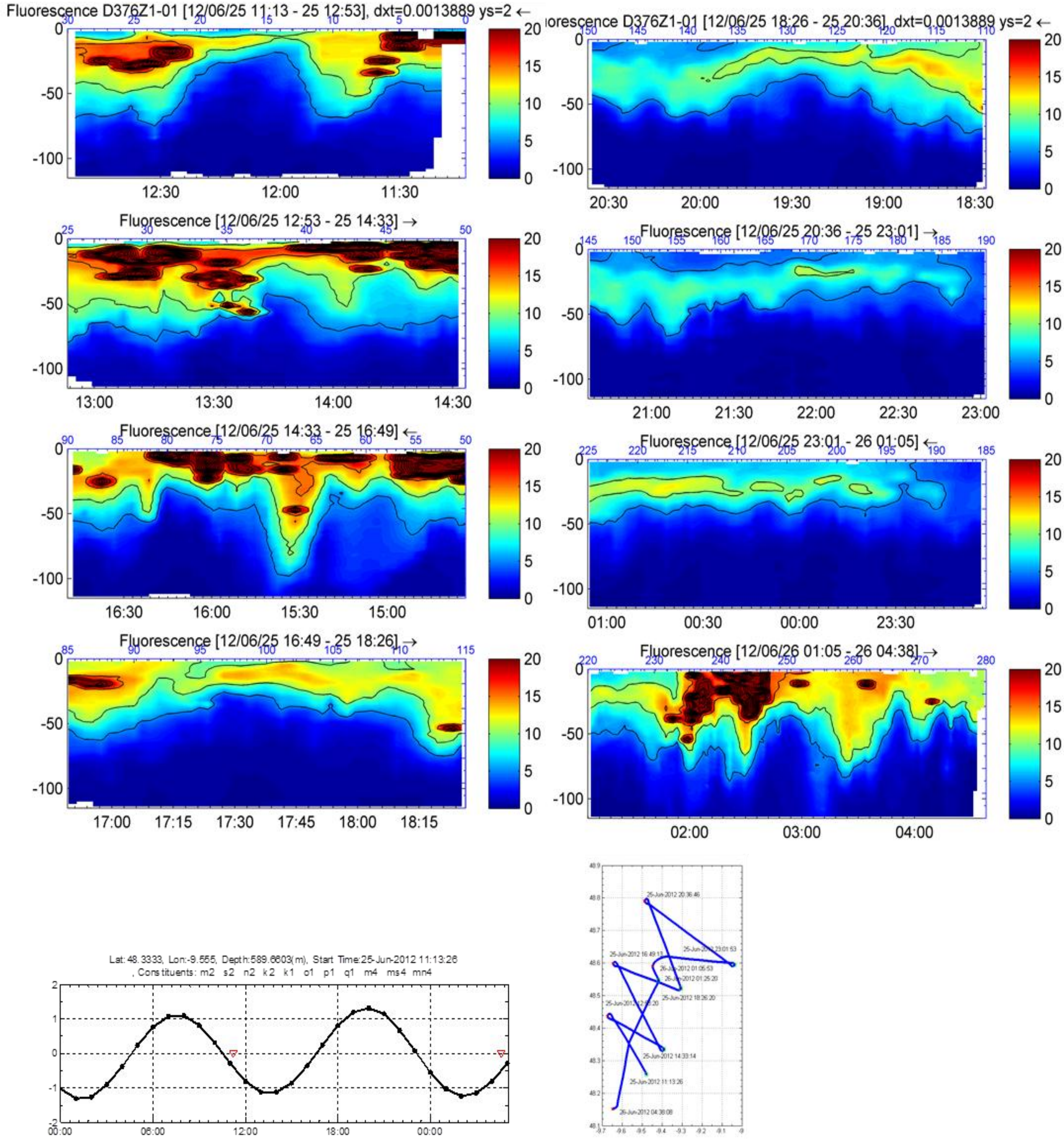


Figure 6.9d. Vertical distributions of fluorescence (µg L^{-1}) along the FSI Scanfish Zigzag transects 25th - 26th June 2012.

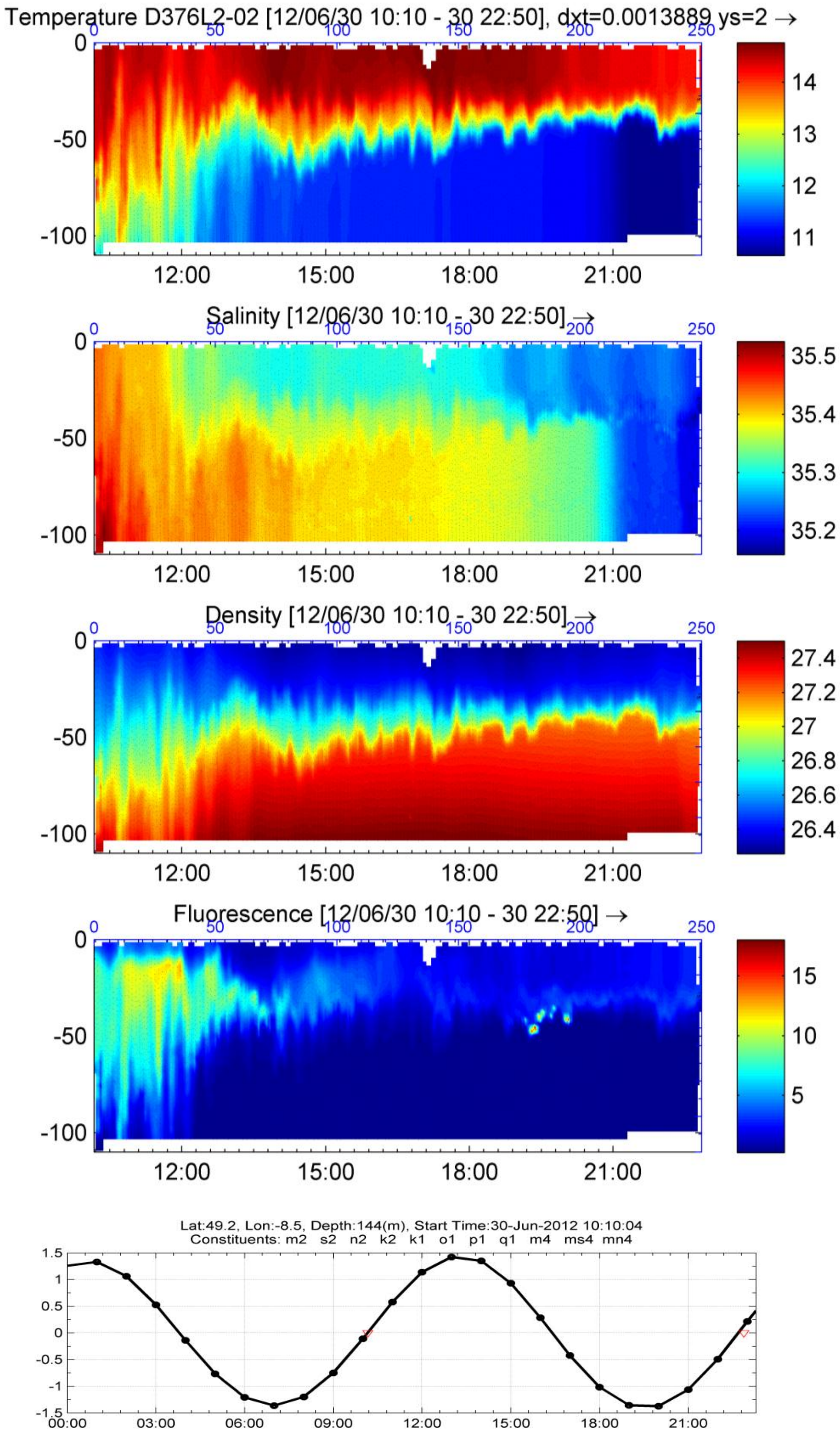


Figure 5. 10a. Vertical distributions of temperature (a), salinity (b), potential density (c) and fluorescence (μg L^{-1}) (d) along the FSI Scanfish Long Line 2 transect 30th June -1st July 2012.

7 Nutrient Biogeochemistry and dissolved oxygen.

Claire Mahaffey, Nealy Carr, Hannah Whitby

7.1 Aims during ***D376***

The aims of the nutrient biogeochemistry team were to (a) identify gradients in inorganic and organic nutrients across the shelf edge of the Celtic Sea, (b) identify gradients in phytoplankton community structure in surface waters across the shelf edge (c) calibrate the fluorescence sensor on the underway uncontaminated seawater supply and the fluorescence and oxygen sensors on the CTD and fluorescence, oxygen and CDOM sensors on the wire-walker and (d) collect seawater samples to determine the stable nitrogen and oxygen isotope composition of nitrate (δ^{15}N and δ^{18}O-nitrate) in deep waters. A series of sampling regimes were followed: (a) a cross shelf transect consisting of 9 stations (transect A), (b) repeat sampling at one on-shelf site and (c) sampling from the uncontaminated seawater supply.

7.2 **Sampling**

Transect A: CTD casts were performed at 9 stations along a transect perpendicular to the shelf edge, allowing cross shelf gradients in organic nutrients and phytoplankton community abundance and structure in surface waters and inorganic nutrients and the δ^{15}N and δ^{18}O-nitrate in deeper waters to be studied.

Table 7.1; Locations of cross-shelf edge stations A1 to A9, approximate water depth (meters, taken from altimeter during CTD casts), date sampled and corresponding CTD number.

Station name	**Latitude (N)**	**Longitude (W)**	**Water depth (approx. m)**	**Date sampled**	**CTD numbers**
A1	48° 1.67’	10° 12.67’	2375 2440	13/06/12 22/06/12	5 28
A2	48° 4.51	10° 16.49	1304 1336 1303	12/06/12 17/06/12 22/06/12	2 12 29
A3	48° 9.24	10° 22.41	633 624	13/06/12 23/06/12	11 30
A4	48° 14.42	10° 27.28	183 188	13/06/12 23/06/12	3 31
A5	48° 20.08	10° 33.57	146 142	16/06/12 24/06/12	10 33
A6	48° 23.85	10° 38.13	141 138	13/06/12 24/06/12	4 34
A7	48° 27.38	10° 40.94	154 155	16/06/12 24/06/12	9 35
A8	48° 30.68	10° 45.17	156 152	16/06/12 24/06/12	8 36
A9	48° 34.44	10° 49.76	159 156	16/06/12 24/06/12	7 37

Twelve depths were sampled between the bottom (10-20m above bed) and surface waters (5-10m depending on the weather). This was subject to successful closing of the Niskin bottles. Samples were collected for the following parameters in the following order: dissolved oxygen, dissolved organic nutrients and coloured dissolved organic matter, inorganic nutrients (concentration and stable N isotopes of nitrate, δ^{15}N-nitrate), chlorophyll and samples for phytoplankton enumeration and identification. Analytical methods are reported below. For details of CTD’s sampled, see table at end of this section. For details of depths sampled on each CTD cast at stations A1 to A9, please refer to Appendix 1.

7.3 **Calibration of sensors on the 'wire *walker':***

A 'wire walker' was deployed at ST3, which is the same site as A5 (see Table 7.1). In an attempt to calibrate the wire walker sensors, specifically the fluorometer (for chlorophyll and CDOM), and optode (for oxygen), the sensors were removed from the wire walker and strapped to the rosette frame on two occasions (CTD 4 on 13th June 2012 and CTD 60 and 61 on 30th June 2012). The CTD was deployed to 100m and samples were collected at between 10 to 20 depths between 0 and 100m.

7.4 ***Sampling the salinity intrusion:***

In order to (a) quantify the temporal variation in inorganic and organic nutrients at one site (with consideration of the tidal excursion) and (b) identify if there is a biogeochemical signal associated with the salinity intrusion (see report by Jo Hopkins), repeat sampling was performed at an on-shelf site (NAME), resulting in approx. 1 CTD cast every hour for 12 hours (Table 7.2). Five depths were sampled: 10m and 100m, then top, peak and base of the salinity intrusion. The signal for the salinity intrusion was weaker than previously observed, making the selection of depths to be sampled challenging. Samples were collected for inorganic and organic nutrients, phycoerthyrin and δ^{15}N and δ^{18}O-nitrate.

Table 7.2:. CTD number, date and time of repeat sampling at station A12 next to wire walker. Five depths sampled per CTD.

CTD no.	Date	Time (GMT)	Parameters sampled
16	18/06/12	22:16	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
17	18/06/12	23:32	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
18	19/06/12	00:32	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
19	19/06/12	01:29	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
20	19/06/12	02:31	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
21	19/06/12	03:34	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
22	19/06/12	04:30	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
23	19/06/12	05:31	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
24	19/06/12	06:30	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
25	19/06/12	07:49	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
26	19/06/12	08:32	Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate
27	*19/06/12*	*09:32*	*Nutrients, CDOM/DOM, phycoerthyrin, δ15N-nitrate*

7.5 *Calibration of the underway fluorescence sensor*

Seawater samples were collected every 6 hours from the uncontaminated seawater supply in the wet laboratory. Briefly, a 500ml HDPE amber bottle was rinsed 3 times and filled completely. The entire content of the 500ml bottle was filtered through a glass fibre filter (0.7 μm nominal pore size) using vacuum filtration. The filter was removed carefully with tweezers and placed in a glass test tube and capped. The vial was wrapped in foil, labelled and placed in the -80°C freezer until analysis (typically within 2 days). On 16th June 2012, a problem was identified in that the sample bottle had been changed from a 250ml to a 500ml bottle. Therefore, it was unclear which volume had been filtered until then.

7.6 ***Calibration of the fluorescence sensor mounted on the rosette frame***

The Chelsea Aquatracka MKIII (S/N: 0882614124) fluorometer was attached to the CTD rosette frame and was used to determine the vertical gradients in the photosynthetic pigment, chlorophyll a Fluorescence (in volts) was converted to fluorophor concentration (in μg l-1, CTDchl) using the manufacturers calibration information (see report on CTD sensors). Vertical profiles of calibrated fluorescence from CTD casts (CTDchl) were compared with extracted chlorophyll concentrations (see below for methods, BOTchl) for each CTD cast (Table 7.4) and for the entire cruise. For each CTD cast, the CTDchl at each bottle depth was correlated with the corresponding extracted chlorophyll concentration (BOTchl) and a regression equation was generated (Table 7.3). Please note that we have excluded data from the top 50m of the water column if the CTD cast was conducted between 7am and 9pm. This is due the well-recognised disagreement between upper water column fluorescence and chlorophyll a during daylight hours due to photo adaptation of phytoplankton cells exposed to high light (see section on calibration of underway fluorometer data).

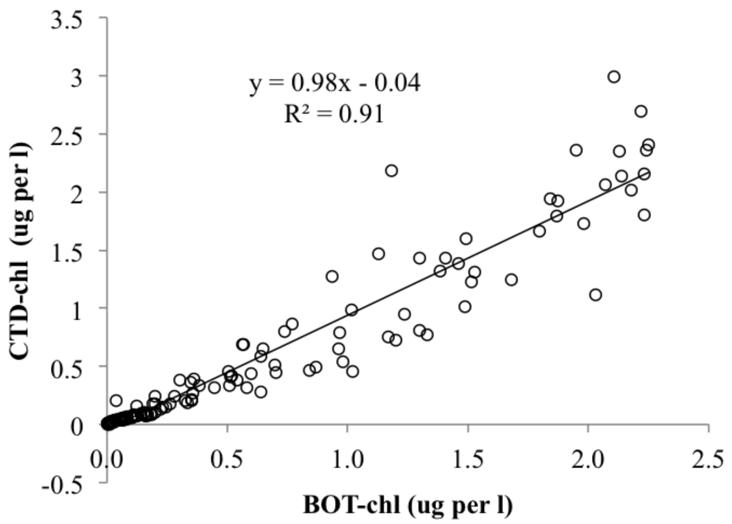
Table 7.3: Slope and R2 of correlations between bottle fluorescence and extracted chlorophyll concentrations.

CTD no.	Slope	R2	Notes
3	0.817	0.911	
4	0.845	0.845	
5	0.957	0.962	
8	1.549	0.938	Top 50m excluded
9	0.948	0.873	Top 50m excluded
10	0.826	0.900	
28	1.065	0.958	
29	1.059	0.992	
30	1.165	0.948	
31	0.888	0.975	
32	1.443	0.978	
33	1.085	0.965	Top 50m excluded
34	0.941	0.992	Top 50m excluded
35	0.826	0.946	Top 50m excluded
36	0.915	0.968	Top 50m excluded
37	0.969	0.964	Top 50m excluded

All CTD bottle fluorescence and extracted chlorophyll concentrations were combined to produce a whole cruise relationship between CTDchl and BOTchl (Figure 1):

$$CTD_{chl} = 0.982 \times BOT_{chl} - 0.042$$

therefore,:



$$CTD_{calib} = 1.018 \times CTD_{chl} + 0.04$$

Figure 1 Relationship between extracted chlorophyll concentrations (BOTchl) and chlorophyll from fluorometer mounted on the CTD rosette frame (CTDchl).

7.7 *Analytical methods*

7.7.1 Nutrients:

Nutrient samples taken from Niskin bottles attached to the CTD rosette frame were analysed within 2 hours of sample collection. From each Niskin bottle, 60ml HDPE bottles were triple rinsed and filled to 80% capacity. Samples were capped immediately and transferred to the chemistry laboratory for immediate analysis.

Nutrient concentrations were determined using a Bran and Luebbe QuAAtro 5-Channel Nutrient Auto-analyser. Specifically, nitrate plus nitrite, phosphate, silicate and nitrite were determined using colorimetry and ammonium using fluorimetry (JASCO FP-2020 Intelligent fluorescence detector). Nitrate plus nitrite was determined via reduction of nitrate to nitrite at pH 8 using a copperised cadmium reduction coil and subsequent reaction of nitrite with sulphanilamide and NEDD to produce a reddish-purple azo dye. Nitrite is measured in the same manner but without the need for the copperised cadmium column. Phosphate was determined by reacting phosphate with molybdate ion and antimony ion followed by reduction with ascorbic acid to produce a phospho-molybdenum complex. Silicate was determined by reducing a silico-molybdate complex in acid solution to a molybdenum blue by ascorbic acid. Oxalic acid is added to minimize interference from phosphate. Ammonium was determined by reacting ammonium with o-phthaladehyde (OPA) at 75°C in the presence of a borate buffer and sodium sulphite to form a fluoresenct species proportional to ammonium concentration.

Stock standards (10mM) were prepared weekly using high purity salts of potassium nitrate, sodium nitrite, potassium dihydrogen phosphate, sodium metasilicate nonahydrate, ammonium sulphate. In addition, a check standard was prepared using commercially available nutrient standards. All standards were prepared in artificial seawater (35g sodium chloride + 0.5g sodium bicarbonate in 1L of Milli-Q water).

Seawater samples were analysed in triplicate using an autosampler. Baseline and drift corrections were applied during analysis. Baseline, calibration slope, OSIL check standard and precision was recorded for every analysis run. Precision for all nutrients was better than 1%. The limits of detection of nitrate plus nitrite, silicate, phosphate, ammonium and nitrite were 0.1, 0.1, 0.05, 0.05 and 0.05 μM, respectively.

A storm event had a notable impact on the vertical distribution of nutrients along the A-transect. Stations A1 to A9 were sampled before/during and after the storm event. Comparison of temperature and nitrate plus nitrite at station A7 (on shelf) shows significant mixing down to 120m during the storm (CTD 9) and an increase in surface nutrient concentrations to 1.5 to 2 μM and a reduction in bottom water nutrients from ~9 to ~ 8 μM (Figure 2).

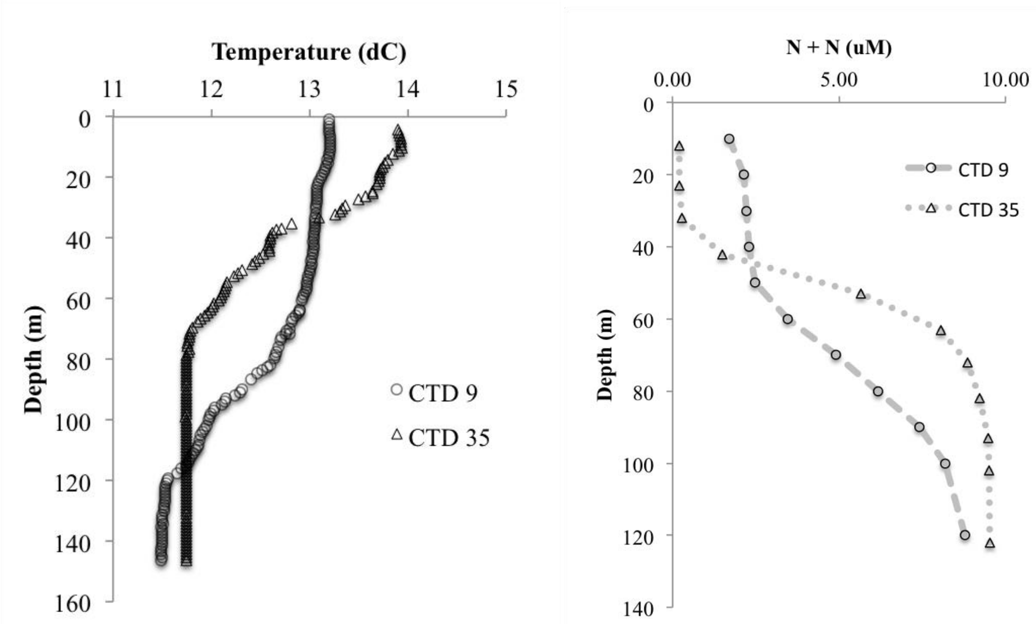


Figure 2. Depth profile of (left) temperature (°C) and (right) nitrate plus nitrite (μM) from CTD 9 (16/06/2012) and CTD 35 (24/06/2012), presenting during and after the storm event.

7.7.2 Oxygen:

Dissolved oxygen concentrations were determined in triplicate from each depth sampled during CTD casts. Using a silicon tube, three 125ml (approx. volume, each bottle calibrated individually) optically clear glass bottles were rinsed, overfilled at least 3 times and filled to capacity. The seawater temperature was recorded during sample collection (see later note on temperature). To each bottle, 1ml of manganese chloride and 1ml of alkaline iodide was added below the surface of the sample. The bottle was capped immediately, ensuring no air bubbles were trapped in the bottle and the bottle was shaken for 30 seconds, allowing light brown floc of manganese (III) hydroxide to develop. Elastic bands were placed around the bottle to keep the cap in place and bottles were stored underwater until analysis.

Analysis was performed within 3 days of sample collection. Storing underwater prevents significant temperature change and prevents exchange between the bottle contents and atmosphere. The oxygen concentration of reagents and samples is determined by development of a manganese (III) hydroxide floc, dissolution of the floc under acidic conditions and quantitative titration of triiodide with sodium thiosulphate to a potentiometric end point using a high precision computer controlled titration system (Metrohm Titrando with Tiamo software). There were three steps to the analysis (a) determination of reagent blank (b) standardisation of thiosulphate and (c) analysis of dissolved oxygen concentration of sample. Reagents blanks were determined by adding sulphuric acid, alkaline iodide and manganese chloride to milli-q water and titrating with sodium thiosulphate after the addition of 2.5ml of 0.025N potassium iodide standard three times. Standardisation of sodium thiosulphate involved adding sulphuric acid, alkaline iodide and manganese chloride to milli-q water and titrating with sodium thiosulphate after the addition of 5ml of 0.01 N CSK potassium iodate standard (available from OSIL, UK). Determination of oxygen concentration in the samples involved the addition of approx. 1ml of 10N sulphuric acid to dissolve the manganese (III) hydroxide floc and titration with sodium thiosulphate. The potentiometric end point was determined using a platinum micro-electrode. The end point was noted and dissolved oxygen calculation noted. Precision was typically better than 1%. Bottle oxygen concentrations were calculated using the following equation:

$$Oxygen\ conc\ (\mu mol\ \ O_2\ l^{-1}) = \frac{(V_t - V_b)\ \times\ N_t\ \times\ E}{\left(V_f - V_r\right)} - DO_r$$

Where Vt, Vb and Vr are the volume of the titrant (sodium thiosulphate) in the sample (in litres) and blank (in litres), respectively, and volume of reagents (0.002 litres=2 ml) Nt is the normality of the titrant, E is the oxygen equivalents (0.2500 μmol O2 μ eq-1) and DOr is the dissolved oxygen content of the reagents (Grasshoff et al).

Note on temperature: On 13th June 2012, the thermometer used to record bottle temperature during collection of samples for dissolved oxygen stopped working. We continued to collect samples until a replacement thermometer was found. We subsequently returned to the same stations (A1 to A9) and measured bottle temperature. Thus, bottle temperature for a selection of data was collected after and not during sample collection. However, comparison of original and later temperature records at the same sites showed that bottle temperature agreed well. In addition, the replacement thermometer was calibrated with a high precision microcat temperature logger and was found to agree within 0.1°C.

The oxygen sensor on the CTD was calibrated with bottle oxygen concentrations. Please see report on calibration of CTD for details.

7.7.3 Chlorophyll:

From 12 depths during shallow (< 200m) casts or the top 6 depths during deep (> 200m) casts, 1L amber coloured HDPE bottles were triple rinsed and filled to capacity. 500 ml (or 250ml during high biomass stations) of seawater was filtered through glass fibre filters (nominal pore size of 0.7 μm) using vacuum filtration. Filters were immediately placed in glass test tubes using tweezers and capped, wrapped in foil and placed in the -80°C freezer until analysis. On the day before analysis, samples were removed from the freezer for one hour and 5ml of 90% HPLC grade acetone was added to each test tube. The tubes and filters were wrapped in foil and placed in the walk-in fridge (set to 4°C) for 24 hours before determination of fluorescence using a Turner 10 Au field fluorometer fitted with the optical kit for extractive chlorophyll measurements (PN: 10-1040 R). Before the fluorescence of samples was determined, the fluorescence of a solid standard (low and high, used to monitor the stability of the instrument) and chlorophyll standards (chlorophyll a extract) were measured and recorded. Chlorophyll a standards of 125 μg l-1 and 250 μg l-1 were prepared in acetone daily from a 1mg l -1 stock, which was stored in an amber glass vial in the fridge. For filter samples, the filter was removed using tweezers and the fluorescence recorded before and after acidification with 1 ml of 10% hydrochloric acid, allowing phaeopigment concentration to be determined. Chlorophyll a concentrations were determined using the following equation;

$$K \times \frac{F_m}{F_m - 1} \times vol.acetone\ (ml) \times\ (F - F_a) \div vol.filtered\ (l)$$

units = μg chl a l-1

Where K is the concentration of the standard in μg chl per ml solvent divided by the fluorescence of the standard, Fm is the ratio of the fluorescence of the standard before and after acidification and F and Fa is the fluorescence of the sample before and after acidification, respectively (Strickland and Parsons, 1972). The extracted chlorophyll concentrations were used to calibrate the fluorometer attached to the CTD rosette frame. If CTD casts were conducted during the day, data above 50m was discarded due to photo-adaptation.

7.7.4 Dissolved organic nutrients:

Seawater was collected in 1L pre-cleaned HDPE bottles and filtered through a pre-combusted glass fibre filter (nominal pore size 0.7 μm) using a metal filter holder and pre-cleaned glass syringe. Filtered seawater samples were collected into acid-washed and combusted glass vials pre-filled with 20μl 50% (v/v) hydrochloric acid. Samples were stored in the fridge at 4°C. The concentration of dissolved organic carbon and dissolved organic nitrogen will be determined at the University of Liverpool by high temperature catalytic oxidation.

7.7.5 Chromophoric

Dissolved organic matter: Seawater from 12 depths was filtered from the same sample in the same manner as above for dissolved organic nutrients. The filtrate was placed directly into a glass test tube, capped and immediately placed in the Turner 10 Au fluorometer fitted with an optical kit for DOM/Ammonium (PN:10-303) and fluorescence was recorded. The DOM was calibrated using quinine sulphate with a calibration being performed approx. 30 minutes before sample measurement. Standard concentrations ranged from 1 to 4 μM. The instrument blank (fluorescence without test tube in test tube holder) was subtracted from each sample (rather than the calibration blank, which consisted of mill-q water) and the result was divided by the slope of the calibration curve to obtain a CDOM concentration in units of quinine sulphate (QSU).

7.7.6 Phytoplankton identification and enumeration:

From the top 6 to 7 depths sampled, 100ml of seawater was collected using a plastic measuring cylinder (triple rinsed) and placed in a 125ml glass amber jar pre-filled with 2% (final conc.) acid Lugol's iodine. Samples were stored in the dark in the fridge. Analysis will be performed at the University of Liverpool.

7.7.7 Stable nitrogen and oxygen isotope composition of nitrate:

From 12 depths sampled on each CTD cast, 125ml or 60ml HDPE bottles were rinsed 3 times and filled to 80% capacity. Samples were immediately frozen at -20°C. The stable nitrogen and oxygen isotope composition of nitrate (δ15N and δ18O of nitrate, respectively) will be analysed according to methods described and updated by McIlvin and Casciotti 2011 using a Gas Bench attached to a Thermo Finnigan isotope ratio mass spectrometer. This stable isotope approach will provide insight into the source and cycling of nitrate at the shelf edge.

7.8 ***References:***

Grasshoff (1999). Method of Seawater Analysis. Wiley-VCH. New York.

McIlvin, M. R. and Casciotti, K. L. (2011). Technical updates to the Bacterial Method for Nitrate Isotopic Analyses. Analytical Chemistry, 83, 1850-1856.

Strickland JDH, Parsons TR (1972) A Practical Handbook of Seawater Analysis. Fisheries Research Board of Canada. 167 pp.

CTD no.	Station ID	Date	Lat (N)	Long (W)	Time (GMT)	Max depth	CTD depth	Depths sampled	Oxygen	Organic Nutrients	Inorganic Nutrients	Chlorophyll	Phyco-erthyrin	Phytopl. ID	δ^{15}N-nitrate
2	A2	12/06/2012	48.08	9.72	23:05	1304	1296	9	X	X	X	X		X	X
3	A4	13/06/2012	48.24	9.54	02:50	183	168	11	X	X	X	X		X	X
4	A6	13/06/2012	48.40	9.37	05:12	141	127	20	X	X	X	X		X	
5	A1	13/06/2012	48.03	9.78	22:49	2380	2375	12	X	X	X	X		X	X
6	ST 4	16/06/2012	48.65	9.11	12:47	152	141	4		X					
7	A9	16/06/2012	48.57	9.17	16:02	159	145	12	X	X	X	X		X	X
8	A8	16/06/2012	48.51	9.24	17:46	156	145	12		X	X	X		X	X
9	A7	16/06/2012	48.45	9.32	19:47	154	144	12	X	X	X	X		X	X
10	A5	16/06/2012	48.33	9.44	22.13	146	135	12		X	X	X		X	X
11	A3	17/06/2012	48.15	9.63	00:39	633	628	12	X	X	X	X		X	X
16	A12	18/06/2012	49.20	8.50	22:06	147	130	5		X	X	X	X		X
17	A12	18/06/2012	49.20	8.50	23.32	145	122	5		X	X	X	X		X
18	A12	19/06/2012	49.34	8.84	00:32	148	100	5		X	X	X	X		X
19	A12	19/06/2012	49.21	8.49	01:29	146	100	5		X	X	X	X		X
20	A12	19/06/2012	49.20	8.50	02:31	148	100	5		X	X	X	X		X
21	A12	19/06/2012	49.20	8.50	03:34	150	100	5		X	X	X	X		X
22	A12	19/06/2012	49.20	8.50	04:30	150	102	5		X	X	X	X		X
23	A12	19/06/2012	49.20	8.50	05:31	150	101	5		X	X	X	X		X
24	A12	19/06/2012	49.20	8.50	06:30	149	102	5		X	X	X	X		X
25	A12	19/06/2012	49.20	8.50	07:49	148	100	5		X	X	X	X		X
26	A12	19/06/2012	49.20	8.50	08:32	147	100	5		X	X	X	X		X
27	A12	19/06/2012	49.20	8.50	09:32	147	100	5		X	X	X	X		X
28	A1	22/06/2012	48.03	9.79	19:05	2585	2440	12	X	X	X	X		X	
29	A2	22/06/2012	48.08	9.72	22:07	1303	1277	11	X	X	X	X		X	
30	A3	23/06/2012	48.15	9.62	01:04	625	610	12	X	X	X	X		X	
31	A4	23/06/2012	48.24	9.55	03:15	188	176	12		X	X	X		X	

CTD no.	Station ID	Date	Lat (N)	Long (W)	Time (GMT)	Max depth	CTD depth	Depths sampled	Oxygen	Organic Nutrients	Inorganic Nutrients	Chlorophyll	Phyco-erthyrin	Phytopl. ID	δ^{15}N-nitrate
32	A0	24/06/2012	47.92	9.91	05:48	3140	3122	12	X	X	X	X			X
33	A5	24/06/2012	48.32	9.44	11:47	142	135	12		X	X	X		X	
34	A6	24/06/2012	48.40	9.37	14:10	138	127	12		X	X	X			
35	A7	24/06/2012	48.46	9.32	15:50	155	142	12		X	X	X		X	
36	A8	24/06/2012	48.51	9.25	17:50	152	145	12		X	X	X			
37	A9	24/06/2012	48.57	9.17	18:40	156	146	12		X	X	X		X	
38	C1	24/06/2012	48.44	9.44	21:03	190	180	12			X				
39	C2	24/06/2012	48.41	9.53	22:24	647	482	12			X				
40	C3	25/06/2012			00:38	787	768	12			X				
41	C4	25/06/2012	48.34	9.72	03:14	1363	1354	12			X				
44	C5	27/06/2012	48.31	9.80	21:32	1651	1620	15			X				
45	ST1	28/06/2012	49.15	9.63	01:18	699	691	12			X				
60	ST3	30/06/2012	48.33	9.43	06:13	131	90	10	X	X	X	X			
61	ST3	30/06/2012	48.33	9.43	07:35	138	92	10	X	X	X	X			

Table 7.4: (above)

8 Drifters

Marie Porter, SAMS

8.1 *Introduction*

Twenty Metocean SVP drifters drogued at 50m were deployed on the self-break around 47° 35'N. The drifters are equipped with Iridium and GPS tracking and report GPS location along with sea surface temperature every 3 hours. They were released in 3 groups with 6 over the 300m isobaths, 8 over the 600m one and 6 over the 1100m one, this is comparable to the LOIS SES experiment conducted at the shelf break at around 56° 15'N conducted in 1999. High winds and big swells meant that these depths could not be accurately recorded using the altimeter onboard the ship, they will however be confirmed at a later date with the use of bathymetric charts.

Number (group)	IMEI number	Location	Deployment time	Approx. depth
1. (1)	300234011751730	47°36.09, -07°18.04	19:35	295
2. (1)	300234011755730	47°36.03, -07°17.04		299
3. (1)	300234011758730	47°36.04, -07°18.08		300
4. (1)	300234011754730	47°36.04, -07°18.10		302
5. (1)	300234011753740	47°36.05, -07°18.14		301
6. (1)	300234011460830	47°36.06, -07°17.19	19:37	600
7. (2)	300234011751720	47°34.242, -07°20.510	20:52	600
8. (2)	300234011754740	47°33.225, -07°20.618	20:53	600
9. (2)	300234011468610	47°34.205, -07°20.675	20:54	600
10. (2)	300234011462820	47°34.182, -07°20.750	20:55	600
11. (2)	300234011460820	47°34.169, -07°20.799	20:56	600
12. (2)	300234011468830	47°34.148, -07°20.865	20:56	600
13. (2)	300234011750720	47°34.129, -07°20.938	20:57	600
14. (2)	300234011467820	47°34.114, -07°20.984	20:58	600
15. (3)	300234011464830	47°32.418, -07°22.991	21:38	1100
16. (3)	300234011465830	47°32.395, -07°23.015	21:39	1100
17. (3)	300234011469820	47°32.372, -07°23.041	21:39	1100
18. (3)	300234011462830	47°32.356, -07°23.058	21:40	1100
19. (3)	300234011462830	47°32.336, -07°23.079	21:40	1100
20. (3)	300234011464820	47°32.317, -07°23.103	21:41	1100

8.2 ***Observations***

On the 16th June 2012 the winds reached force 7-8. The thermocline was depressed to around 60m; as a result the drifters were temporarily drogued in the Ekman layer. Within the following days the thermocline returned to 30m and thus the drifters are now following subsurface water.

The drifters initially stayed in the three deployment groups and travelled southwards, across the shelf slope. They have since split into two groups, with one continuing south westwards, parallel to the shelf edge and one recirculating back onto the shelf. Within the second group, 3 drifters have once again started to travel south westwards along the shelf edge and 4 are continuing up the break and onto the self.

The locations of the drifters at 12:00 (GMT) on the 29th June 2012 are shown in Figure 8.1.

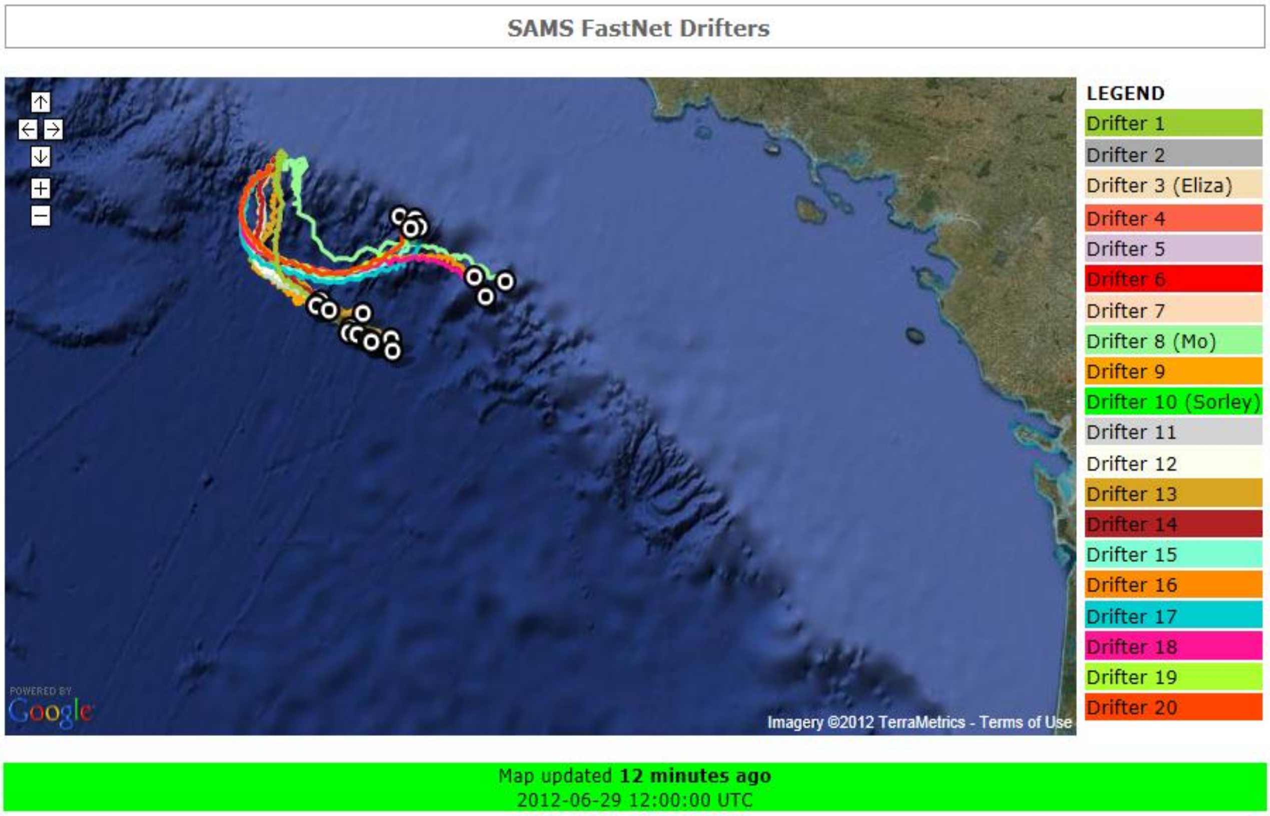


Figure 8.1: The locations of the 20 FASTNet drifters at 12:00 (GMT) on the 29th June 2012

9 Microstructure profiler

Matthew Palmer

Microstructure measurements were made using two different profilers. The first of these instruments, the VMP750 was used for the majority of deployments and the second instrument, MSS90 was used for approximately half of the second deployment period due to instrument failure with the VMP750.

9.1 Velocity Microstructure Profiler (VMP)

Rockland Scientific International manufactured Velocity Microstructure Profiler (VMP750, s/n 043) provided by the National Oceanography Centre (NOC): The VMP750 (Figure 9.1) is a free-falling instrument rated to 750m depth that was deployed from the aft of the RRS Discovery, connected via a neutrally buoyant Kevlar tether which is fed sufficiently fast over the ship's stern to prevent any interference with the free-fall of the instrument from the surface to the desired depth or the seabed. To ensure safe deployment of the loose tether the ship moves forward slowly through the water during deployment which can result in some movement around the station position depending on wind and tide. During descent the instrument simultaneously measures shear microstructure, from which the dissipation rate of turbulent kinetic energy can be derived (Dewey et al, 1987), temperature and conductivity microstructure, fluorescence, optical backscatter, pressure, tri-axis acceleration and auxiliary Seabird sensors provide temperature, conductivity.

Figure 9.1: The VMP750 on the aft deck of RRS James Cook

The descent of the instrument is controlled by buoyancy and brushes to maintain an optimal fall-speed ~$0.7ms^{-1}$ whilst keeping the instrument falling vertically. With a typical profile depth of 100-120m each profile therefore took ~3 minutes descent time with a similar time for recovery to the surface from which the next profile was made.

The VMP750 weighs ~50kg in air and is connected to a winch via a line thrower system (Figure 2), both of which are hydraulically powered.

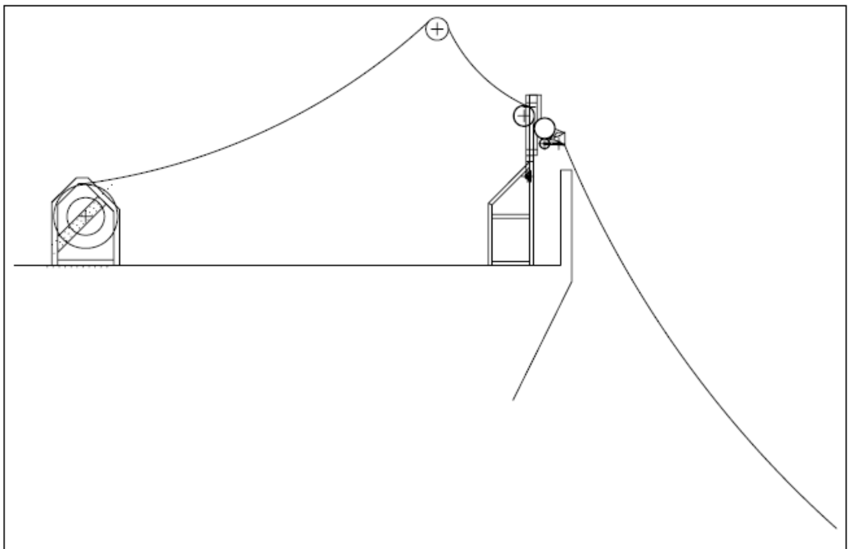


Figure 2. Typical setup of winch, sheave and line-puller when the VMP is profiling down. Notice that there is slack in the tether between the winch and line-puller. There is also slack in the tether in the water near the ship so that the VMP can descend freely.

9.2 *ISW Wassermesstechnik manufactured MSS90*

ISW Wassermesstechnik manufactured MSS90 (Figure 9.3) provided by the Scottish Association for Marine Science (SAMS):

This is a similar but smaller instrument to the VMP750, it measures shear microstructure, temperature microstructure, temperature, conductivity, pressure and tri-axis acceleration. The instrument is lightweight, ~15kg in air, and is operated in a similar manner to the VMP750 from a simple electronic winch (Figure 9.4).

Figure 9.3: MSS90 microstructure profiler

Figure 9.4: ISW Wassermesstechnik swm1000 electric

Microstructure profiler measurements were made within a region between mooring station ST3 and ST4 and designed to provide comparable data to the OMG. Due to the risk of collision with the OMG the ship maintained position within 5km of the central OMG transects position but no closer than 2km.

9.3 *Time-series 1:*

The first time series began at 20:16 (GMT) 20th June 2012 at 48°30.42'N 9°18.67'W and continued until 11:56 22nd June 2012. Following 2 test casts (005 and 006) to check instrumentation and warm the hydraulic system 328 successful profiles were made with the VMP750. The majority of profiles were made to approx. 100m to capture thermocline physics with hourly full-depth profiles made around the half hour. Following 8 casts excessive noise was detected on channel sh1 and probes were replaced requiring a pause in profiling of 45 minutes. Channel sh1 continued poor performance but profiling continued to avoid further disruption. Probe and instrument serial numbers (as provided by Rockland) were as follows;

Shear1: M843 up to cast 014, replaced with M854 after
Shear2: M853 up to cast 014, replaced with M855 after
Fast temperature 1:T644 up to cast 014, replaced with T328 after
Fast temperature 2: T331
Micro Conductivity: C51
Fluorometer: N/A
SBE Temperature: 3F-4634
SBE Conductivity: 4C-3240

Following time-series 1 probe connections were investigated and sh1 found to be defective. Repairs were undertaken.

9.4 *Time-series 2:*

The second time series began at 10:32 (GMT) 26th June 2012 at 48°30.48'N 9°19.30'W continuing until 07:08 27th June 2012. Following 2 test casts (364 and 365) to check instrumentation and warm the hydraulic system 158 successful profiles were made with the VMP750. The majority of profiles were made to approx. 100m to capture thermocline physics with hourly full-depth profiles made around the half hour. Channel sh1 was operating correctly however channel T1 unfortunately recorded no usable data. At 01:13 communication errors were identified by 'bad buffer' warnings in the VMP software. The number of errors increased until the decision to terminate the connecting wire was made at 02:29. Profiling was continued using the MSS profiler. Despite attempts to redeploy the terminated VMP at 05:07 communication errors were not resolved and the VMP time-series cancelled at 07:08. Probe and instrument serial numbers (as provided by Rockland) were as follows;

Shear1: M854
Shear2: M855

Fast temperature 1: T331
Fast temperature 2: T644
Micro Conductivity: C51
Fluorometer: N/A
SBE Temperature: 3F-4634
SBE Conductivity: 4C-3240

10 Wirewalker mooring

Jo Hopkins and Terry Doyle

10.1 *Introduction*

The short term mooring (LT3) deployed at 48° 20.212 N, 9° 26.419 W at 18:03 GMT on 13th June 2012 consisted of a Wirewalker mounted on a 90m length of wire. The Wirewalker is a wave-powered autonomous profiler, developed at Scripps Institute of Oceanography, and was kindly loaned to us by Andrew. J. Lucas for use in this FASTNEt cruise. It uses the surface wave field to power continual vertical profiling. Internally powered and recording instrumentation attached to the Wirewalker collects a two-dimensional depth-time record. Briefly, the mooring itself includes a surface buoy, a wire suspended from the buoy, a weight at the end of the wire, and the profiler attached to the wire via a cam mechanism. A mooring diagram is included below. The wire and weight follow the surface motion of the buoy. The wave-induced motion of the water is reduced with increasing depth, and the relative motion between the wire and the water is used to propel the profiler. The cam engages the wire as it descends and releases it as it ascends, pulling the profiler downwards. At the bottom of the wire, the wirewalker hits a mechanical stop that causes the cam to remain open and the profiler free floats to the surface. At the top of the wire, the cam is reset and the wirewalker is ratcheted downwards again.

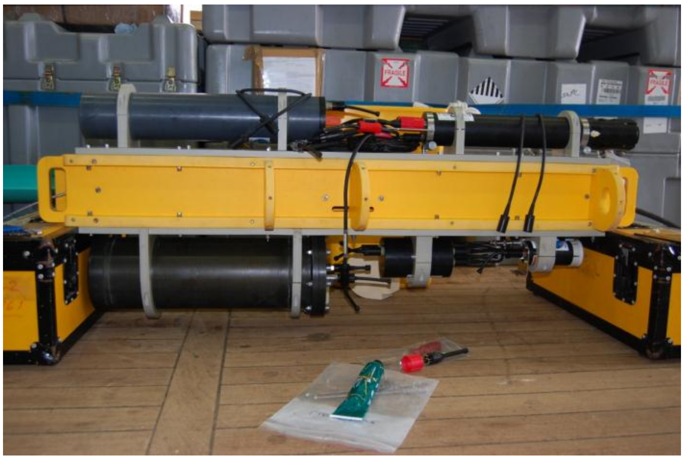


Figure 10.1 Wirewalker setup (minus side buoyancy and guards)

10.2 *Instrumentation*

A TRDI Citadel CTD-NV measuring temperature, conductivity and pressure, an Aanderra optode for oxygen concentration, and a Wetlabs ECO Triplet recording Chlorophyll-a, CDOM and Phycoerthrin fluorescence were all mounted on the Wirewalker. The CTD and oxygen sensor were both powered by a custom made external battery pack and logged to the CTD internal memory. The Triplet was connected to a Wetlabs DH4 data logger and both were powered by an external Wetlabs battery.

The following table details the instrumentation mounted on the Wirewalker. All instruments were setup on a laptop whose clock was set at 13:17:45 GMT on 13th June 2012.

Instrument	Serial number	Sampling rate	Internal clock set (GMT)	Logging started (GMT)	Logging stopped (GMT)	Drift (sec)
Wetlabs ECO Custom TRIPLET 600m (Chlorophyll-a, CDOM and Phycoerthrin)	2560	4 Hz	13:56:00 13/06/2012	14:15:44 13/06/2012	16:00:03 27/06/2012	+10
TRDI Citadel CTD-NV	2277	3 Hz	14:19:02 13/06/2012	14:22:58 13/06/2012	16:03:50 27/06/2012	+6
Aanderra Optode	1126	1 Hz	n/a	14:22:58 13/06/2012	16:03:50 27/06/2012	+6
Wetlabs DH4 data logger *	161	n/a	Time taken form PC	14:15:44 13/06/2012	16:00:03 27/06/2012	+10
Wetlabs battery (model BPA50B)	175	n/a	n/a	n/a	n/a	n/a

*A 2 minute warm up period was programmed for the DH4-Triplet set up which started at 14:13:44 on 13th June 2012.

10.3 *Calibration*

Two calibration casts were performed where the instrumentation was attached to the main CTD and bottle samples were taken for oxygen, CDOM, chlorophyll and phycoerthrin.

The first cast (CTD 4) took place pre-deployment on 13th June 2012 at 05:22 GMT at 48° 23.83 N, 9° 22.14 W. For this cast a spare FSI CTD was used (S/N 2278) to log the oxygen. Unfortunately the pressure rating on this instrument was over estimated and the pressure record beyond 100m is out of the calibration range.

A second and third calibration cast (CTDs 60 and 61) were performed on 30th June 2012 at 06:13 and 07:35 respectively (48° 19.80 N, 9° 26.00 W). On this occasion FSI S/N 2277 was used. The internal battery on this instrument failed during deployment and no useable pressure, temperature and salinity data was collected.

The following manufacturer's calibrations need to be applied to the Triplet data:

Chlorophyll

CHL (µg/l) = scale_factor x (output - dark_counts)
scale_factor = 0.0121 µg/l/count
dark_counts = 51 counts

CDOM

CDOM (ppb) = scale_factor x (output - dark_counts)
scale_factor = 0.0906 ppb/counts
dark_counts = 50 counts

Phycoerthrin

PHYCO (ppb) = scale_factor x (output - dark_counts)
scale_factor = 0.0426 ppb/counts
dark_counts = 54 counts

The following conversion and calibration was applied to the optode:

Oxygen (µM/l) = (oxygen voltage / 5) x 500

oxygen voltage = (oxygen counts / saturation count) x full scale voltage
saturation count = 65535
full scale voltage = 5

Full calibration with the in-situ samples will take place post-cruise.

10.4 ***Results***

Unfortunately the mooring failed to operate as designed. Instead of profiling continually up and down the wire the profiler remained trapped at the bottom (approx. 90m). After inspection of the pressure record, it is thought that during deployment a bight of rope became wrapped around the profiler, pinning it to the bottom stopper and preventing it from rising to the surface. A time series of temperature, conductivity, oxygen, chlorophyll, CDOM and phycoerthrin was therefore collected at approx. 90m.

An instrumentation setup error meant that 1 Hz, instead of 4Hz data was recorded by the Triplet.

10.5 ***Mooring diagram***

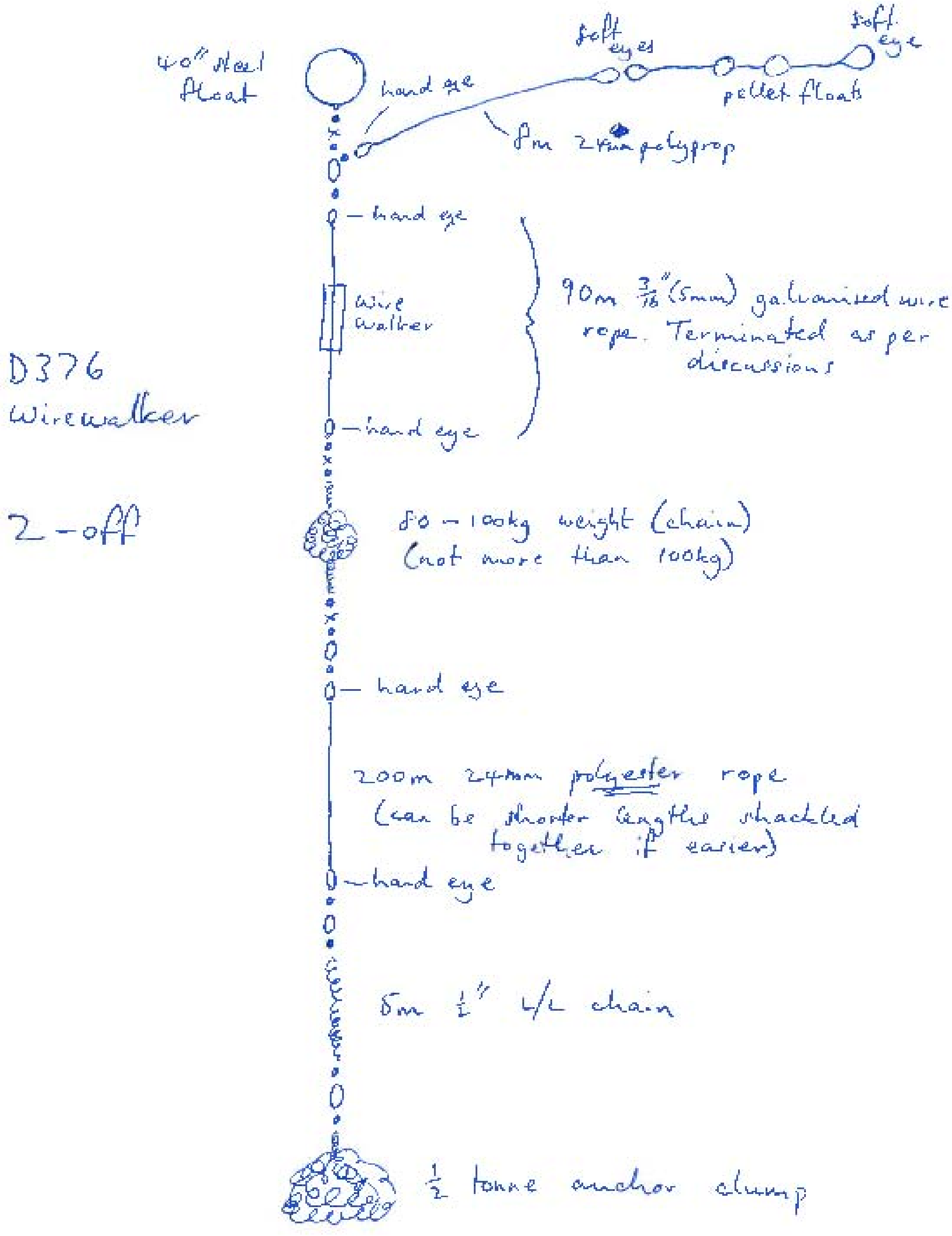


Figure 10.2: *Wirewalker mooring diagram*

11 Lowered ADCP (LADCP) Processing

Marie Porter

11.1 *Introduction*

Lowered Acoustic Doppler Current Profiler (LADCP) data were obtained from every CTD cast. A single downward looking 300 kHz RDI 'Workhorse' LADCP was deployed on the frame (rather than the more common 2 ADCPs) because there have been some recent problems with the integrity of the transducer heads under repeated deep cycling of new ADCPs and it was not considered prudent to risk two at once. After cast 4 the ADCP was replaced due to beam failure, however an LADCP profile has been created for each CTD cast throughout this cruise. The second ADCP had intermittent beam errors (Table 11.1). The specification details of the LADCP are given elsewhere, this section describes data processing.

11.2 *Processing*

All profiles were processed by the end of the cruise using 'Visbeck' routines recently adapted and improved (A.M. Thurnherr, 2008, 'How to process LADCP data with the LDEO software') and identified as LDEO version IX.5. They were combined with CTD data to provide accurate information on vertical velocity of the frame through the water, and with the ship's navigation data to calculate its exact position in the water using the ship as a reference. Each processed cast is listed in Table 11.1 along with the depth of that cast and comments about it.

11.3 *Results*

Figure11.2 is an example of the Visbeck processing output from an on shelf station, CTD025. East (U) velocity is shown in red and North (V) velocity is shown in green. Flow appears to be south-westward throughout the water column.

Figure 11.3 shows the velocities of 4 stations (casts 28-31) along a transect with the barotropic tide removed. It appears that in the deep section the flow is north-easterwards and that it becomes south-westwards on the shelf. This suggests the presence of the shelf edge current at depth, however only 4 stations have been analysed in this way at the moment and hence this is only a preliminary finding.

A series of "Yo-Yo" CTDs will allow for the creation of velocity time series at one location (48°22.35' N 9°37.09' W). This is yet to be analysed.

Cast number	Date	Max depth (of LADCP)	Errors	Comments
1	12/6 17:14	632	Beam 1 weak	Shear solution only
2	12/6 23:59	1297	Beam 1 weak	
3	13/6 03:03	169	Beam 1 weak	
4	13/6 05:25	128	Beam 1 broken	
5	13/6 23:48	2380		New ADCP
6	16/6 12:59	142		
7	16/6 16:15	147		
8	16/6 17:57	146		
9	16/6 19:59	145		
10	16/6 22:26	136		
11	17/6 01:10	629		
12	17/6 03:58	1323		
13	18/6 14:32	122		
14	18/6 17:50	157		
15	18/6 20:15	152		
16	18/6 22:28	132		
17	18/6 23:40	122	Beam 2 bad, beam 1 weak	
18	19/6 00:38	100	Beams 1 and 2 bad, beam 4 weak	
19	19/6 01:35	100		
20	19/6 02:34	37?	Beam 1 bad, beams 2 and 4 weak	CTD went to 100m. ADCP is artificially shallow
21	19/6 03:42	102		
22	19/6 04:39	102		
23	19/6 05:40	101		
24	19/6 06:39	102		
25	19/6 07:57	101	Beam 2 bad	
26	19/6 08:43	101		
27	19/6 09:41	100	Beam 2 bad, beam 4 weak	
28	22/6 20:04	2587		
29	22/6 22:22	1278		
30	23/6 01:26	611		
31	23/6 03:27	185		
32	24/6 07:01	3140		
33	24/6 12:03	136		
Cast number	**Date**	**Max depth (of LADCP)**	**Errors**	**Comments**
34	24/6 14:22	127		
35	24/6 16:01	144		
36	24/6 17:32	147		
37				
38	24/6 21:14	181		
39	24/6 22:50	635		

40	25/6 01:04	769		
41	25/6 03:52	1364		
42	25/6 07:00	1282		
43	26/6 09:53	153	Beam 2 weak	
44	27/6 22:13	1621		
45	28/6 01:18			
46	29/6 13:01			Yo-yo
47	29/6 14:13			Yo-yo
48	29/6 15:23			Yo-yo
49	29/6 16:35			Yo-yo
50	29/6 17:47			Yo-yo
51	29/6 18:53			Yo-yo
52	29/6 20:02			Yo-yo
53	29/6 21:03			Yo-yo
54	29/6 22:04			Yo-yo
55	29/6 23:07			Yo-yo
56	30/6 00:02			Yo-yo
57	30/6 01:18			Yo-yo
58	30/6 02:33			Yo-yo
59	30/6 03:40			Yo-yo
60	30/6 06:13			
61	30/6 07:35			

Table11.1: The depth of each LADCP cast and comments about them. For location information see the log sheets.

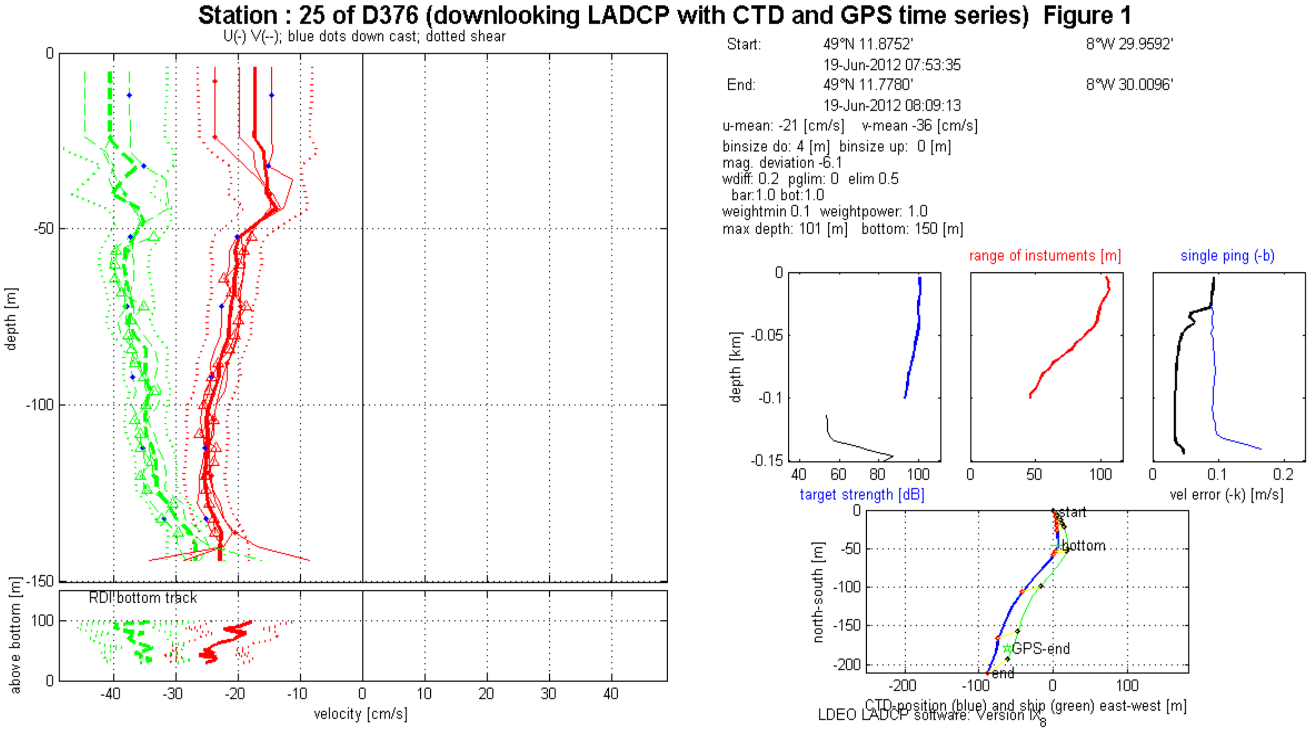


Figure 11.2: Velocity at ST12, on the shelf during the yo-yo casts.

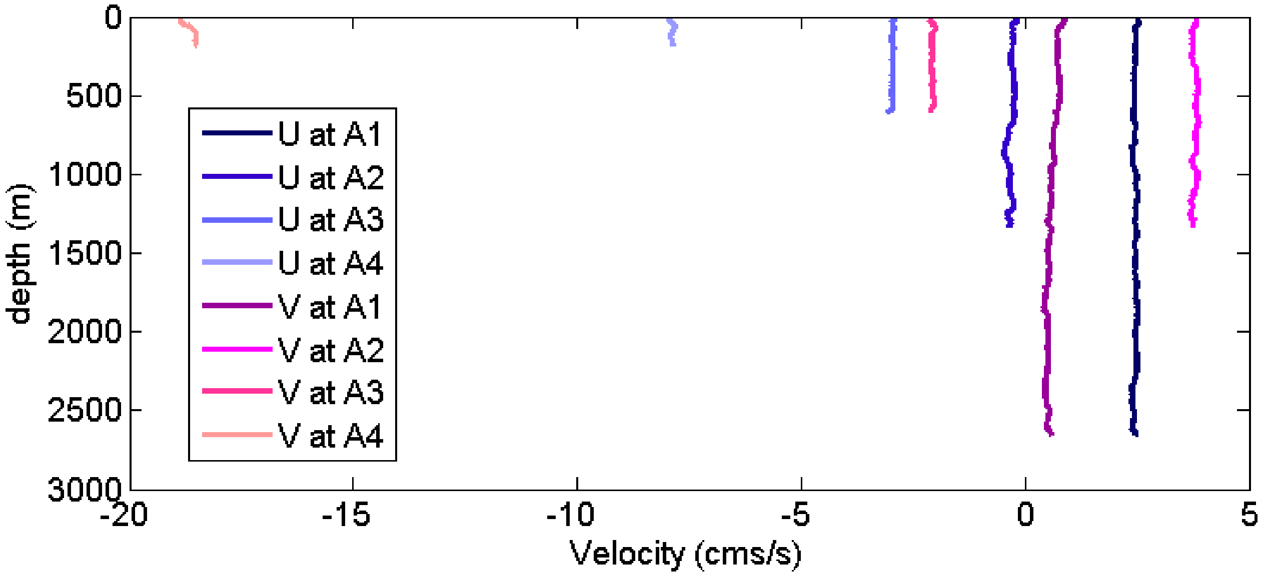


Figure 11.3: The detided velocities for casts 28-31 (A1 - A4)

12 Moorings

Robert Maclachlan, Thomas Roberts, Terry Doyle, Joanne Hopkins, Juliane Wihsgott, Estelle Dumont & Colin Griffiths

12.1 *Objectives*

- To deploy a series of short term moorings, ST1 > ST5, for the duration of the cruise.
- To deploy a drifting mooring between ST3 & ST4 for several days during the cruise.
- To deploy two long term moorings, LT1 & LT2. These two moorings will be recovered in early 2013.

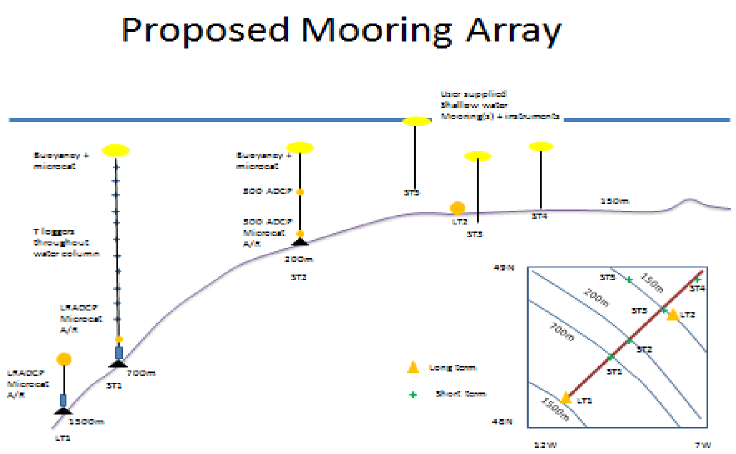


Figure 12.1 D376 Mooring Array

Objectives 1 & 3 were fulfilled; however the weather prevented the deployment of the drifting mooring. With the exception of the Wire-walker mooring and the Met buoy deployed at ST3 all moorings were sub-surface rigs using standard NMF-SS & SAMS designs. All in-line releases were tested prior to deployment. Fishing in the working area was very light during the trip so there was no requirement to deploy any surface markers alongside the shelf moorings. Two calibration dips were performed following recovery of all the short term moorings

.

12.2 *Mooring Summary*

Station	Description	Position	Depth	Deployed	Recovered
ST1	In-line	N48º 08.812’ W009º 37.798’	688m	21:40Z 12/06/2012	07:54Z 28/06/2012
ST2	In-line	N48º 14.660’ W009º 32.780’	184m	09:32Z 13/06/2012	10:07Z 28/06/2012
ST3	Bedframe	N48º 20.215’ W009º 26.311’	143m	16:30Z 13/06/2012	18:01Z 27/06/2012
ST3	Wire Walker	N48º 20.167’ W009º 26.354’	143m	18:02Z 13/06/2012	16:04Z 27/06/2012
ST3	Met buoy	N48º 20.160’ W009º 26.190’	143m	19:42Z 13/06/2012	20:12Z 27/06/2012
ST4	In-line	N48º 38.959’ W009º 06.237’	156m	14:51Z 16/06/2012	14:35Z 28/06/2012
ST4	Bedframe	N48º 39.904’ W009º 06.358’	155m	15:03Z 16/06/2012	15:35Z 28/06/2012
ST5	In-line	N48º 45.993’ W009º 24.179’	170m	13:18Z 13/06/2012	08:45Z 29/06/2012
ST5	Bedframe	N48º 46.130’ W009º 24.370’	170m	13:32Z 13/06/2012	09:40Z 29/06/2012
LT1	In-line	N48º 04.500’ W009º 44.400’	1503m	18:08Z 22/06/2012	TBC – early 2013
LT2	Bedframe	N48º 19.875’ W009º 26.496’	145m	22:01Z 16/06/2012	TBC – early 2013

Figure 12.2 D376 Mooring Array

12.3 *Instrument Summary*

A number of instruments failed to record good quality data for various reasons. These have not been included in the instrument summary tables.

The codes for the instruments:-

ML – VEMCO Minilogs (Temperature)

CT – STAR-ODDI DST centi-T (Temperature)

C – SBE37 CTD (Conductivity, Temperature & Pressure)

AC – RDI ADCP (U, V, W, Temperature & Pressure)

SM – STAR-ODDI Starmon mini (Temperature)

ST1 – In-line mooring

Code	Serial No:	Mean depth (m)
MC	5790	8.9
CT	3599	11.4
ML	350772	13.9
CT	3614	16.4
ML	350773	18.9
ML	350774	31.1
CT	3269	33.6
ML	350775	36.1
CT	3271	38.6
MC	6912	41.1
CT	3276	43.6
ML	350776	46.1
CT	3661	48.6
ML	350777	51.1
CT	3654	53.6
ML	1594	56.1
ML	1596	61.1
ML	1599	66.1
ML	1600	71.1
ML	1601	76.1
ML	1608	81.1
ML	1609	91.1
ML	1610	101.1
ML	1612	111.1
ML	1618	131.1
ML	1689	191.1
CT	4602	211.1
CT	4603	231.1

ML	3895	251.1
ML	3891	291.1
ML	3892	311.1
CT	4610	331.1
ML	3893	361.1
ML	1629	398.2
ML	3896	448.2
ML	5591	498.2
ML	5592	548.2
ML	6178	598.2
MC	9141	666.9
AC	9201	673.5

ST2 – in-line Mooring

Code	Serial No	Mean depth (m)
MC	5793	24.2
CT	3606	26.7
SM	2849	29.2
CT	3613	31.7
SM	2836	34.2
SM	2838	44.2
SM	2841	46.7
CT	3653	49.2
MC	6911	50.8
CT	3278	53.3
SM	2842	55.8
CT	3655	58.3
SM	2848	60.8
CT	3270	63.3
AC	7301	75.2
SM	2837	77.7
SM	3902	80.2
SM	3577	85.2
SM	3579	90.2
SM	3903	95.2

SM	3901	105.2
SM	3905	115.2
SM	3906	125.2
SM	3578	142.1
AC	14449	143.1
SM	3584	153.6
MC	9140	158.6

ST3 – Wire-Walker mooring (See Section 10)

ST4 – In-line mooring

Code	Serial No	Mean depth (m)
MC	5433	8.4
CT	3619	10.9
SM	3583	13.3
CT	3602	15.8
SM	3582	18.3
ML	1691	23.3
MC	6910	29.6
CT	3268	32.1
SM	3581	34.6
CT	4620	37.1
MC	6918	39.9
CT	4613	42.4
SM	3585	44.9
CT	4605	47.4
MC	6909	49.9
CT	4614	52.3
SM	3576	54.8
SM	3580	59.8
SM	3888	64.7
SM	3887	69.7

SM	3889	74.6
SM	3890	79.6
SM	3891	89.5
SM	3893	99.4
SM	3892	109.3
SM	3894	119.2
MC	8479	134.8
MC	4550	155.4

ST5 – In-line mooring

Code	Serial No	Mean depth (m)
MC	4966	14.0
CT	3604	16.5
SM	3896	18.9
SM	3898	23.9
MC	6913	37.6
SM	3897	42.6
CT	4611	45.1
MC	6904	48.0
CT	4617	50.5
CT	4609	55.4
MC	6914	57.7
CT	4608	60.2
SM	3895	62.7
SM	3899	67.6
ML	350778	72.6
ML	350779	77.6
ML	350780	82.5
ML	350781	87.5
ML	350782	97.4
ML	350783	107.3
ML	1619	117.2
ML	1628	135.5
SM	3904	140.5
MC	8478	156.2

MC	7769	168.5

LT1 – In-line mooring
150kHz RDI ADCP Ser No 5476
150kHz Flowquest ADCP Ser No 11626
SBE37SMP Ser No 9113

LT2 – Bedframe
150kHz RDI ADCP Ser No 1148
SBE37SM CTD Ser No 3479

ST3 – Bedframe
150kHz Flowquest ADCP Ser No 11043
SBE16+ CTD Ser No 4848

ST4 – Bedframe
150kHz Flowquest ADCP Ser No 11625
SBE37SM CTD Ser No 4550

ST5 – Bedframe
150kHz RDI ADCP Ser No 1149
SBE37SMP CTD Ser No 7769

13 RRS Discovery Cruise D376 Glider Operations

Chris Balfour – NOC Liverpool

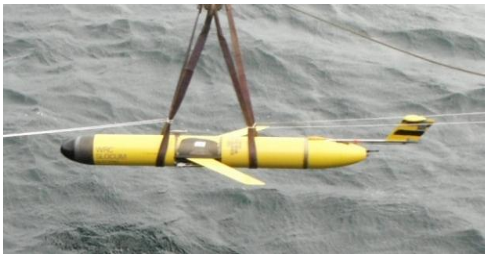
13.1 *Introduction*

This document summarises the glider operations undertaken during the RRS Discovery based D376 research cruise. The work area was close to the Celtic Sea continental shelf edge and formed part of the FASTNEt Ocean Shelf Exchange research project. The schedule required the preparation and potential piloting of four Slocum Electric Gliders, listed in *Fig. 13.1*, by Chris Balfour during the cruise. RRS Discovery departed from Swansea, UK on Monday 11th June 2012 and will return to Southampton, UK on Monday 2nd July 2012. The requested small boat support for glider operations was not available for the cruise. *Table 13.1* summarises the scientific objectives for the glider based survey operations during D376.

13.2 *The D376 Slocum Electric Glider Fleet*

The Unit 175 Turbulence Glider 200m depth capable. The science sensors are a non-pumped Seabird CTD and a specialist micro-Rider turbulence probe

Unit 194 a 200m depth capable glider This science sensors are a pumped Seabird CTD, a WetLabs Triplet (CDOM, Chlorophyll-a and OBS Turbidity) and a Aanderaa dissolved oxygen Optode



Unit 051 – Bellamite is a 1000m depth rated glider with a non-pumped Seabird CTD sensor

Unit 052 – Coprolite is a 1000m depth rated glider with a non-pumped Seabird CTD sensor

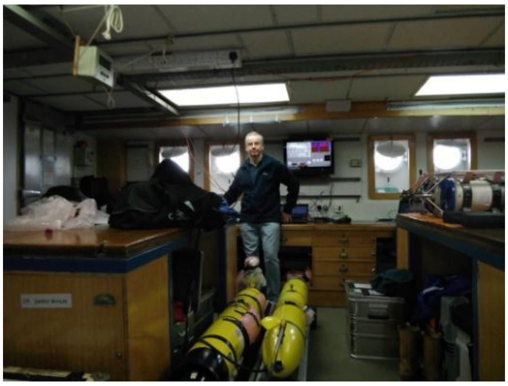
Figure 13.1 The D376 Research Cruise Slocum Electric Glider Fleet

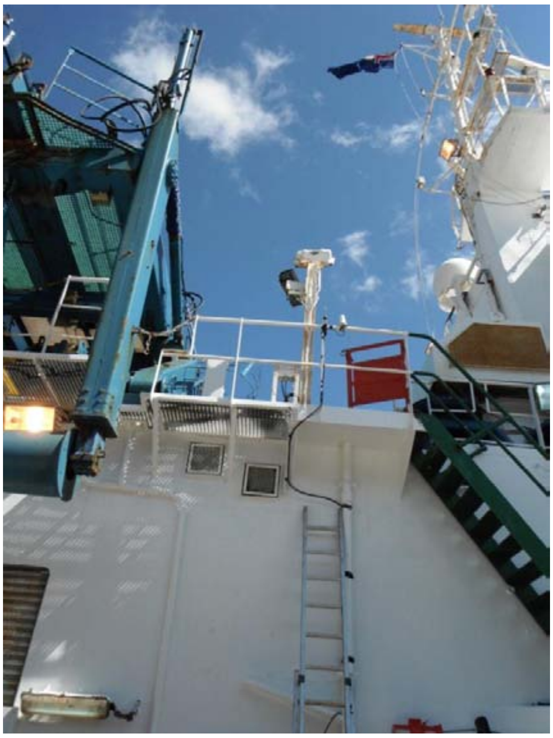
Table 13.1: – Initial Glider Survey Transects and Scientific Rationale

Glider	Initial GPS Waypoints	Scientific Rationale for Survey
Unit 175	48^0 28.416'N, 09^0 17.868'W to 48^0 30.642'N, 09^0 15.57'W	To determine the nature of the dissipation rates of kinetic energy for mixing between the ST3 and ST4 moorings. The glider results are validated with vertical profiling (VMP) measurements nearby for a proportion of the time.
Unit 051	47^0 58.00'N, 09^0 53.00'W to 47^0 46.50'N, 10^0 05.00'W	To determine background and intermittent off shelf fluxes by operating in deep waters off the Celtic Sea shelf edge.
Unit 052	47^0 58.00'N, 09^0 53.00'W to 47^0 46.50'N, 10^0 05.00'W	To determine background and intermittent off shelf fluxes by operating in deep waters off the Celtic Sea shelf edge.
Unit 194	48^0 27.00'N, 09^0 20.00'W to 48^0 05.00'N, 09^0 45.00'W	Providing over the shelf edge CTD measurements to help to determine water mass intrusion, slope currents and stratification. Sensors for Chlorophyll-a, CDOM and dissolved oxygen are likely to only be used for a limited time to conserve battery energy.

13.3 *Glider Preparation Testing and Mission Simulation*

Following the packing, transportation, mobilisation and unpacking of the four Slocum electric gliders on RRS Discovery a programme of testing and deployment preparation was undertaken. This is to verify the integrity of the gliders and identify any deficiencies that may have occurred during the glider preparation operations prior to the D376 research cruise. To facilitate effective glider communications, satellite phone communications and a glider preparatory base a series of work areas were prepared on RRS Discovery. *Fig.13.2* provides some selected photographs of these.





Multiple glider mission simulations and glider re-ballasting in the Wet Lab.

Iridium (satellite phone) and FreeWave (short range wireless data communications with a glider) Antennas, Starboard – Close to CTD winch to the right of the spotlight mounting

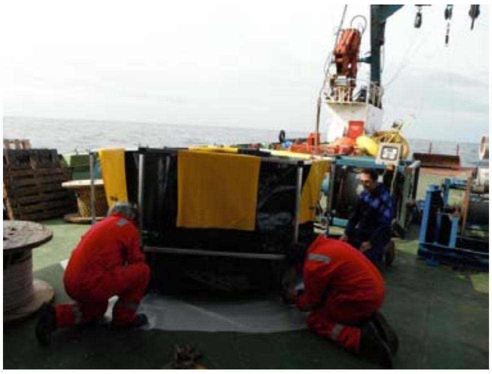
External antennas allowed short range (<=2km) wireless glider communications and Iridium Satellite phone calls using an external antenna

Figure 13.2 Slocum Electric Glider Communications and Preparation

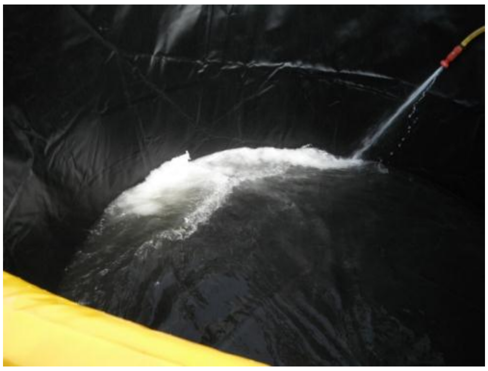
A key initial objective was to set up a glider testing and evaluation base and the wet lab in RRS Discovery proved to be well suited for this purpose. The intended and evolving survey missions for the gliders were simulated inside the gliders to test modifications and help to derive reliable mission configurations. If required, glider hull seals were serviced and internal vacuum monitoring was used as an indication of the effectiveness of the glider hull seals.

13.4 *Glider Deployment and Ballasting Testing*

The absence of small boat support during the D376 cruise resulted in difficulties being encountered in devising a suitable deployment method. This resulted in a series of discussions with the crew during the cruise to devise a suitable deployment method. A distinct possibility was the inability to perform an initial glider dive test with a tether and surface float. This is a manufacturer's recommended procedure to allow a recovery of a glider if satisfactory ballasting or glider operation does not occur during initial dive testing. As an intermediate step a portable ballasting tank was used for these trials. *Fig 13.3* and *Fig. 13.4* show a sequence of pictures of these operations.



FASTANK 5 – glider ballasting tank assembly



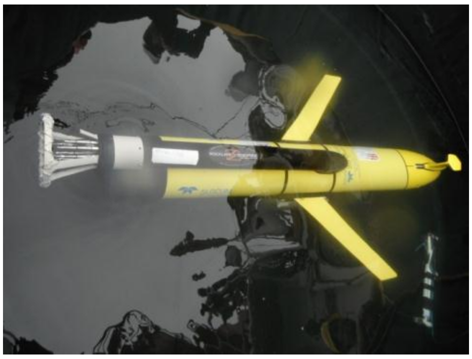
Tank filling with the ships seawater hose

Preparations for glider lifting and release rehearsal

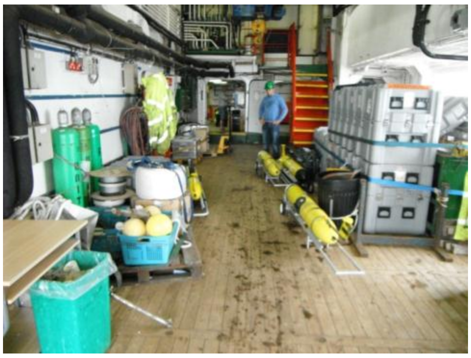
Figure 13.3 Slocum Electric Glider Ballasting Tank and Lifting Preparations

Lifting of gliders – double strops – stay lines, release hook and trigger Line

Glider release arrangement testing



Unit 175 – Turbulence Glider – ballasting check on RRS Discovery – The Seabird Microcat CTD is Visible to the lower right of the picture



Gliders temporarily stored in the ship's hangar after the ballasting tests and subsequent washing down with fresh water

Figure 13.4 Slocum Electric Glider Deployment Mechanism and Ballasting Tests

The release mechanism consisted of two strops looped around the fore and aft hull sections of the glider. One side of these strops was coupled to a release hook with a pull line. Two stay lines were looped between each of the strops just above the glider hull to keep tension on the strops around the glider hull. This prevented slippage of the glider during lifting. The release procedure was to loosen and remove the say lines with the glider just above the water. The crane then lowered the glider into the water and the release hook was operated. The crane then lifted the strops away from the glider. This mechanism worked well during tank testing. For the ballasting tests the ship's seawater hose was used to pump near surface seawater with a density and temperature that is representative of the conditions in which the glider will be deployed. A calibrated Seabird Microcat CTD was used to measure the tank water temperature and salinity in order to derive the water density. The most recent ships CTD casts were then consulted to check the water column properties. Any temperature deviations of the seawater while it was used in the test tank were closely monitored. This information was used to compare with readings from historical records for the work area that were used to determine the pre-cruise glider ballasting conditions. These records showed that in a 100m water column ~1027kg/m^3 at ~12.5^{O}C represent reasonable average conditions. For a standard Slocum electric glider the buoyancy pump is capable of compensating for mass variation of between ~± 250g from the neutrally buoyant 'ballasting' condition, or ~± 4 sigma units. Glider ballasting is usually inferred from fresh or salt water test tanks. Internal trim weight adjustments are usually made to ensure that the vehicle is neutrally buoyant for the mean conditions of the deployment water column. In a vehicle that has a typical mass in the order of 60kg there is clearly only a small margin for error. The tank tests were designed to provide assurance of or identify problems with the glider ballasting before a glider deployment is considered. The ships most recent CTD was used as a reference for the tests at a GPS location of 48^O 17.90035N, 09^O 32.09370W. The CTD values and densities are summarised in Table 13.5. Considering the turbulence glider required depth of 100m and 140m for the unit 194 glider, these values appeared to be a reasonable ballasting starting point, as verified by the ship's CTD readings in *table 13.5.*

Depth(m)	Temperature(^{O}C)	Salinity(PSU-78)	Density(kg/m^3)
10	13.20	35.61	1026.87
70	13.08	35.61	1027.16
112	12.05	35.64	1027.58
134.5	11.74	35.64	1027.74

Table 13.5 RRS Discovery Ships CTD Results

The Teledyne Webb Research (TWR) glider ballasting spreadsheet was used to estimate the ballasting adjustments between the tank (near surface water, taking into account the on deck temperature elevations of the water) and the ships most recent CTD cast. An estimate was that the gliders should be ~40g to 50g too heavy, i.e. slightly heavy in the water. The ship was not moving around significantly and the tank was about 40% full of water. A recently calibrated Seabird Microcat CTD, serial number 5434, was used to determine the tank temperature, conductivity and PSS-78 Salinity. Tank CTD checks were conducted at the beginning, part of the way through and the end of the testing to account for drift, particularly the water temperature. Table 13.6 summarises the tank CTD measurements during the ballasting trials.

Comment	Temperature(^{O}C)	Salinity(PSU-78)	Density(kg/m^3)
Tank at start 10:02 (UTC)	15.1563	35.4062	1026.25
Tank during test 12:07 (UTC)	15.9785	35.6292	1026.24
Tank during test 13:54 (UTC)	17.0363	35.6524	1026.01

Table 13.6 RRS Discovery Tank CTD Results – Sunday 17th June 2012

The gliders were placed in the tank one by one and the unit 175 turbulence glider lifting and release method was rehearsed. Units 175, 194 and 051 were tested first and these gliders seemed to be well ballasted. Unit 051 sank and a spring scale attached to the cleat measured (oscillated around) ~50g. Unit 052 also sank and this registered >= 100g on the spring scale, suggesting a potential ballasting problem. If a glider performed in this way in the NOCL tank I would normally consider reducing the ballast weight. An estimate would be to say remove at least 50g, 25g from the front, if this is possible with the oil pump type 1000m depth rated Slocum glider, and 25 g from the rear inside the glider hull. That said, a larger ballasting weight correction of a reduction of in the order of 100g would be recommended in this case. Although the tank on the ship was moving the gliders seemed to not exhibit too much parasitic pitch or roll, with the exception of unit 194. Although this glider was well ballasted the glider exhibited parasitic positive pitch, with the nose section slightly raised. Before the deployment it was noticed that the cleat had been fitted to the aft of the science bay rather than the usual mounting location ahead of the science bay. This problem was corrected before the unit 194 deployment.

After some debate a request was made from NOC Southampton for the unit 052 – Coprolite glider to be re-ballasted. A delay of one day for the planned deployment occurred while 100g of ballast for this glider was removed. This involved opening the glider, removing 50g from the front and 50g from the rear internal ballasting. The glider seals were serviced, the o rings were replaced and the vacuum port o ring was replaced. The glider was then put back under vacuum and extensively tested before deployment.

13.5 *Glider Deployment Procedure and Operations*

During the unit 175 turbulence glider deployment an attempt was made to tether the glider to perform an initial dive test. The intention was to perform a shallow initial test dive and have the option to keep the glider on station for an emergency recovery if a problem occurred. An initial tethered dive test is in line with the manufacturer guidelines for the early phases of the deployment of Slocum Electric Gliders. This was a difficult problem to solve without small boat support and snagging of the extra line caused the glider to impact with the hull of the ship. A decision was then made to release the glider and risk an un-tethered initial test. A net was also on standby for an emergency recovery if this was required. It became clear that lightweight fending off poles were required to ensure a deployed glider does not impact with RRS Discovery during the deployment operations. *Fig. 13.7* shows some picture of the unit 175 turbulence glider deployment.

Unit 175 Turbulence glider deployment – Monday 18th June 2012

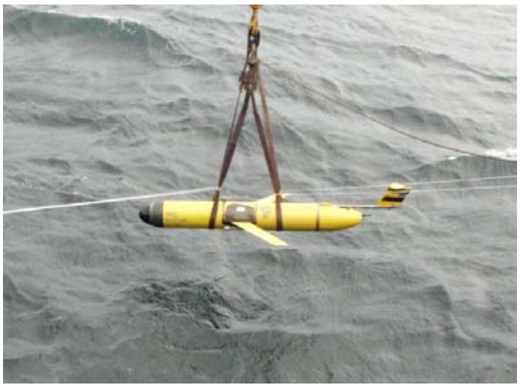
Fending off poles required for Unit 175

Figure 13.7 Unit 175 Turbulence Glider Deployment Photographs

Two lightweight fending off poles were then constructed by cutting in half the original long telescopic pole that was supplied by NOC Southampton. The telescopic pole was fully extended and locked in place. Initial testing showed that the telescopic pole could be easily pulled apart by hand in certain sections. In order to prevent this, adhesive tape was used to prevent the pole retracting or sections being pulled apart. The long pole was intended to allow snaring of the upper cleat of a standard Slocum glider. Concerns over the ability or accuracy required to snag a line to a glider upper cleat, the cleat dynamic load bearing ability and the potential excessive movement, snatching and so on that may occur caused this untested recovery system to be abandoned. The cushioned fending off poles that were subsequently constructed proved to be particularly useful for controlling a glider position when it is close to the deployment ship. The micro-Rider turbulence probe mounted on the upper part of the glider hull precludes the easy installation of a load bearing pick up point.

Therefore the fending off poles offered a more suitable alternative. Photographs of the fending off poles with curved cushioned ends and the revised deployment method are shown in *Fig. 13.8.*

Curved cushioned ends were added to the dual fending off poles. The requirement was to aim for the glider hull fore and aft sections, clear of nose, air bladder cowling, wings and CTD

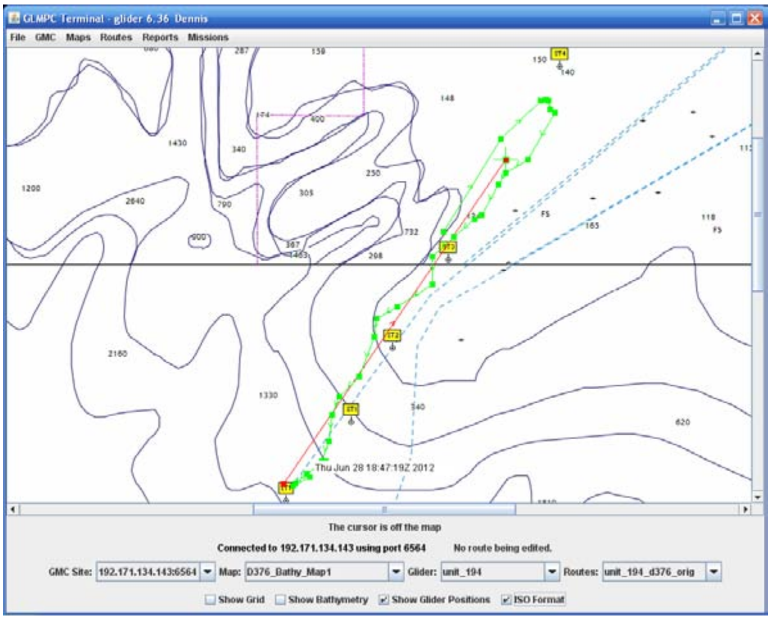


Deployment of unit 051 – Bellamite without a tether for initial dive testing

Figure 13.8 Glider Cushioned Fending Off Poles and Revised Deployment Method

13.6 ***Glider Piloting***

As the gliders were progressively deployed the piloting duties expanded. The unit 051 – Bellamite and 052 – Coprolite glider deployments were coordinated by the use of an on-board satellite phone at a glider control station, as previously shown in Fig.13.2. When the initial glider dive testing was complete and the gliders were confirmed as operating satisfactorily control of the gliders was handed over. Pilots based in Southampton (David Smeed and David White) then operated these gliders using Iridium satellite based long range communications. Chris Balfour assumed primary responsibility for piloting the unit 175 turbulence glider with Phil Knight acting as a backup pilot. For unit 194, Chris Balfour and Phil Knight have been operating this glider and implementing a series of progressive power management refinements to the glider setup. *Fig. 13.9* shows sample TWR GLMPC positional plotting for the unit 194 G2 glider.



Unit 194 initial survey close to the cruise mooring stations and across the Celtic Sea shelf edge. The green rectangles represent the reported glider surfacing positions and the red rectangles with a line between, when visible, represent the intended survey area.

Figure 13.9 Slocum Electric Glider GLMPC Positional Plot

13.7 *Glider Recovery*

The proposed glider recovery system was used for the first time on Wednesday 27th June and *Fig. 13.10* shows a series of photographs to illustrate the method used. The unit 175 turbulence glider was recovered at the first attempt without incurring any damage to the glider.

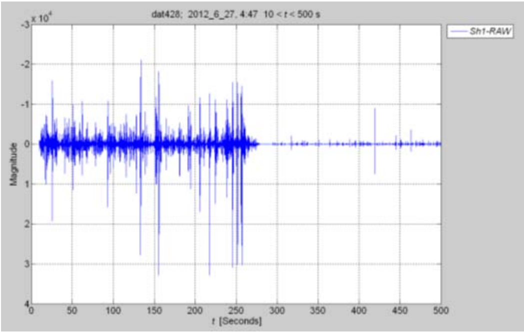
Unit 175 Turbulence Glider alignment for recovery

Cushioned fending off poles used for the Unit 175 Turbulence Glider recovery

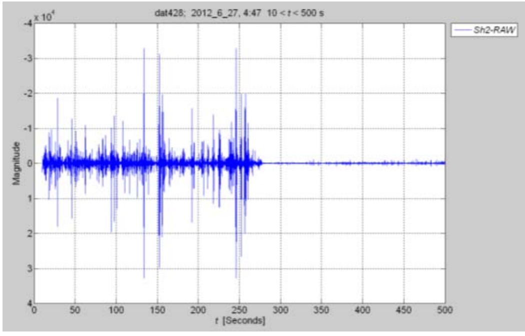
Figure 13.10 Unit 175 Turbulence Glider Recovery

13.8 *Initial Unit 175 Turbulence Data Assessment*

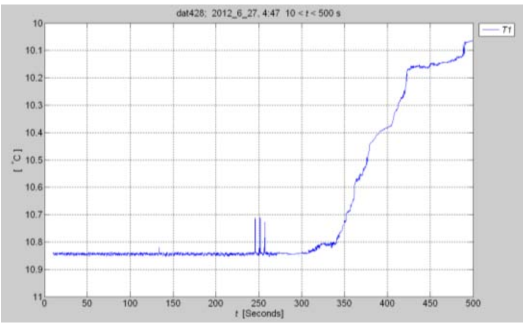
Plots of the initial turbulence glider data assessment are shown in Fig. 13.11, Fig.13.12 and Fig 13.13.



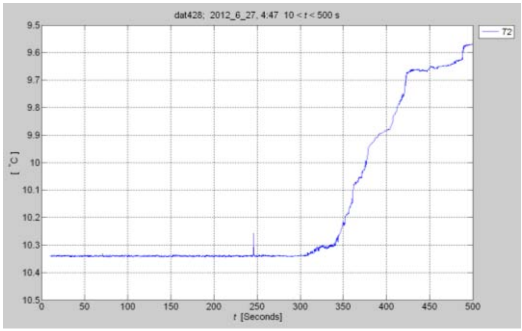
Shear 1 channel – X axis – high and low level signals throughout the data set indicating that the probe is operating correctly.



Shear 1 channel – X axis – high and low level signals throughout the data set indicating that the probe is operating correctly.

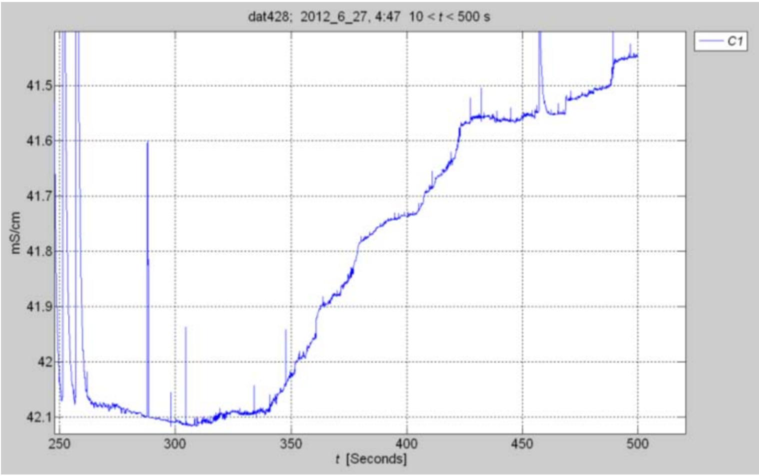


Temperture probe T1 shows rapid measuremnts of water column temperature changes indicating the probe is operating correctly.



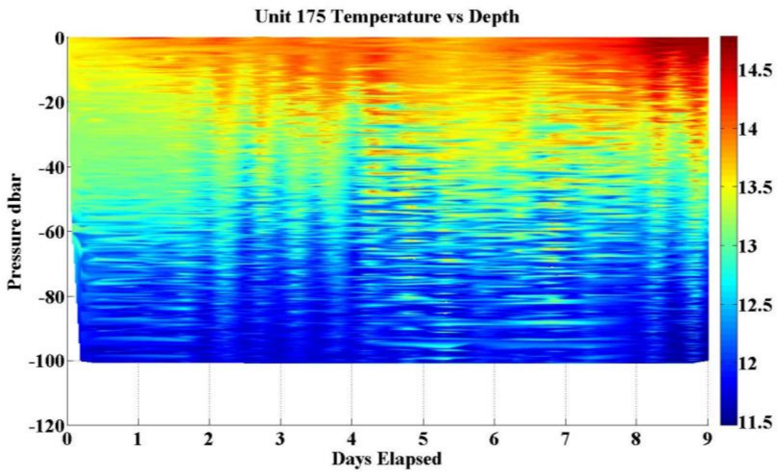
Temperture probe T2 shows rapid measuremnts of water column temperature changes indicating the probe is operating correctly.

Figure 13.11 Recorded micro-Rider shear and temperature turbulence data at a sample rate of 512Hz during profiling at the end of the glider deployment indicating sustained correct probe operation

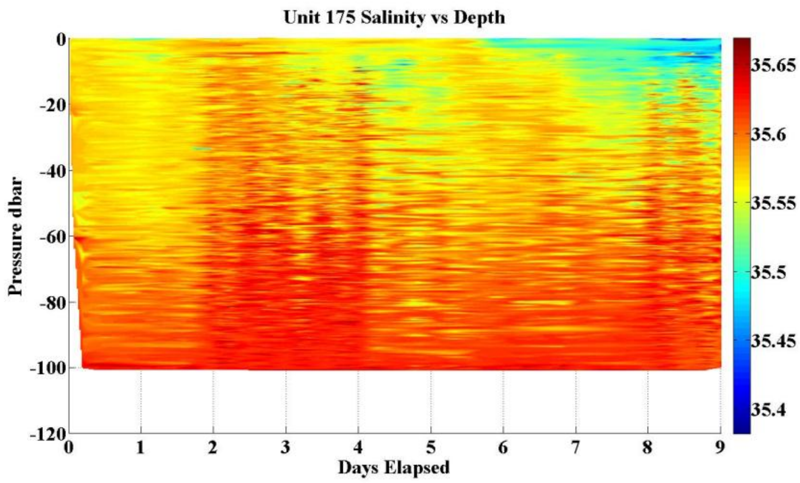


Micro-conductivity measurements demonstrating the probe is still producing rapid measurments in conductivity changes during glider profiling at the end of the deployment. No indication of fouling of the micro-conductivity probes is evident in the recorded data that has been analysed to date

Figure 13.11 Recorded Micro-Rider micro-conductivity at a sample rate of 512Hz during profiling at the end of the glider deployment indicating sustained correct probe operation



Glider temperature measurements over the 9 day unit 175 turbulence glider deployment



Glider salinity measurements over the 9 day unit 175 turbulence glider deployment

Figure 13.12 Glider CTD profiles have been recorded over the full deployment

14 Underway measurements

Jo Hopkins

14.1 *Introduction*

All the ships navigation, echo soundings, surface hydrography and meteorology (surfmet), magnetometer and winch data are stored on a central logging system, TECHSAS (TECHnical and Scientific sensors Acquisition System), in NetCDF format. This underway data can be transferred from TECHSAS to an RVS Level-C logging system where data processing modules (described later) are applied. On D376 navigation, echo soundings, surface hydrography and meteorology data were taken every 1 second from these processed data streams.

14.2 *RVS Level-C data streams and processing*

The following processed Level-C files were produced daily containing 1 second data.

Filename	**Start of file**	**End of file**
D376-163-1s-dos.txt	11-Jun-2012 14:35:40	12-Jun-2012 12:00:00
D376-164-1s-dos.txt	12-Jun-2012 12:00:00	13-Jun-2012 12:00:00
D376-165-1s-dos.txt	13-Jun-2012 12:00:00	14-Jun-2012 12:00:00
D376-166-1s-dos.txt	14-Jun-2012 12:00:00	15-Jun-2012 12:00:00
D376-167-1s-dos.txt	15-Jun-2012 12:00:00	16-Jun-2012 12:00:00
D376-168-1s-dos.txt	16-Jun-2012 12:00:00	17-Jun-2012 12:00:00
D378-169-1s-dos.txt	17-Jun-2012 12:00:00	18-Jun-2012 12:00:00
D378-170-1s-dos.txt	18-Jun-2012 12:00:00	19-Jun-2012 12:00:00
D378-171-1s-dos.txt	19-Jun-2012 12:00:00	20-Jun-2012 12:00:00
D378-172-1s-dos.txt	20-Jun-2012 12:00:00	21-Jun-2012 12:00:00
D378-173-1s-dos.txt	21-Jun-2012 12:00:00	22-Jun-2012 12:00:00
D378-174-1s-dos.txt	22-Jun-2012 12:00:00	23-Jun-2012 12:00:00
D378-175-1s-dos.txt	23-Jun-2012 12:00:00	24-Jun-2012 12:00:00
D378-176-1s-dos.txt	24-Jun-2012 12:00:00	25-Jun-2012 12:00:00
D378-177-1s-dos.txt	25-Jun-2012 12:00:00	26-Jun-2012 12:00:00
D378-178-1s-dos.txt	26-Jun-2012 12:00:00	27-Jun-2012 12:00:00
D378-179-1s-dos.txt	27-Jun-2012 12:00:00	28-Jun-2012 12:00:00
D378-180-1s-dos.txt	28-Jun-2012 12:00:00	29-Jun-2012 12:00:00
D378-181-1s-dos.txt	29-Jun-2012 12:00:00	30-Jun-2012 12:00:00
D378-182-1s-dos.txt	30-Jun-2012 12:00:00	30-Jun-2012 23:00:00

The table below details the data contained within each file and the instrument that it has come from. Details of any processing routines applied are described below.

Heading	Description	Instrument / processing
Time	YY DDD HH:MM:SS where DDD is the Julian day of the year	1 second intervals
Latitude	Latitude [decimal degrees]	Seastar 9200 G2
Longitude	Longitude [decimal degrees]	Seastar 9200 G2
SMG	Speed over the ground [knots] (speed made good)	Seastar 9200 G2
CMG	Course over the ground [degree true] (course made good)	Seastar 9200 G2
AshHeading	True heading of ship [degree]	Ashtech ADU5 GPS
Pitch	Pitch [degree]. Bow up gives positive value.	Ashtech ADU5 GPS
Roll	Roll [degree]. Starboard roll gives positive value.	Ashtech ADU5 GPS
UncDepth	Sounding value [m]	Simrad EA500
CorDepth	Sounding value [m]	Simrad EA500, calculated by *prodep*
Temp_h	Water temperature measured in SBE45 housing [degree Celsius]	Seabird Micro TSG SBE45
Cond	Conductivity measured by the SBE45 [siemen per metre]	Seabird Micro TSG SBE45
SndSpeed	Velocity of sound in the sampled water calculated by the SBE45 [metre per second]	Seabird Micro TSG SBE45
SST	Water temperature measured by the SBE38 remote thermometer at the raw water inlet to the ship (Temp_r)	Seabird SBE8 Digital Oceanographic Thermometer
Salinity	Water salinity calculated by the SBE45 [pss]	Seabird Micro TSG SBE45
Fluorescence*	Voltage measured by the Nudam Analogue to Digital Convertor (ADC) [volts]	Wetlabs WS3S Fluorometer
Transmittance*	Raw voltage measured by the Nudam ADC	Wetlabs C-Star Transmissometer
AirTemp	Air temperature [degree Celsius]	Vaisala HUMICAP temperature sensor (model HMP45A)
Pressure	Atmospheric pressure [hPa]	Vaisala BAROCAP (model PTB110)
PPAR* and SPAR*	Photosynthetically Active Radiation. Voltage measured by the Nudam ADC in millivots and multiplied by 100 in the surfmet software [volt x 10^{-5}]	Skye Instruments Photosynthetically Active Radiation Sensor (model SKE 510) on port/starboard side
PTIR* and STIR*	Total Incidental Radiation.Voltage measured by the Nudam ADC in millivolts and multiplied by 100 in the surfmet software [volt x 10^{-5}]	Kipp and Zonen Total Incidental Radiation sensor (model CM6B) on port/starboard side
RelWindSPD	Relative wind velocity [m/s]	Gill Windsonic anemometer on ships met

		platform (approx. 18.7 m above sea surface)
RelWindDIR	Relative wind direction [degree] with 0° being at the bow.	Gill Windsonic anemometer on ships met platform (approx. 18.7 m above sea surface)
Humidity	Relative humidity of the air [%]	Vaisala HUMICAP 180 humidity sensor (model HMP45A)
AbsWindSpd	Absolute wind speed [m/s]	from *pro_wind* (every 10 seconds)
AbsWindDir	Absolute wind direction [degree]	from *pro_wind* (every 10 seconds)
Heading	True heading of ship	Ships Gyro Heading

**Requires manufacturer calibration*

14.2.1 Corrected depth variable

The corrected depth variable (CorDepth) was obtained from the processing routine ***prodep***. The programme corrects the raw depths (UncDepth) recorded by the hull-mounted, single beam echo sounder (Simrad EA500) for local variations in sound velocity using values from the Carter tables published by the Hydrographic Office. These tables divide the world's oceans into areas of similar water masses and provide depth corrections for each area. The program uses a navigation file to find the position of each depth record and applies the relevant correction.

14.2.2 Calculation of absolute winds

Unlike all other variables, the absolute wind speed and direction (AbsWindSpd, AbsWindDir) is output every 10 seconds (as opposed to every 1 second). This is due to the routine ***pro_wind*,** which calculates the absolute wind, relying on output from the programme *bestnav*, which is only available every 10 seconds. ***pro_wind*** removes the relative variables from the wind. It removes any fixed offsets in the system and any effect of the ship motion (using heading, CMG and SMG produced by *bestnav* – not those in the table above) to produce a true representation of the ships wind.

bestnav reads position fixes from up to three GPS sources (1. Seastar 9200 G2, 2. AshTech ADU5, 3. Trimble 4000) along with the ships motion (calculated by *relmov*). When the primary GPS source (Seastar 9200 G2) fails the program resorts to the secondary GPS source (AshTech ADU5) until the primary source resumes and so on. Dead reckoning is used to fill in gaps where all three sources fail and draws upon the relative motion of the ship calculated in *relmov* and an estimate of the ships drift velocity. *bestnav* also calculates speed and course made good. Given the reliability of the primary GPS feed (Seastar 9200 GPS), and the desire for 1 second instead of 10 second navigational data *bestnav* is only used to produce the variables required by *pro_wind*.

relmov: Calibrates and calculates the relative movement of the ship. Data are obtained from the electromagnetic speed log and the ship's gyro. *relmov* calibrates the ships gyro heading by applying a fixed offset to obtain a true heading. The electromagnetic log is calibrated for misalignment, maximum slew and a multiplier. *Relmov* then calculates the ship's northward and eastward velocities. The relative movement of the ship is used to calculate the ship's track during periods of dead-reckoning.

bestdrf: This is a product of *bestnav*. When run *bestnav* uses the *relmov* data which contains a predicted vn and ve (ships velocities) 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.

14.3 *Matlab processing and calibration*

Each Level-C file was read into Matlab so that further processing, calibration and quality control could be performed on selected variables.

14.3.1 Manufacturer calibrations

The SBE 45 and SBE 38 sensors have manufacturer calibrations applied prior to ingestion into the TECHSAS and RVS data formats. Channels requiring a manufacturer calibration are: fluorimetry, transmissometry, PAR, and TIR. No calibrations are necessary for air temperature and pressure, humidity, wind speed and direction.

Chlorophyll (WETLabs WETStar)
The following calibration was applied to obtain chlorophyll concentration, CHL:

CHL(μg/l) = SF x (output – CWO)

SF = Scale factor = 14.2 μg/l/V
CWO = Clean water offset = 0.077 V
Output in volts

Transmission (WETLabs C-Star)
The following calibration was applied to obtain beam transmission (Tr) and the beam attenuation coefficient (c):

Beam transmittance = $T_r = (Vs_{ig} - V_d) / (V_{ref} - V_d)$
Beam attenuation coefficient = $c = -1/x * \ln(T_r)$

V_d Meter output with the beam blocked (the offset) 0.060 V
V_{air}Meter output in air with a clear beam path4.766 V
V_{ref}Meter output with clean water in the path4.658 V
V_{sig}Measured signal outputV
XPathlength0.25 m

The beam transmission is a value between 0 and 1 (or 0-100%)

PPAR and SPAR (Skye Instruments)
For the calculation of Photosynthetically Active Radiation (PAR) the following equation was applied:

$$PAR\ (W/m^2) = (output\ \ x\ 10\ )\ [\mu V]\ /\ sensitivity\ [\mu V/W/m^2]$$

The PAR output in the processed files is in a non-standard voltage unit (millivolts x 100). This means that the output needs to be multiplied by 10^{-5} to convert to volts (V) or by 10 to convert to microvolts (μV). The sensitivity for the port and starboard sensors is 11.21 and 10.53 μV/W/m^2 respectively.

PTIR and STIR (Kipp and Zonen)
For calculation of solar irradiance the following equation is applied:

$$TIR\ (W/m^2) = (pyranometer\ output\ x\ 10)\ [\mu V]\ /\ sensitivity\ [\mu V/W/m^2]$$

The TIR output in the processed files is in a non-standard voltage unit (millivolts x 100). This means that the output needs to be multiplied by 10^{-5} to convert to volts (V) or by 10 to convert to microvolts (μV). The sensitivity for the port and starboard sensors is 9.84 and 11.97 μV/W/m^2 respectively.

14.3.2 In-situ calibrations

Samples from the ships underway water supply were taken every 6 hours up until 25th June 2012, and then every 4 hours thereafter, in order to provide calibration for salinity and chlorophyll concentration.

14.3.3 Salinity

A total of 86 useable salinity samples were analyzed using a Guildline Autosal salinometer (S/N 60839) against standard seawater. Two readings were excluded as extreme outliers leaving a total of 84 samples from which the mean and standard deviation of residuals (Sample – SBE45 reading) is 0.0035 ± 0.0024. An offset of 0.0035 has therefore been applied to the SBE45 underway salinity.

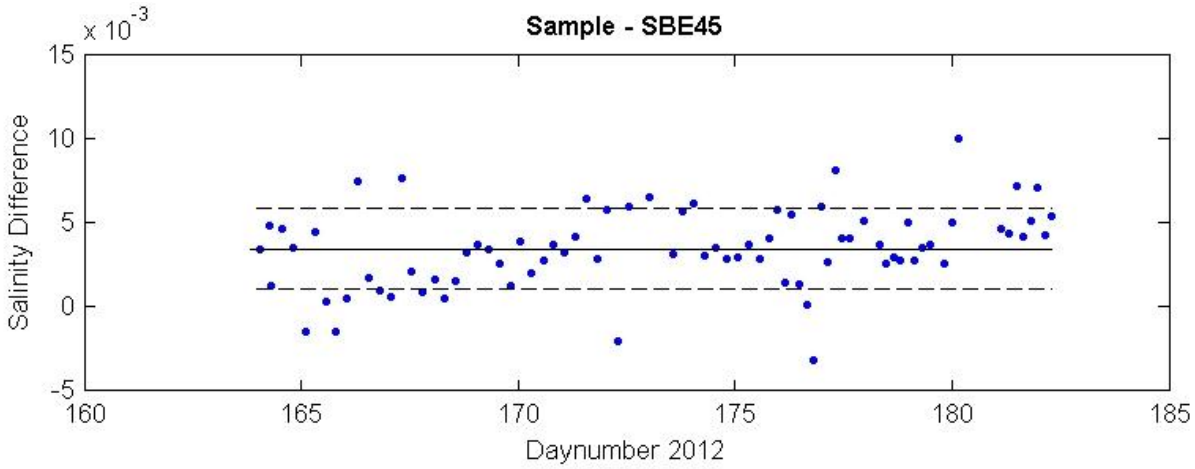


Figure 14.1 *Residual salinity (Sample – SBE45). Dashed lines mark 1 standard deviation above and below the mean residual (solid line)*

14.3.4 Chlorophyll

A chlorophyll calibration was <u>not</u> attempted while at sea. The voltage (Fluor) and manufacturer calibration (CHL in µg/l) are provided in the .mat files but should be treated with caution. Calibration of underway fluorimetry is notoriously difficult because of daytime fluorescence quenching in surface waters. During the day when the amount of incoming solar radiation is highest, light levels exceed the amount that phytoplankton cells in the surface can process and the excess energy is dissipated as heat rather than fluorescence. In this situation, the amount of fluorescence measured, relative to the amount of chlorophyll pigment present is decreased. In-situ measurements of chlorophyll concentration would therefore not show the same amount of chlorophyll present in the water. Other factors that can add significant variability in the relationship between fluorescence and pigment concentration are: community composition, light history of the cells (changes in mixed layer depth or stratification caused for example by a wind event), and nutrient limitation.

14.3.5 Quality control, de-spiking and smoothing

The worst spiking from a number of channels was removed (turned into a NaN), by identifying measurements falling beyond *x* standard deviations of the median within a ∆t second window. In exceptional cases, spikes were identified and removed manually. The window size and standard deviation used for each variable are detailed in the table below. A 10 second median smoothing window was also applied to these data streams. Variables NOT in the table below have not been de-spiked or smoothed.

Variable	Window size (∆t in seconds)	No. of standard deviations (*x*)
Temp_h, Temp_r (SST), Salinity	30	3
CHL, Fluor	30	2
Tr (beam transmission), c (beam attenuation coef.)	30	2
PPAR/SPAR, PTIR/STIR	30	3
AirTemp, Pressure, Humidity	30	3
AbsWindSpd, AbsWindDir	300	2.5

Smoothing of the absolute winds was performed on the complex wind vector Z = R exp(-*i*θ), where R = absolute wind speed and is θ the absolute wind direction in radians. The speed and direction scalars were then re-formed after smoothing.

In an attempt to account for shading of the sensors total PAR and TIR values were created by taking the maximum value recorded between the port and starboard sensors (TIR = max([PTIR STIR]), PAR = max([PPAR SPAR])). The de-spiked and smoothed versions of PPAR/SPAR and STIR/PTIR were used to do this.

Any headings in either AshHeading or Heading > 360 or <0 were removed. Heading readings from the gyro compass between 23rd June 2012 18:37:09 and 24th June 2012 00:10:33 were noise and were also removed. Subsequent comparison of the headings recorded by the ships gyro and the AshTech GPS revealed a median offset of -0.622 degrees (gyro > AshTech).

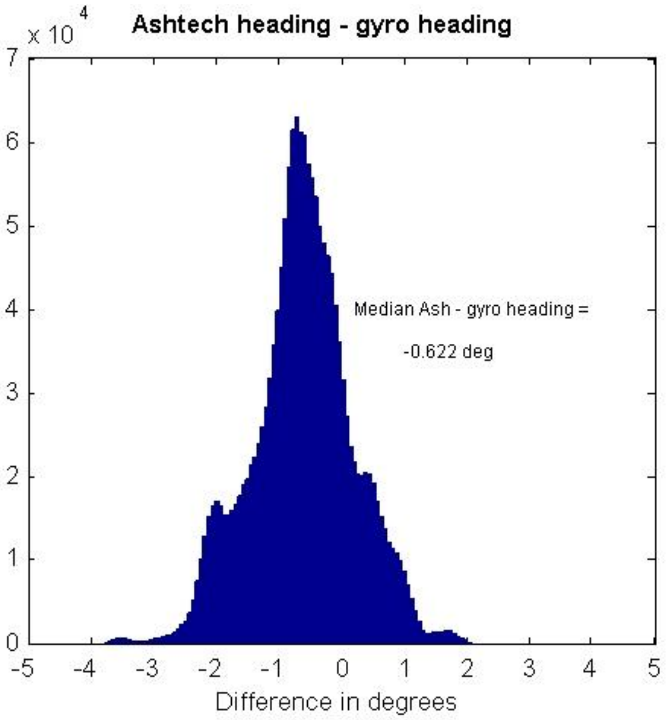


Figure 14.2 AshTech – Gyro compass heading comparison.

14.3.6 Notes

Air temperature and humidity sensor errors started appearing at 09:22:10 GMT on 24th June 2012. The sensor was subsequently changed on 26th June 2012 at 14:45 GMT. This section of data has been completely removed. When changing the sensor it was noted at the sensor cap was still in place! All the humidity data before the sensor change has been removed. The air temperature record has been kept but should be treated with caution.

29th June 2012 – Through flow rate dropped to 0, and then recovered back to 1.5. This was coincident with the temperature readings being far too high.

From 22:40 GMT on the 28th June the precision echo sounder (Simrad EA500), mounted in the FISH, rather than in the ship's hull was used. Deploying the transducer in this way avoids much of the cavitation and ships noise (e.g. engine) that interferes with soundings made from the hull mounted transducers.

The following Matlab *.mat* files were produced containing concatenated data streams for the entire cruise:

File name	Variables in file	Time stamp (sec)
D376_NAV1_1sec.mat	Latitude, Longitude, date, daynum[*], dd[$], AshHeading, Heading, SMG, CMG	1
D376_NAV2_1sec.mat	Latitude, Longitude , daynum[*], dd[$], CorDepth	1
D376_SURF1_1sec.mat	Latitude, Longitude , daynum[*], dd[$], Temp_h, Temp_r, Salinity	1
D376_SURF2_1sec.mat	Latitude, Longitude , daynum[*], dd[$], Fluor, CHL, Tr, c	1
D376_PAR_1sec.mat	Latitude, Longitude , daynum[*], dd[$], PPAR, SPAR, PAR	1
D376_TIR_1sec.mat	Latitude, Longitude , daynum[*], dd[$], PTIR, STIR, TIR	1
D376_MET1_1sec.mat	Latitude, Longitude , daynum[*], dd[$], AirTemp, Pressure, Humidity	1
D376_MET2_10sec.mat	Latitude, Longitude , daynum[*], dd[$], AbsWindSpd, AbsWindDir	10

[*] Decimal Julian day number (01-Jan-2012 = daynum 1)
[$] Matlab serial date number

An additional file, *gebco_depths_1sec.mat*, has been created containing the nearest GEBCO depth (30 minute grid) to each latitude and longitude in the 1 second underway navigation (D376_NAV1_1sec.mat).

14.4 *Instrumentation*

The following table contains details of instrumentation, calibration dates and serial numbers (where known).

Instrument	Serial Number	Calibration date
WETLabs Chlorophyll WETStar (model WS3S)	134	11th November 2011
WETLabs C-Star transmissometer (model CST)	112R	11th October 2011
Seabird SBE45 thermosalinograph	4548881-0231	17th December 2011
Seabird SBE38 Thermometer	3854115-0491	27th June 2011
Vaisala temperature and humidity (model HMP45A)	D1440038 (up until 13:00 GMT on 26/06/12)	21st October 2011
Vaisala temperature and humidity (model HMP45A)	B4950011 (from 26/06/12 14:45 GMT onwards)	16th May 2012
Vaisala barometric air pressure (model PTB110)	F4740025	15th May 2012
Gill Windsonic anemometer	71123	Not required
Skye PAR (model 510) on forward mast port	28559	22nd July 2010
Skye PAR (model 510) on forward mast starboard	28556	7th June 2011
Kipp and Zonen TIR (model CMB6) on forward mast port	962301	26th April 2011
Kipp and Zonen TIR (model CMB6) on forward mast starboard	047462	26th July 2011

14.5 ***Result***

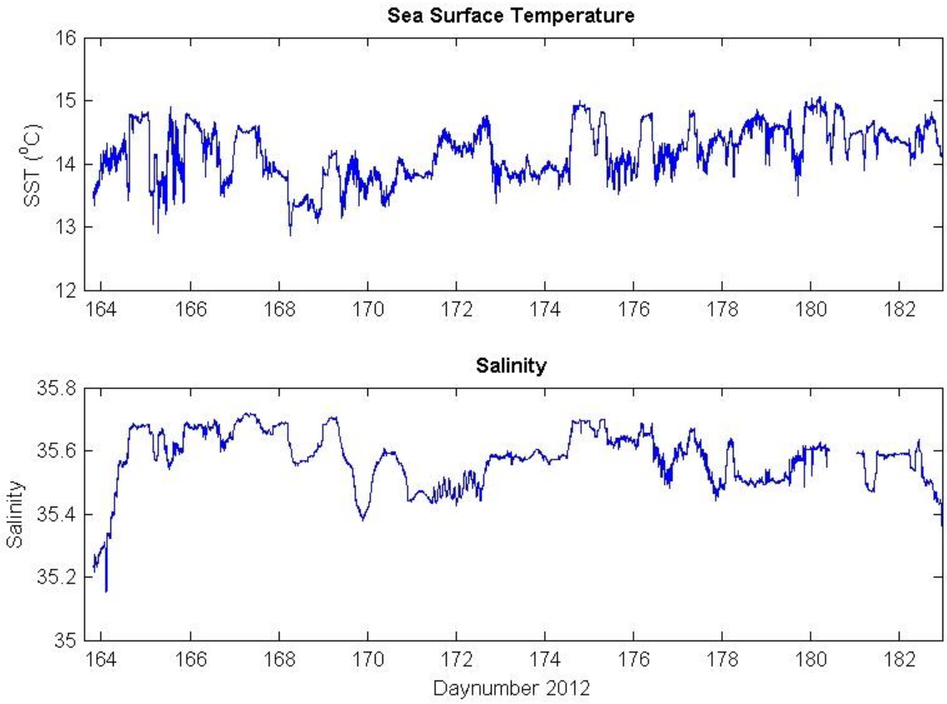


Figure: 14.3 Underway sea surface temperature and salinity

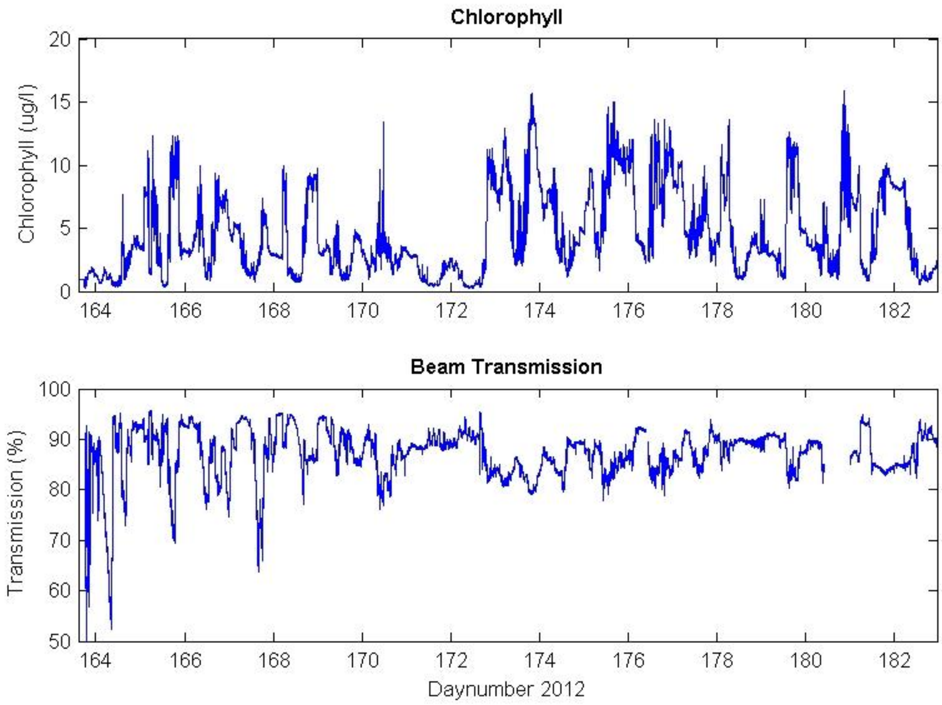


Figure14.4 Underway chlorophyll and beam transmission

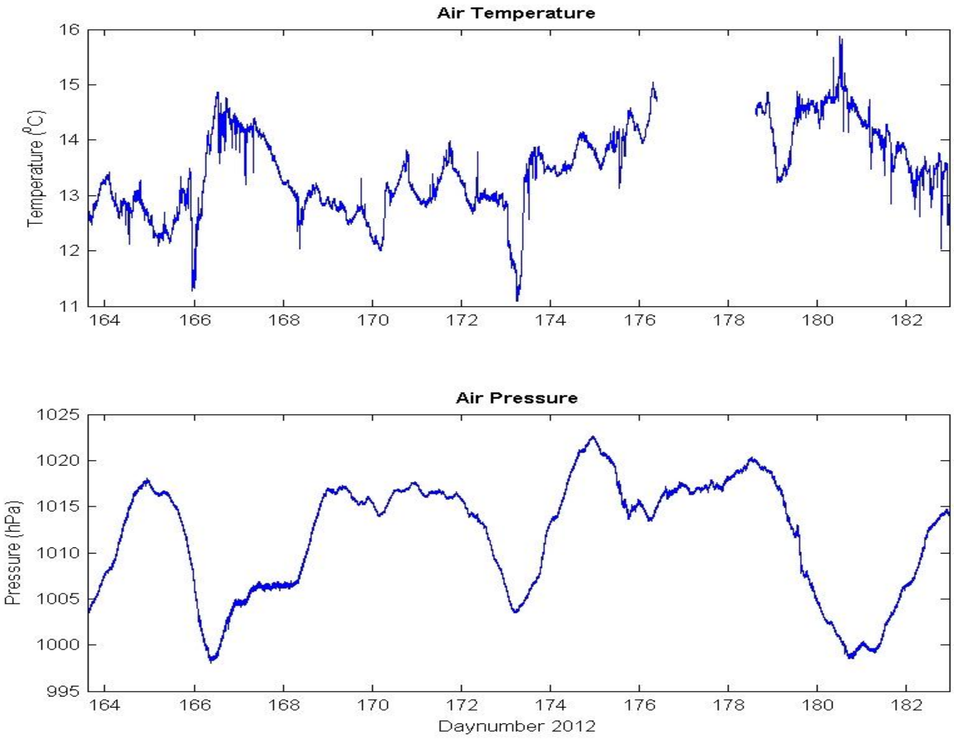


Figure14.5 Air temperature, air pressure during D376

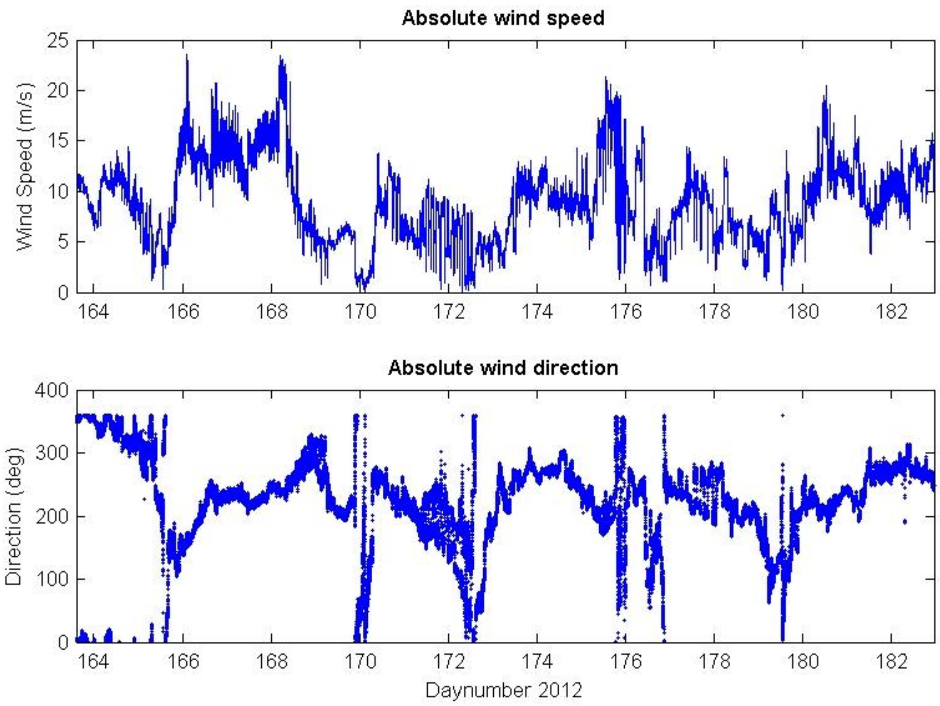


Figure 14.6 Absolute wind speed and direction

15 Computing and Ship Systems Report

Martin Bridger

15.1 *RVS LEVEL C System*

Level C - The level C system is a Sun Solaris 10 UNIX Workstation discovery1 also known as ABCGATE. The RVS software suite is available on this machine. This suite of software allows the processing, editing and viewing of all data within the RVS data files. This system also has monitors that allow us to ensure that the level C is receiving data from the level B.

15.2 *Ifremer Techsas System*

The Ifremer data logging system is the system that will inevitably replace the existing Level A + B system while for the most part the Level C will remain as the main system for outputting, viewing and editing the acquired data.

The Techsas software is installed on an industrial based system with a high level of redundancy. The operating system is Red Hat Enterprise Linux Edition Release 3. The system itself logs data on to a RAID 0 disk mirror and is also backed up from the Level C using a 200GB / 400GB LTO 2 Tape Drive. The Techsas interface displays the status of all incoming data streams and provides alerts if the incoming data is lost. The ability exists to broadcast live data across the network via NMEA.

The storage method used for data storage is NetCDF (binary) and also pseudo-NMEA (ASCII). At present there are some issues on some data streams with file consistency between the local and network data sets for the ASCII files. NetCDF is used as the preferred data type as it does not suffer from this issue.

The Techsas data logging system was used to log the following instruments:

1) Trimble GPS 4000 DS Surveyor (converted to RVS format as gps_4000)
2) Chernikeef EM speed log (converted to RVS format as log_chf)
3) Ships Gyrocompass (converted to RVS format as gyro)
4) Simrad EA500 Precision Echo Sounder (ea500)
5) NMFD Surface-water and Meteorology (surfmet) instrument suite
6) ASHTECH ADU-2 Altitude Detection Unit (gps_ash)
7) NMFD Winch Cable Logging And Monitoring CLAM (winch)
8) Fugro Seastar 9200 G2 XP Differential (gps_g2)
9) Seabird SBE45 MicroTSG (seabird)

15.3 *Fugro Seastar DGPS Receiver*

The Fugro Seastar G2 is a Glonass and GPS receiver that is used to provide 10cm accuracy and also receives differential from the Fugro differential system. This signal is then buffered out to multiple systems including the Trimble 4000 DS. The Seastar was purchased as an upgrade to the old Seastar and G12 combination. The system is designed to cope with the future expected solar activity that is expected to disable part of the existing GPS network. The system is also capable of receiving corrections via Internet if necessary.

NetCDF files for this system s9200G2s-FUGRO.gps
RVS Stream gps_g2
Forms part of the bestnav stream

15.4 *Trimble 4000 DS Surveyor*

The Trimble 4000DS is a single antenna survey-quality advanced GPS receiver with a main-masthead antenna. It uses differential corrections from the Fugro Seastar unit to produce high quality differential GPS (DGPS) fixes. It is the prime source of scientific navigation data aboard RRS Discovery and is used as the data source for Navigation on the ships display system (SSDS). This antenna is directly on top of the mast and suffers from negligible interference from other items on the mast. It is also almost directly at the centre point of the ship making it an ideal navigation system.

The Techsas NetCDF File ends with the following extensions :
Position-4000.gps
Satelliteinfo-4000.hps
RVS Stream gps_4000
Forms part of the bestnav stream

15.5 *Ashtec ADU-2*

This is a four antenna GPS system that can produce attitude data from the relative positions of each antenna and is used to correct the VMADCP for ship motion. Two antennae are on the Bridge Top and two on the boat deck.
The Ashtec system worked reliably throughout the cruise with some gaps that are quite usual with this system due to the amount of calculations necessary. No Large data gaps are present. The ADU-2 forms part of the bestnav system which is an assembly of multiple GPS signals including the gyronmea and emlog stream in order to calculate the best possible position, speed heading pitch and roll of the ship. The Ashtech is not as reliable as the Fugro Seastar G2 and the 4000DS mainly due to its low position on the ship it is hard for this system to maintain locks on satellites when the ship is maneuvering and the bridge and main mast come into its direct line of sight with the satellites.

The Techsas NetCDF File ends with the following extensions :
ADUPOS-PAPOS.gps
gppat-GPPAT.att
RVS Stream gps_ash
Forms part of the bestnav stream

15.6 *Gyronmea*

The Gyronmea is a file that receives its data from the Ships gyro compass located on the bridge. There are two such Gyros on the bridge and we are able to use either one of them as a source of heading. The selected Gyro is logged by the TECHSAS system and is used as part of the bestnav calculation.

The NetCDF File for Techsas ends with gyro-GYRO.gyr
RVS data stream gyro

15.7 *RDI 150KHz Vessel Mounted ADCP (VMADCP)*

The RDI Ocean Surveyor was setup by the science party at the start of the cruise with a bottom track and water track file that is included with the dataset. The configuration was changed when we left the shelf and went to deeper water. The Ocean surveyors are fed with data from the ships GPS, Gyro and ADU systems in order so that the system can calculate true speeds and direction of the currents below the ship.

50 Bins
8 Meter Bin Size
4 meter Blank
5.3 Meter Transducer Depth
Low Resolution (Long Range)
Ping as fast as possible.
Bottom Tracking

15.8 *Chernikeef EM log*

The Chernikeef EM log is a 2-axis electromagnetic water speed log. It measures both longitudinal (forward-aft) and transverse (port – starboard) ships water sped.

The EM log was not calibrated prior to the cruise and was reading at 0.0 knots when alongside.

The system was logged by the TECHSAS logging system.
DYLog-LOGCHF-DYLog
RVS Stream chernikeef

15.9 *Simrad EA500 Precision Echo Sounder (PES)*

The PES system was used throughout the cruise, with a variation between use of the Fish and use of the hull transducer. The fish is more accurate than the hull transducer as it is capable of being deployed deeper and is also decoupled from the noise of the ship.

The PES outputs its data to a stream called ea500 on the Level C System.

15.10 *Surfmet System*

This is the NMFD surface water and meteorology instrument suite. The surface water component consists of a flow through system with a pumped pickup at approx 5m depth. Non-Toxic flow is approx 25 litres per minute whilst fluorometer and transmissometer flow is approx 1.5 l/min. Flow to instruments is degassed using a debubbler with 40 l/min inflow and 10/l min waste flow. During this cruise, the inlet to the debubbler was lowered to between 10 and 15 l/min in order to allow more pressure to another water sampling system. This could have had an effect on the amount of bubbles that built up in the system

The meteorology component consists of a suite of sensors mounted on the foremast at a height of approx. 10m above the waterline. Parameters measured are wind speed and direction, air temperature, humidity and atmospheric pressure. There is also a pair of optical sensors mounted on gimbals on each side of the ship. These measure total irradiance (TIR) and photo-synthetically active radiation (PAR).

The Non Toxic system was enabled as soon as we were far enough away from land. It is also used as a coolant for the container labs.

The SBE45 unit was cleaned prior to sailing.

All underway water sampling instruments were checked daily, and cleaned periodically, while on station. Full records of cleaning and checking times are available on the TSG log sheet.

Techsas NetCDF Files for Surfmet

Surf-SURFMET.SURFMETv2
MET-SURFMET.SURFMETv2
Light-SURFMET.SURFMETv2
SBE45-SBE45.TSG

Surfmet rvs stream is the raw data captured from the TECHSAS System

The temp_h temp_m and cond data in the surfmet file is a direct copy of the seabird data however it can be delayed in time. For that reason, always use the data from the seabird instead of the surfmet for protsg and salinity calibrations.

These files contain
Temp_h (Housing Temperature from the SBE45 in the wetlab)
Temp_m (Marine Temperature from the Hull intake)
Cond (Conductivity from the SBE45 in the wet lab)
Trans (Raw Voltage from Transmissometer)
Fluo (Raw Voltage from Fluorometer)

Speed (Wind Speed from Gill Windsonic Anemometer)

Direct (Wind Direction from Gill Windsonic Anemometer)
Airtemp (Air Temperature from Vaisala HMP45A)
Humid (Air Temperature from Vaisala HMP45A)

Pressure (Air Pressure from Vaisala PTB100)
PPAR (Photosynthetic Active Radiation from SKE510 PAR Sensor on PORT Gimbal)
SPAR (Photosynthetic Active Radiation from SKE510 PAR Sensor on STBD Gimbal)
PTIR (Total Incidental Radiation from CM6B TIR Sensor on PORT Gimbal)
STIR (Total Incidental Radiation from CM6B TIR Sensor on STBD Gimbal)

Seabird is the raw log of the SBE45 and SBE38 through the SBE45 Junction Box.
Temp_h (Housing Temperature of SBE45 TSG)
Temp_m (Remote or Marine Temperature from Inlet pipe)
Cond (Conductivity in SBE45 TSG)
Salin (Calculated Salinity from Instrument)
Sndspeed (Calculated Sound Velocity from Instrument)

16 Surfmet: The Sensor List

16.1 *Met Platform Sensors*

16.1.1 Wind Speed and Direction

Manufacturer: Gill
Model: Windsonic (Option 3)

Ultrasonic Output Rate 1, 2, 4Hz
Wind Speed Range 0-60 m/s
Wind Direction Range 0-359 no dead band
Operating Temp Range -35 ºC to +70 ºC
Moisture Protection IP65
External Construction Luran
Digital O/P Options RS232 / 422 / 485 / SDI-12
NMEA O/P Yes
Analogue Outputs 2 (optional)
Calibration Generic

16.1.2 Total Incidental Radiation

Manufacturer: Kipp and Zonen
Model Number: CM6B

Spectral range 305...2800 nm (50%points)
Sensitivity 9...15 μV/Wm-2
Impedance 70...100 Ohm
Response time 1/e 5 s, 99 % 55 s
Non-linearity <1.5 % (<1000 W/m 2)
Tilt error <1.5 % at 1000 W/m 2
Operating temperature -40...+90 _C
Temperature dependence of sensitivity _2 % (-10...+40_C)
Maximum irradiance 2000 W/m2
Directional error < _20 W/m2 at 1000 W/m2
Weight 0.85 kg
Cable length 10 m

16.2 ***Temperature and Humidity***

Manufacturer: Vaisala
Model Number: HMP45A

16.2.1 Relative humidity measurement

HMP45A
Measurement range0.8 ... 100 % RH
Accuracy at +20 °C (+68 °F)± 2 % RH (0 ... 90 % RH)
± 3 % RH (90 ... 100 % RH)
SensorVaisala HUMICAP® 180

16.2.2 Temperature measurement

HMP45A
Measurement range -39.2 ... +60 °C (-38.6 ... +140 °F)
Accuracy +20 °C (+68 °F) ± 0.2 °C (± 0.36 °F)
Sensor Pt 1000 IEC 751

16.2.3 Operating environment

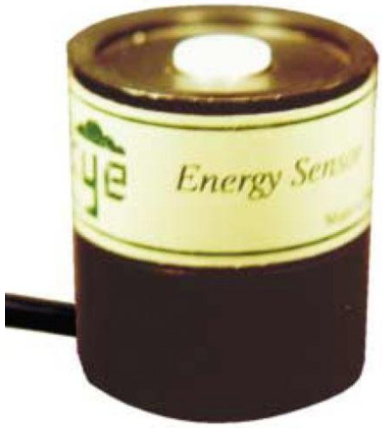
Temperature
operation-40 ... +60 °C (-40 ... +140 °F)
storage -40 ... +80 °C (-40 ... +176 °F)

16.2.4 Inputs and outputs

Operating Voltage 7 ... 35 VDC
Power consumption< 4 mA
Output load > 10 kohm (to ground)
Output scale-40 ... +60 °C (-40 ... +140 °F) equals to 0...1V
Output signalresistive 4-wire connection

16.3 *Photosynthetic Active Radiation*

Manufacturer: Skye Instruments
Model Number: SKE 510



Spectral Range400-700nm
Sensitivity Current3.5µA/100Wm^2
Sensitivity Voltage1mV/100Wm^2
Working Range0 – 5000Wm^2
Linear Error<0.2%
Absolute Calibration Errortyp <3% max 5%
Cosine Error3%
Azimuth Error<1%
Temperature coefficient+/-0.1%/ºC
Longterm Stability+/-2%
Response Time10ns
Internal Resistance300Ohms
Temperature Range-35ºC … +70ºC
Humidity Range0 – 100% RH

16.4 *Barometric Pressure*

16.4.1 Barometric pressure measurement

Pressure range800 ... 1100 hPa
Accuracy at +20 °C (+68 °F)±0.3 hPa
SensorVaisala

16.4.2 Operating environment

Temperature range-5 ... +45 °C (+23 ... +113 °F)
Humidity range<80 % RH

16.4.3 Inputs and outputs

Operating voltage9 ... 16 VDC
Power consumption:
operation mode2 mA (typical)
shutdown mode150 µA (typical)
Output voltage0 … 2.5 VDC

16.5 ***Sea Surface Instruments***

16.5.1 Fluorometer

Manufacturer: WetLabs
Model Number: WetStar

Temperature Range 0-30 C
Depth Rating 600m
Response time 0.17s
Input Voltage 7-15vdc
Current Draw < 40 mA
Output 0-5VDC

16.5.2 Transmissometer

Manufacturer: WetLabs
Model Number: CStar

Pathlength	25cm
Wavelength	660nm
Bandwidth	~ 20nm
Rated Depth	600m
Temperature	0-30ºC

Power Input 7-15VDC
Current Draw < 40mA
Data Output 0-5Volts
Time Constant 0.167 sec
Temperature Error 0.02 percent F.S./deg C

16.6 *Seabird Micro TSG SBE45*

Measurement Range
Conductivity: 0-7 S/m (0-70 mS/cm)
*Temperature *:* -5 to 35 °C

Initial Accuracy
Conductivity: 0.0003 S/m (0.003 mS/cm)
*Temperature *:* 0.002 °C
Salinity: 0.005 PSU, typical

Typical Stability *(per month)*
Conductivity: 0.0003 S/m (0.003 mS/cm)
*Temperature *:* 0.0002 °C
Salinity: 0.003 PSU, typical

Resolution
Conductivity: 0.00001 S/m (0.0001 mS/cm)
*Temperature *:* 0.0001 °C
Salinity: 0.0002 PSU, typical

Calibration Range
Conductivity: 0-6 S/m (60 mS/cm); physical calibration 2.6-6 S/m (26-60 mS/cm), plus zero conductivity (air)
*Temperature *:* +1 to +32 °C

Time Resolution 1 second
Clock Stability 13 seconds/month
Input Power 8-30 VDC
Acquisition Current 34 mA at 8 VDC; 30 mA at 12-30 VDC
Quiescent Current 10 microamps
Acquisition Rate 1 Hz maximum
Operating Pressure 34.5 decibars (50 psi) maximum
Flow Rate 10 to 30 ml/sec (0.16 to 0.48 gal/min)
Materials PVC housing
Weight 4.6 kg (10.2 lbs)

16.7 ***Seabird SBE 38 Digital Oceanographic Thermometer***

Measurement Range: -5 to +35 °C

Initial Accuracy: ± 0.001 °C (1 mK)

Typical Stability: 0.001 °C (1 mK) in 6 months, certified

Resolution : 0.00025 °C (0.25 mK)

Calibration: -1 to +32 °C

Response Time 500 milliseconds
Self-Heating Error less than 200 µK

RMS Noise
(at temperature equivalent of 8.5 °C)
NAvg Noise (°C)
1 0.000673
2 0.000408
4 0.000191
8 0.000133
160.000081
32 0.000052

Note:
NAvg = number of A/D cycles per sample.
Interval between samples (seconds)
= (0.133 * NAvg) + 0.339

RS-232 (standard):
8 – 15 VDC at 10 milliamps average
External Power *RS-485 half-duplex (optional):*
8 – 15 VDC at 6 milliamps average

Materials Titanium pressure case rated
at 10,500 meters (34,400 feet)

Weight In water: 0.5 kg (1.2 lbs)
In air: 0.9 kg (2.0 lbs)

16.8 ***Processed Data files***

16.8.1 Relmov

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

16.8.2 Bestnav

Bestnav uses all 3 GPS Systems logged, gps_4000, gps_g2, gps_ash 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_4000 being primary, gps_g2 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.

16.9 ***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.

16.10***Protsg***

Protsg is the Processed Thermosalinograph data. The raw data is taken from the seabird stream or seatemp stream if cleaned and then ran through a salinity calculation. The data varies slightly from the raw seabird salin variable as they use a slightly different algorithm for the calculation of salinity.

16.11***Pro_wind***

This program is designed to remove the relative variables from the wind data logged by surfmet. By removing any fixed offsets in the system and removing the affect of ship motion pro_wind is a true representation of ships wind data.
Intdep – Intdep is a Interpolated data set that extrapolates data where none was logged based on a 2min band pass filter. Intdep is then passed to which takes Carters tables into account.

16.12 *Prodep*

Prodep is an automated process that access the bestnav position fix data and then uses a pre programmed Carter tables of corrections and corrects the echo sounder data for that given time.

16.13 *Network Services*

Networking worked well throughout the cruise despite a few hiccups with one of the wireless access points on the Forecastle Deck.

16.14 *Data Storage*

DISCOFS is an advanced Network Attached Storage device. All scientific cruise data was stored on this device under the Cruises/D376 folder, and organised with a standard template of folders

All cruise data was stored on this storage area.

All CTD, ADCP and LADCP data was backed up to DISCOFS on acquisition.

16.15 *Data Backups*

Backups of the Level C data were done twice daily as a tar file to LTO tape. Alternating between the standard backup below and a full /rvs backup. The following paths were included in the tar file:

/rvs/raw_data
/rvs/pro_data
/rvs/def7/control
/rvs/users

The LTO2 system was backed up on a daily basis in a rolling 2 tape system.

16.16 *Data Archiving*

The Data archive will be provided on USB Hard Drives
1 x HDD to BODC, disk to be returned once data extracted.
2 x HDD to PSO
1 x HDD to NOCS held by NMFSS for 6 Months

16.17 *D376 Miscellaneous Cruise Notes*

16.17.1 Techsas

Both Techsas loggers were attached to separate UPS backup devices. They were also connected to the KVM switcher.

Techsas1 crashed and the Level C alarm sounded on the following dates and times:

time gap : 11 284 09:05:58 to 11 284 09:12:47
time gap : 11 285 06:25:36 to 11 285 06:34:45
time gap : 11 286 05:09:09 to 11 286 05:17:23

Each time, the techsas screen had gone blank. After some investigating, and to prevent too much downtime, and data loss, the hot-swappable power supplies were swapped with the spare techsas machine. This resulted in no further blackouts for the rest of the cruise. Both techsas loggers were then configured to log all the data independently, and to prevent any further potential data loss due to techsas hardware failure.

16.18 *Surfmet*

This was a completely new flurometer, transmissometer, TSG layout being trialed during this cruise. It has proved to be more consistent, and accumulating less air bubbles than before. Both transmissometer and fluorometer are mounted in the vertical orientation, and the addition of a bleed valve to help remove trapped air from the system. The flow rates and other information labels were added to help identify the direction of flow, and the recommended flow rates in each part of the system.

16.19 *Data Storage*

D376 CTD
D376 SCIENTIFIC BACKUP

Level C Data backup to tape (because I don't trust DiscoFS to actually perform a reliable backup). Using LTO tape on odd, even day schedule.

16.20 *ADCP*

The 75kHz ADCP was installed during the cruise mobilization in Avonmouth, and was operated during the cruise with settings based on the previous cruise configuration files.

16.21 *PCO2*

The PCO2 flow rates were calibrated using a stopwatch and a measuring jug to ensure the water flow was at the recommended rates for the 3 parts of the system.

Occasionally it was necessary to blow moisture out of the internal equilibrator. The moisture build up coincided with a period of very high atmospheric humidity, and rain storm.

An internal pump was replaced in the main PCO2 unit with a spare on the 9th of November 2011.

16.22 *Echosounder & PES fish*

The PES fish was inspected at the start of the cruise. The fairings and clips were replaced where necessary. Before we sailed, 2 lengths of fairing were replaced as they had been left damaged from the previous cruise. During the cruise, several more lengths of fairings were replaced due to them becoming damaged. After the mooring deployments, the fish was brought back onboard and not used any more as an accurate depth was not deemed necessary, and could expose the fish and cable to unnecessary risk of further damage.

16.23 *EL4*

EL4 Computer Network Terminations

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
578A EA500	569A	559B SBE45		578B	577D WINCH	566A	507E COMMS RM	507G CLOCK	582A	507B GYRO	507C LOG	507H ADU	507F TRIMB-LE	577C WINCH	579B SURF-MET
17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
USED			507I		579D	*574B* *D366-7*			579C		559A	507D	**USED**		553A

16.24 *Millipore*

Millipore tank level sensor faulty at approx. 50% level. The tank level on the display was reading full when the tank was only half full. Due to the high demand for the milli-q water, the level sensor calibration factor was changed to 1.075 (was 1.125). .This ensured that the tank filled up. A new level sensor is required.

17 Surfmet Sensor Information

Ship	RRS Discovery
Cruise	D376
Technician	Martin Bridger
Date	June 2011

Manufacturer	Sensor	Serial No.	Comments (eg. port)	Calibrated output?	Last calibration date
Seabird	SBE45	0231	TSG	Y	19th Dec 11
Seabird	SBE38	0491	Remote Temp.	Y	27th Jun 11
Wetlabs	Fluorometer	WS3S-134		N	11th Nov 11
Wetlabs	Transmissometer	CST-112R		N	11th Oct 11
Vaisala	Barometer PTB110	F4740025		Y	15th May 12
Vaisala	Temp/humidity HMP45A	D1440038 B4950011		Y	21st Oct 11 16th May 12
SKYE	PAR SKE510	28559	PORT	N	02nd Sep 11
SKYE	PAR SKE510	28556	STBD	N	22nd Jul 10
Kipp and Zonen	TIR CMB6	962301	PORT	N	26th Apr 11
Kipp and Zonen	TIR CMB6	47462	STBD	N	26th Jul 11
Sensors without calibration					
Seabird	P/N 90402 SBE45 JB	66	Junction Box		
Gill	Windsonic Option 3	071123			

Manufacturer	Sensor	Serial No.	Comments	Calibration applied?	Last calibration date
Seabird	SBE45	232			24th Aug 11
Seabird	SBE38	0489	Remote Temp.		
Wetlabs	Fluorometer	WS3S-248			21st Apr 10
Wetlabs	Transmissometer	CST-113R			27th Jun 10
Vaisala	Barometer PTB110	G0820001			29th Nov 10
Vaisala	HMP45A Temp/humidity	B4950011			
SKYE	PAR SKE510	28557			07th Jun 11
KIPP & ZONEN	CM6B	47463			
Sensors without calibration					
Seabird	P/N 90402 SBE45 JB	63	Junction Box		
Gill	Windsonic Option 3	071121			

18 CT Config

I*nitially, the config file used for the s/s CTD was the following:*

Instrument configuration file: C:\Program Files\Sea-Bird\SeasaveV7\D376\Raw data\D376_NMEA.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed: 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : No
Scan time added : Yes

1) Frequency 0, Temperature

Serial number: 03P-4116
Calibrated on: 12 Oct 2011
G : 4.42749444e-003
H : 6.87799641e-004
I : 2.68980952e-005
J : 2.59632070e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number: 04C-2841
Calibrated on: 12 Oct 2011
G : -1.03592332e+001
H : 1.42614451e+000
I : 1.03396304e-003
J : 2.33396604e-006
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number: 121341
Calibrated on: 6 March 2012
C1 : -4.817191e+004
C2 : -2.790175e-001
C3 : 1.471600e-002
D1 : 3.995300e-002
D2 : 0.000000e+000
T1 : 3.031710e+001
T2 : -3.320637e-004
T3 : 3.758500e-006
T4 : 4.062020e-009
T5 : 0.000000e+000
Slope : 1.00000000
Offset : 0.00000
AD590M : 1.282700e-002
AD590B : -9.212862e+000

4) Frequency 3, Temperature, 2

Serial number: 03P-4872
Calibrated on: 24 Jan 2012
G : 4.34388340e-003
H : 6.38260659e-004
I : 2.26833531e-005
J : 1.70209433e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number: 04C-3258
Calibrated on: 21 Jan 2012
G : -1.06666967e+001
H : 1.36337782e+000
I : -5.61910912e-004
J : 1.06598880e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number: 43-0709
Calibrated on: 29 April 2011

Equation : Sea-Bird
Soc : 4.76900e-001
Offset : -4.92400e-001
A : -1.28560e-003
B : 2.50580e-005
C : -6.17210e-007
E : 3.60000e-002
Tau20 : 1.26000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Turbidity Meter, WET Labs, ECO-BB

Serial number: 167
Calibrated on: 6 July 2011
Scale Factor : 1.000000
Dark output : 0.000000

9) A/D voltage 3, Altimeter

Serial number: 874
Calibrated on: 10 Mar 2010
Scale factor: 15.000
Offset : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Transmissometer, Chelsea/Seatech

Serial number: 161-050
Calibrated on: 29 Feb 2012
M : 23.8318
B : -0.5171
Path length : 0.250

13) A/D voltage 7, Fluorometer, Chelsea Aqua 3

Serial number: 088-2615-124
Calibrated on: 23 Mar 2011
VB : 0.398200
V1 : 2.146300
Vacetone : 0.439900
Scale factor: 1.000000

Slope : 1.000000
Offset : 0.000000

Scan length : 41

This was changed from cast 2 onwards to:

Instrument configuration file: C:\Program Files\Sea-Bird\SeasaveV7\D376\Raw data\D376_NMEA_1.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed: 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : No
Scan time added : Yes

1) Frequency 0, Temperature

Serial number: 03P-4116
Calibrated on: 12 Oct 2011
G : 4.42749444e-003
H : 6.87799641e-004
I : 2.68980952e-005
J : 2.59632070e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number: 04C-2841
Calibrated on: 12 Oct 2011
G : -1.03592332e+001
H : 1.42614451e+000
I : 1.03396304e-003
J : 2.33396604e-006
CTcor : 3.2500e-006
CPcor : -9.57000000e-008

Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number: 121341
Calibrated on: 6 March 2012
C1 : -4.817191e+004
C2 : -2.790175e-001
C3 : 1.471600e-002
D1 : 3.995300e-002
D2 : 0.000000e+000
T1 : 3.031710e+001
T2 : -3.320637e-004
T3 : 3.758500e-006
T4 : 4.062020e-009
T5 : 0.000000e+000
Slope : 1.00000000
Offset : 0.00000
AD590M : 1.282700e-002
AD590B : -9.212862e+000

4) Frequency 3, Temperature, 2

Serial number: 03P-2919
Calibrated on: 13 Mar 2012
G : 4.31717713e-003
H : 6.44896358e-004
I : 2.31322169e-005
J : 2.20771235e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number: 04C-3258
Calibrated on: 21 Jan 2012
G : -1.06666967e+001
H : 1.36337782e+000
I : -5.61910912e-004
J : 1.06598880e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number: 43-0709

Calibrated on: 29 April 2011
Equation : Sea-Bird
Soc : 4.76900e-001
Offset : -4.92400e-001
A : -1.28560e-003
B : 2.50580e-005
C : -6.17210e-007
E : 3.60000e-002
Tau20 : 1.26000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Turbidity Meter, WET Labs, ECO-BB

Serial number: 167
Calibrated on: 6 July 2011
Scale Factor : 1.000000
Dark output : 0.000000

9) A/D voltage 3, Altimeter

Serial number: 874
Calibrated on: 10 Mar 2010
Scale factor: 15.000
Offset : 0.000

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Transmissometer, Chelsea/Seatech

Serial number: 161-050
Calibrated on: 29 Feb 2012
M : 23.8318
B : -0.5171
Path length : 0.250

13) A/D voltage 7, Fluorometer, Chelsea Aqua 3

Serial number: 088-2615-124
Calibrated on: 23 Mar 2011
VB : 0.398200

V1 : 2.146300
Vacetone : 0.439900
Scale factor: 1.000000
Slope : 1.000000
Offset : 0.000000

Scan length : 41

19 The Scientifc Crew of D376 - Photo

20 Appendices 1 and 2 Event Logs and CTD Logs

Appendix 1

D376 Event Log

Key to Event Log

Mooring deployments: Position/depth/time at anchor/bed frame release.

Mooring recoveries: Position/depth/time mooring back on deck.

Cruise D376 Event Log

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
001	12/06/2012	-	48° 09.12’ N	009° 37.17’ W	626	15:49	16:00	16:19	WIRE TEST	
002	12/06/2012	ST1	48° 09.16’ N	009° 37.48’ W	636	17:00	17:20	18:02	CTD001	Acoustic release test.
003	12/06/2012	ST1	48° 08.812’ N	009° 37.798’ W	688	21:40	-	-	MOORING DEPLOYMENT	In-line mooring. Deployment began ~18:23
004	12/06/2012	A2	48° 04.60’ N	009° 43.32’ W	1305	23:06	23:56	00:55	CTD002	
005	13/06/2012	A4	48° 14.447’ N	009° 32.636’ W	180	02:50	03:01	03:39	CTD003	
006	13/06/2012	A6	48° 23.874’ N	009° 22.073’ W	140	05:12	05:22	05:51	CTD004	
007	13/06/2012	ST2	48° 14.66’ N	009° 32.78’ W	184	09:32	-	-	MOORING DEPLOYMENT	In-line mooring.
008	13/06/2012	ST5	48° 45.993’ N	009° 24.179’ W	343	13:18	-	-	MOORING DEPLOYMENT	In-line mooring. Deployment began 12:56.
009	13/06/2012	ST5	48° 46.13’ N	009° 24.37’ W	339	13:32	-	-	MOORING DEPLOYMENT	Bed frame mooring.
010	13/06/2012	ST3	48° 20.215’ N	009° 26.311’ W	281	16:30	-	-	MOORING DEPLOYMENT	Bed frame mooring.
011	13/06/2012	ST3	48° 20.167’ N	009° 26.354’ W	283	18:02	-	-	MOORING DEPLOYMENT	Wire Walker. Deployment began 17:02.
012	13/06/2012	ST3	48° 20.16’ N	009° 26.19’ W	280	19:42	-	-	MET GUARD BUOY DEPLOYMENT	Deployment began ~19:10.
013	13/06/2012	A1	48° 01.74’ N	009° 47.28’ W	2500	22:49	23:47	01:10	CTD005	

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
014	14/06/2012	Transect 1	47˚ 36.06' N	007˚ 18.22' W	306	18:35	-	-	DRIFTER DEPLOYMENTS	Drifters 1-6 released.
015	14/06/2012	Transect 2	47˚ 34.21' N	007˚ 20.66' W	-	19:53	-	-	DRIFTER DEPLOYMENTS	Drifters 7-14 released. 500 m transect.
016	14/06/2012	Transect 3	47˚ 32.27' N	007˚ 23.14' W	-	20:42	-	-	DRIFTER DEPLOYMENTS	Drifters 15-20 released.
017	16/06/2012	ST4	48˚ 39.096' N	009˚ 06.761' W	155	12:47	12:58	13:21	CTD006	
018	16/06/2012	ST4	48˚ 38.959' N	009˚ 06.237' W	156	14:51	-	-	MOORING DEPLOYMENT	In-line mooring. Deployment started 14:42.
019	16/06/2012	ST4	48˚ 38.904' N	009˚ 06.358' W	155	15:03	-	-	MOORING DEPLOYMENT	Bed frame mooring.
020	16/06/2012	A9	48˚ 34.36'N	009˚ 10.24' W	160	16:02	16:11	16:39	CTD007	
021	16/06/2012	A8	48˚ 30.57' N	009˚ 14.80' W	155	17:46	17:54	18:23	CTD008	
022	16/06/2012	A7	48˚ 27.275' N	009˚ 19.154' W	154	19:47	19:57	20:28	CTD009	
023	16/06/2012	A5/LT2	48˚ 19.875' N	009˚ 26.496' W	145	22:01	-	-	MOORING DEPLOYMENT	LT2 Lander.
024	16/06/2012	A5	48˚ 19.959' N	009˚ 26.646' W	146	22:12	22:24	22:50	CTD010	
025	17/06/2012	A3	48˚ 09.235' N	009˚ 37.639' W	633	00:39	01:08	01:57	CTD011	
026	17/06/2012	A2	48˚ 04.51' N	009˚ 43.55' W	1336	03:22	03:55	04:32	CTD012	No samples taken.
027	17/06/2012	~A1	48˚ 00.91' N	009˚ 46.92' W	100	06:25	-	07:26	SCANFISH TEST	Continued to sampling.

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
028	17/06/2012 to 18/06/2012	~A2-ST3	48° 06.168' N	009° 43.838' W	-	07:35 (17th)	-	09:22 (18th)	SCANFISH	Survey 1.
029	18/06/2012	OMG	48° 29.758' N	009° 16.894' W	160	10:55	-	-	GLIDER 175 DEPLOYMENT	
030	18/06/2012	OMG	48° 31.36' N	009° 15.03' W	160	14:25	14:32	14:49	CTD013	CTD dive in synch with glider 175 dive for calibration.
031	18/06/2012	A10	48° 49.71' N	008° 54.01' W	168	17:41	17:50	17:58	CTD014	No samples.
032	18/06/2012	A11	49° 01.167' N	008° 41.321' W	160	20:06	20:15	20:22	CTD015	No samples.
033	18/06/2012	A12	49° 12.055' N	008° 29.859' W	147	22:16	22:26	22:55	CTD016	Start of Station A12 'yo-yo' casts.
034	18/06/2012	A12	49° 12.119' N	008° 30.102' W	147	23:32	23:40	23:54	CTD017	
035	19/06/2012	A12	49° 12.129' N	008° 30.146' W	148	00:32	00:39	00:53	CTD018	
036	19/06/2012	A12	49° 12.224' N	008° 29.661' W	148	01:29	01:34	01:51	CTD019	
037	19/06/2012	A12	49° 11.798' N	008° 29.948' W	149	02:31	02:37	02:53	CTD020	
038	19/06/2012	A12	49° 11.99' N	008° 29.93' W	150	03:34	03:41	03:53	CTD021	
039	19/06/2012	A12	49° 12.01' N	008° 29.96' W	150	04:30	04:37	04:58	CTD022	
040	19/06/2012	A12	49° 11.97' N	008° 29.97' W	150	05:31	05:38	05:55	CTD023	
041	19/06/2012	A12	49° 11.93' N	008° 30.01' W	149	06:30	06:37	06:56	CTD024	

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
042	19/06/2012	A12	49° 11.922' N	008° 29.871' W	148	07:38	07:56	08:10	CTD025	
043	19/06/2012	A12	49° 12.015' N	008° 29.959' W	147	08:32	08:42	08:59	CTD026	
044	19/06/2012	A12	49° 11.978' N	008° 30.051' W	147	09:32	09:40	09:56	CTD027	End of Station A12 'yo-yo' casts.
045	19/06/2012	~A12	49° 15.42' N	008° 34.96' W	148	10:42	-	23:00	SCANFISH	Survey 2.
046	20/06/2012	WP1	49° 15.32' N	008° 24.47' W	-	00:14	-	14:22	SCANFISH	Survey 3 (lattice). Recovery: position 49°08.613' N, 008° 18.595' W, water depth 149 m.
047	20/06/2012	OMG	48° 30.473' N	009° 18.521' W	163	20:10	-	21:45	VMP	VMP Survey 1. Recovered for repair. Recovery position 48° 30.73' N, 009° 19.62'W.
048	20/06/2012 to 22/06/2012	OMG	48° 30.58' N	009° 18.88' W	165	22:16 (20th)		12:15 (22nd)	VMP	VMP Survey 1 (restarted).
049	22/06/2012	LT1	48° 04.50' N	009° 44.40' W	1503	18:08	-	-	MOORING DEPLOYMENT	Position/depth at anchor release point.
050	22/06/2012	A1	48° 01.643' N	009° 47.39' W	2440	19:05	20:03	21:18	CTD028	
051	22/06/2012	A2	48° 04.508' N	009° 43.317' W	1303	22:07	22:40	23:44	CTD029	
052	23/06/2012	A3	48° 09.154' N	009° 37.207' W	625	01:04	01:23	02:10	CTD030	
053	23/06/2012	A4	48° 14.37' N	009° 32.72' W	186	03:15	03:25	03:53	CTD031	
054	23/06/2012	A1/LT1	48° 04.53' N	009° 43.19' W	1290	07:15	-	-	GLIDER 051 DEPLOYMENT	
055	23/06/2012 to 24/06/2012	ST3	48° 17.71' N	009° 26.22' W	151	10:18 (23rd)	-	01:30 (24th)	SCANFISH	Survey 4. Recovery position: 48° 26.917' N, 009° 43.199' W.

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
056	24/06/2012	A0	47° 55.43’ N	009° 54.30’ W	3122	05:48	07:30	08:36	CTD032	
057	24/06/2012	A5	48° 19.566’ N	009° 26.200’ W	142	11:47	12:01	12:34	CTD033	
058	24/06/2012	A6	48° 23.763’ N	009° 22.188’ W	140	14:10	14:19	14:53	CTD034	
059	24/06/2012	A7	48° 27.46’ N	009° 19.07’ W	155	15:50	16:00	16:28	CTD035	
060	24/06/2012	A8	48° 30.76’ N	009° 14.87’ W	156	17:15	17:30	17:55	CTD036	
061	24/06/2012	A9	48° 34.38’ N	009° 10.20’ W	154	18:40	18:50	19:17	CTD037	
062	24/06/2012	C1	48° 26.265’ N	009° 26.307’ W	190	21:03	21:13	21:37	CTD038	
063	24/06/2012	C2	48° 24.493’ N	009° 31.733’ W	466	22:22	22:47	23:30	CTD039	
064	25/06/2012	C3	48° 22.590’ N	009° 36.539’ W	772	00:38	01:01	01:53	CTD040	
065	25/06/2012	C4	48° 20.53’ N	009° 42.90’ W	1325	03:14	03:49	04:43	CTD041	
066	25/06/2012	LT1	48° 05.54’ N	009° 43.46’ W	1276	06:27	06:58	07:28	CTD042	
067	25/06/2012	LT1	48° 05’ 14’’ N	009° 43’ 47’’ W	1301	08:03	-	-	GLIDER 052 DEPLOYMENT	
068	25/06/2012 to 26/06/2012		48° 15.472’ N	009° 28.768’ W	168	11:13 (25th)	-	04:50 (26th)	SCANFISH	Survey 5. Scanfish of canyon. Recovered at LT1: 48° 08.92’ N, 009° 39.75’ W, water depth 772m.
069	26/06/2012		48° 30.99’ N	009° 17.47’ W	167	07:48	-	-	GLIDER 194 DEPLOYMENT	Glider deployed.

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
070	26/06/2012		48° 30.080' N	009° 20.343' W	158	09:44	09:53	09:59	CTD043	Calibration dip prior to VMP session (Niskin bottles removed from frame).
071	26/06/2012 to 27/06/2012	OMG	48° 30.28' N	009° 19.77' W	162	10:27 (26th)	-	02:40 (27th)	VMP	VMP Survey 2. Pressure sensor failure necessitated early recovery.
072	27/06/2012	OMG	48° 29.83' N	009° 18.87' W	165	03:30	-	05:05	MSS	MSS Survey 1.
073	27/06/2012	OMG	48° 30.85' N	009° 18.27' W	163	05:07	-	05:10	VMP	VMP Survey 2 (continued). Further failure resulted in early recovery.
074	27/06/2012	OMG	48° 30.84' N	009° 18.26' W	163	05:22	-	06:55	MSS	MSS Survey 2.
075	27/06/2012	OMG	48°30.46' N	009° 19.15' W	163	07:08	-	07:15	VMP	VMP Survey 2 (continued). Further failure.
076	27/06/2012	OMG	48° 30.27' N	009° 19.35' W	165	07:35	-	12:04	MSS	MSS Survey 3.
077	27/06/2012	OMG	48° 29.473' N	009° 14.425' W	153	-	-	12:52	GLIDER 175 RECOVERY	
078	27/06/2012	ST3	48° 20.153' N	009° 26.430' W	143	-	-	16:04	MOORING RECOVERY	Wire-Walker recovery. Recovery started 14:50.
079	27/06/2012	ST3	48° 20.430' N	009° 26.533' W	-	-	-	18:01	MOORING RECOVERY	Bed frame recovery. Mooring released at 17:39. At surface 17:43.
080	27/06/2012	ST3	48° 20.161' N	009° 26.145' W	87	-	-	20:12	MET GUARD BUOY RECOVERY	
081	27/06/2012	C5	48° 18.469' N	009° 47.483' W	1652	21:32	22:11	23:20	CTD044	
082	28/06/2012	ST1	48° 08.879' N	009° 37.769' W	682	01:18	01:37	02:31	CTD045	
083	28/06/2012	ST1	48° 08.63' N	009° 37.45' W	-	-	-	07:54	MOORING RECOVERY	Point mooring. Recovery started @ 06:41.

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
084	28/06/2012	ST2	48° 14.72' N	009° 32.63' W	368	-	-	10:07	MOORING RECOVERY	Point mooring. Recovery started @ 09:01.
085	28/06/2012	ST4	48° 38.840' N	009° 06.095' W	155	-	-	14:35	MOORING RECOVERY	Point mooring. Mooring grappled @ 13:58.
086	28/06/2012	ST4	48° 38.85' N	009° 06.29' W	154	-	-	15:35	MOORING RECOVERY	Bed frame recovery.
087	28/06/2012	-	48° 22' N	009° 37' W	1083	22:40	-	-	PES FISH DEPLOYMENT	
088	29/06/2012	ST5	48° 45.7' N	009° 29.0' W	-	08:45	-	-	MOORING RECOVERY	Point mooring.
089	29/06/2012	ST5	48° 46.21' N	009° 24.21' W	-	09:40	-	-	MOORING RECOVERY	Bed frame recovery. On surface 09:30.
090	29/06/2012	C3	48° 22.5' N	009° 36.6' W	809	13:01	13:25	13:43	CTD046	Start of Station C3 'yo-yo' casts.
091	29/06/2012	C3	48° 22.581' N	009° 36.946' W	772	14:13	14:35	14:53	CTD047	
092	29/06/2012	C3	48° 22.44' N	009° 36.73' W	866	15:23	15:49	16:08	CTD048	
093	29/06/2912	C3	48° 22.37' N	009° 37.01' W	864	16:35	17:04	17:23	CTD049	
094	29/06/2912	C3	48° 22.41' N	009° 36.90' W	860	17:47	18:11	18:31	CTD050	
095	29/06/2012	C3	48° 22.44' N	009° 36.86' W	837	18:53	19:15	19:35	CTD051	
096	29/06/2012	C3	48° 22.486' N	009° 36.555' W	803	20:02	20:22	20:39	CTD052	
097	29/06/2012	C3	48° 22.554' N	009° 36.583' W	782	21:04	21:25	21:41	CTD053	

Event No.	Date	Station	Latitude	Longitude	Depth (m)	Time IN (GMT)	Time BOTTOM (GMT)	Time OUT (GMT)	Activity	Comments
098	29/06/2012	C3	48˚ 22.55' N	009˚ 36.58' W	782	22:07	22:28	22:44	CTD054	
099	29/06/2012	C3	48˚ 22.50' N	009˚ 36.68' W	821	23:07	23:29	23:45	CTD055	
100	30/06/2012	C3	48˚ 22.816' N	009˚ 36.40' W	711	00:11	00:38	00:57	CTD056	
101	30/06/2012	C3	48˚ 22.492' N	009˚ 37.103' W	794	01:18	01:49	02:09	CTD057	
102	30/06/2012	C3	48˚ 22.351' N	009˚ 37.016' W	894	02:33	03:08	03:31	CTD058	
103	30/06/2012	C3	48˚ 22.09' N	009˚ 37.13' W	1010	03:40	04:14	04:41	CTD059	End of Station C3 'yo-yo' casts.
104	30/06/2012	ST3	48˚ 19.86' N	009˚ 25.98' W	135	06:13	06:20	06:53	CTD060	
105	30/06/2012	ST3	48˚ 19.686' N	009˚ 25.84' W	137	07:35	07:44	08:06	CTD061	
106	30/06/2012	ST1	48˚ 02.28' N	009˚ 38.24' W	830	10:06	-	22:54	SCANFISH	Survey 6: Transect JB3
107	30/06/2012	Jones Bank	49˚ 44.736' N	008˚ 02.614' W	-	-	-	23:13	PES FISH RECOVERY	

Appendix 2

D376 CTD Log Sheets

Key to CTD Log Sheets

I/W = in water
O/W = out of water

Shaded rows of CTD logs indicate problems with bottle firings.

Positions and depths are those noted at the bottom of the CTD downcast.

D376 CTD log sheet

Station	ST1	CTD No	001	Date	12/06/2012
Lat	48° 08.94' N	Event No	002	Time I/W (GMT)	17:00
Lon	009° 37.38' W	Water Depth (m)	646	Time bottom (GMT)	17:20
Filename	D376_01.hex	Cast Depth (m)	630	Time O/W (GMT)	18:02
Weather	Wind Force 5				
Comments	Releases tested at 630 m. Bottle 12 did not close. Bad secondary temp, sal, dens etc. due to faulty temp sensor.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	630	17:38								x	1
2	2	2	630	17:39								x	2
3	3	3	631	17:39								x	3
4	4	4	630	17:39									4
5	5	5	630	17:39									5
6	6	6	630	17:39									6
7	7	7	631	17:40									7
8	8	8	630	17:40									8
9	9	9	631	17:40									9
10	10	10	630	17:40									10
11	11	11	630	17:41									11
12	12	12	631	17:41									12
13	13	13	52	17:55								x	13
14	14	14	52	17:55								x	14
15	15	15	53	17:55								x	15
16	16	16	53	17:56									16
17	17	17	52	17:56									17
18	18	18	52	17:56									18
19	19	19	52	17:57									19
20	20	20	52	17:57									20
21	21	21	51	17:57									21
22	22	22	52	17:57									22
23	23	23	52	17:58									23
24	24	24	52	17:58									24
			Sampler									Estelle	

D376 CTD log sheet

Station	A2	CTD No	002	Date	12/06/2012
Lat	48° 04.90’ N	Event No	004	Time I/W (GMT)	23:06
Lon	009° 43.41’ W	Water Depth (m)	1304	Time bottom (GMT)	23:56
Filename	D376_02.hex	Cast Depth (m)	1296	Time O/W (GMT)	00:55
Weather	Wind Force 4				
Comments	Secondary T changed to #2919. Bottles 9-14, 20, 22 did not close properly. Bottle 24 did not fire.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	1296	23:57	x	x	x	x		x			1
2	2	2	1296	23:57								x	2
3	3	3	1002	00:06	x	x	x	x		x			3
4	4	4	1002	00:06								x	4
5	5	5	753	00:13	x	x	x	x		x			5
6	6	6	753	00:13								x	6
7	7	7	503	00:21	x	x	x	x		x			7
8	8	8	503	00:21									8
9	9	9	253	00:29									9
10	10	10	253	00:29									10
11	11	11	204	00:33									11
12	12	12	203	00:33									12
13	13	13	153	00:37									13
14	14	14	154	00:37									14
15	15	15	104	00:41	x	x	x	x	x	x			15
16	16	16	103	00:41								x	16
17	17	17	84	00:44	x	x	x	x	x	x			17
18	18	18	83	00:44									18
19	19	19	63	00:47	x	x	x	x	x	x			19
20	20	20	64	00:47									20
21	21	21	38	00:50	x	x	x	x	x	x		x	21
22	22	22	39	00:50									22
23	23	23	8	00:54	x	x	x	x	x	x			23
24	24	24	8	00:54									24
			Sampler		Hannah Nealy	Holly	Holly	Holly	Claire	Holly		Mark H	

D376 CTD log sheet

Station	A4	CTD No	003	Date	13/06/2012
Lat	48° 14.510’ N	Event No	005	Time I/W (GMT)	02:50
Lon	009° 32.627’ W	Water Depth (m)	179	Time bottom (GMT)	03:01
Filename	D376_03.hex	Cast Depth (m)	168	Time O/W (GMT)	03:39
Weather	Wind Force 4				
Comments	Header in file not changed completely. Bottles 9 and 10 did not close.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	168	03:02	x	x	x	x		x			1
2	2	2	168	03:02								x	2
3	3	3	140	03:05	x	x	x	x		x			3
4	4	4	140	03:06									4
5	5	5	120	03:09	x	x	x	x		x			5
6	6	6	120	03:09									6
7	7	7	100	03:12	x	x	x	x		x			7
8	8	8	100	03:12								x	8
9	9	9	80	03:15									9
10	10	10	80	03:15									10
11	11	11	60	03:18	x	x	x	x	x	x			11
12	12	12	60	03:18									12
13	13	13	50	03:20	x	x	x	x	x	x			13
14	14	14	50	03:21									14
15	15	15	40	03:23	x	x	x	x	x	x			15
16	16	16	40	03:23								x	16
17	17	17	30	03:25	x	x	x	x	x	x			17
18	18	18	30	03:25									18
19	19	19	20	03:28	x	x	x	x	x	x			19
20	20	20	20	03:28									20
21	21	21	10	03:30	x	x	x	x	x	x			21
22	22	22	10	03:31								x	22
23	23	23	6	03:34	x	x	x	x	x	x			23
24	24	24	6	03:34									24
			Sampler		Hannah Nealy	Andy	Andy	Andy	Andy	Andy		Dima Marie	

D376 CTD log sheet

Station	A6	CTD No	004	Date	13/06/2012
Lat	48˚ 23.836' N	Event No	006	Time I/W (GMT)	05:12
Lon	009˚ 22.149' W	Water Depth (m)	139	Time bottom (GMT)	05:22
Filename	D376_04.hex	Cast Depth (m)	127	Time O/W (GMT)	05:51
Weather	Wind Force 4				
Comments	Wetlabs fluor / FSI oxy optode attached to frame near bottle 21 (unable to fire bottle 21). Bottle 6 did not close.				

Fire Seq.	Bot. No.	Rosette Pos.	Depth (m)	Time (GMT)	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	Bot. No.
1	1	1	127	05:23	X		X	X					1
2	2	2	127	05:23								X	2
3	3	3	118	05:25									3
4	4	4	108	05:27	X		X	X					4
5	5	5	90	05:29	X		X	X					5
6	6	6	85	05:31									6
7	7	7	80	05:32	X		X	X				X	7
8	8	8	75	05:33	X			X					8
9	9	9	70	05:35	X		X	X	X				9
10	10	10	65	05:36	X			X					10
11	11	11	60	05:37	X		X	X	X				11
12	12	12	54	05:38	X			X					12
13	13	13	50	05:40	X		X	X	X				13
14	14	14	45	05:41	X			X					14
15	15	15	40	05:42	X		X	X	X				15
16	16	16	34	05:43	X			X				X	16
17	17	17	30	05:44	X		X	X					17
18	18	18	30	05:44	X			X	X				18
19	19	19	25	05:46	X			X					19
20	20	20	25	05:46	X		X	X	X				20
21	22	22	20	05:47	X		X	X	X				22
22	23	23	15	05:48	X			X					23
23	24	24	10	05:49	X		X	X	X			X	24
			Sampler		Donal		Hannah Nealy	Hannah Nealy	Claire	Claire		Dima Marie	

D376 CTD log sheet

Station	A1	CTD No	005	Date	13/06/2012
Lat	48˚ 01.79' N	Event No	013	Time I/W (GMT)	22:49
Lon	009˚ 46.54' W	Water Depth (m)	2380	Time bottom (GMT)	23:47
Filename	D376_05.hex	Cast Depth (m)	2375	Time O/W (GMT)	01:10
Weather	Wind Force 6-7. Rain.				
Comments	Bottle 23 fired too quickly. Possible leak on bottle 11.				

Fire Seq.	Bot. No.	Rosette Pos.	Depth (m)	Time (GMT)	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	Bot. No.
1	1	1	2375	23:48	X	X	X			X			1
2	2	2	2375	23:48								X	2
3	3	3	1983	23:58	X	X	X			X			3
4	4	4	1983	23:58								X	4
5	5	5	1398	00:12	X	X	X			X			5
6	6	6	1398	00:12								X	6
7	7	7	1000	00:23	X	X	X			X			7
8	8	8	1000	00:23								X	8
9	9	9	704	00:32	X	X	X			X			9
10	10	10	704	00:32									10
11	11	11	504	00:39	X	X	X	X	X	X			11
12	12	12	504	00:40									12
13	13	13	305	00:46	X	X	X	X	X	X			13
14	14	14	305	00:47									14
15	15	15	150	00:52	X	X	X	X	X	X			15
16	16	16	150	00:52									16
17	17	17	90	00:55	X	X	X	X	X	X			17
18	18	18	90	00:56									18
19	19	19	50	00:59	X	X	X	X	X	X			19
20	20	20	50	00:59									20
21	21	21	30	01:02	X	X	X	X	X	X			21
22	22	22	30	01:02									22
23	23	23	19	01:04									23
24	24	24	19	01:05	X	X	X	X	X	X		X	24
			Sampler		Hannah Nealy	Hannah Nealy	Juliane	Juliane	Claire	Claire		Estelle Mark H	

D376 CTD log sheet

Station	ST4	CTD No	006	Date	16/06/2012
Lat	48° 39.211' N	Event No	017	Time I/W (GMT)	12:47
Lon	009° 06.88' W	Water Depth (m)	152	Time bottom (GMT)	12:58
Filename	D376_06.hex	Cast Depth (m)	141	Time O/W (GMT)	13:21
Weather	Wind Force 4.				
Comments	Organic nuts – humics only. Slight chance bottle 10 was leaking, but unlikely. Sal replicate - bottle 10.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	δ^{15}N	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	141	12:59		X							1
2	2	2	141	13:00								X	2
3	3	3	100	13:04									3
4	4	4	100	13:05								X	4
5	5	5	70	13:10		X							5
6	6	6	70	13:11								X	6
7	7	7	35	13:14		X							7
8	8	8	35	13:15									8
9	9	9	10	13:18		X						X	9
10	10	10	10	13:19								X	10
			Sampler			Hannah Nealy						Mark H Terry Nealy	

D376 CTD log sheet

Station	A9	CTD No	007	Date	16/06/2012
Lat	48.57270° N	Event No	020	Time I/W (GMT)	16:02
Lon	9.17052° W	Water Depth (m)	160	Time bottom (GMT)	16:11
Filename	D376_07.hex	Cast Depth (m)	146	Time O/W (GMT)	16:39
Weather	Wind Force 4				
Comments	Bottle 15 leaked.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	δ^{15}N	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	146	16:12	X	X	X	X		X			1
2	2	2	146	16:12									2
3	3	3	136	16:15	X	X	X	X		X			3
4	4	4	136	16:15								X	4
5	5	5	121	16:17	X	X	X	X		X			5
6	6	6	122	16:17									6
7	7	7	102	16:20	X	X	X	X		X			7
8	8	8	101	16:20									8
9	9	9	81	16:22	X	X	X	X		X			9
10	10	10	81	16:22								X	10
11	11	11	71	16:24	X	X	X	X		X			11
12	12	12	72	16:24									12
13	13	13	61	16:26	X	X	X	X	X	X			13
14	14	14	61	16:26									14
15	15	15	51	16:28									15
16	16	16	51	16:28	X	X	X	X	X	X			16
17	17	17	41	16:30	X	X	X	X	X	X			17
18	18	18	41	16:30									18
19	19	19	31	16:32	X	X	X	X	X	X			19
20	20	20	32	16:32								X	20
21	21	21	21	16:34	X	X	X	X	X	X			21
22	22	22	21	16:34									22
23	23	23	11	16:36	X	X	X	X	X	X			23
24	24	24	11	16:36								X	24
			Sampler		?	?	?	?	?	?		?	

D376 CTD log sheet

Station	A8	CTD No	008	Date	16/06/2012
Lat	48° 30.54' N	Event No	021	Time I/W (GMT)	17:46
Lon	009° 14.91' W	Water Depth (m)	156	Time bottom (GMT)	17:54
Filename	D376_08.hex	Cast Depth (m)	145	Time O/W (GMT)	18:23
Weather	Wind Force 4				
Comments	Bottle 12 did not fire. Reject salinity sample in sample bottle number 535 – unknown source.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	145	17:55		x	x	x		x			1
2	2	2	145	17:56									2
3	3	3	126	17:58		x	x	x		x			3
4	4	4	126	17:58								x	4
5	5	5	101	18.01		x	x	x		x			5
6	6	6	101	18:01									6
7	7	7	92	18:03		x	x	x		x			7
8	8	8	92	18:03									8
9	9	9	81	18:05		x	x	x		x			9
10	10	10	81	18:05									10
11	11	11	72	18:08		x	x	x	x	x			11
12	12	12	71	18:08								x	12
13	13	13	60	18:10		x	x	x	x	x			13
14	14	14	61	18:10									14
15	15	15	50	18:12		x	x	x	x	x			15
16	16	16	50	18:13									16
17	17	17	41	18:15		x	x	x	x	x			17
18	18	18	41	18:15								x	18
19	19	19	31	18:17		x	x	x	x	x			19
20	20	20	32	18:17									20
21	21	21	21	18:19		x	x	x	x	x			21
22	22	22	21	18:19									22
23	23	23	11	18:21		x	x	x	x	x			23
24	24	24	11	18:21								x	24
			Sampler			?	?	?	?	?		?	

D376 CTD log sheet

Station	A7	CTD No	009	Date	16/06/2012
Lat	48° 27.288' N	Event No	022	Time I/W (GMT)	19:47
Lon	009° 19.392' W	Water Depth (m)	154	Time bottom (GMT)	19:57
Filename	D376_09.hex	Cast Depth (m)	144	Time O/W (GMT)	20:28
Weather	Wind Force 4				
Comments	Bottles 2, 11 and 22 leaked. Suspect salinity sample taken from bottle 1, not 2.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	144	19:58	x	x	x	x		x			1
2	2	2	144	19:59								x	2
3	3	3	120	20:01	x	x	x	x		x			3
4	4	4	120	20:02									4
5	5	5	100	20:04	x	x	x	x		x			5
6	6	6	100	20:05								x	6
7	7	7	90	20:07	x	x	x	x		x			7
8	8	8	90	20:07									8
9	9	9	80	20:09	x	x	x	x		x			9
10	10	10	80	20:09									10
11	11	11	70	20:11									11
12	12	12	70	20:11	x	x	x	x	x	x			12
13	13	13	60	2014	x	x	x	x	x	x			13
14	14	14	60	20:14									14
15	15	15	50	20:16	x	x	x	x	x	x			15
16	16	16	50	20:16								x	16
17	17	17	40	20:19	x	x	x	x	x	x			17
18	18	18	40	20:19									18
19	19	19	30	20:21	x	x	x	x	x	x			19
20	20	20	30	20:21									20
21	21	21	20	20:23	x	x	x	x	x	x			21
22	22	22	20	20:23									22
23	23	23	10	20:25	x	x	x	x	x	x			23
24	24	24	10	20:25								x	24
			Sampler		?	?	?	?	?	?		?	

D376 CTD log sheet

Station	A5	CTD No	010	Date	16/06/2012
Lat	48° 19.959' N	Event No	024	Time I/W (GMT)	22:12
Lon	009° 26.696' W	Water Depth (m)	146	Time bottom (GMT)	22:24
Filename	D376_10.hex	Cast Depth (m)	135	Time O/W (GMT)	22:50
Weather	Wind Force 2				
Comments	Salinity replicate on bottle 2				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	135	22:25		x	x	x		x			1
2	2	2	135	22:25								x	2
3	3	3	120	22:27		x	x	x		x			3
4	4	4	120	22:27									4
5	5	5	100	22:30		x	x	x		x			5
6	6	6	100	22:30									6
7	7	7	90	22:32		x	x	x		x			7
8	8	8	90	22:32									8
9	9	9	80	22:34		x	x	x		x			9
10	10	10	80	22:34									10
11	11	11	70	22:36		x	x	x	x	x			11
12	12	12	70	22:36									12
13	13	13	60	22:38		x	x	x	x	x			13
14	14	14	60	22:38									14
15	15	15	50	22:40		x	x	x	x	x			15
16	16	16	50	22:40									16
17	17	17	40	22:42		x	x	x	x	x			17
18	18	18	40	22:42									18
19	19	19	30	22:44		x	x	x	x	x			19
20	20	20	30	22:44									20
21	21	21	20	22:46		x	x	x	x	x			21
22	22	22	20	22:46									22
23	23	23	10	22:47		x	x	x	x	x			23
24	24	24	10	22:47								x	24
			Sampler			?	?	?	?	?		?	

D376 CTD log sheet

Station	A3	CTD No	011	Date	17/06/2012
Lat	48° 09.242' N	Event No	025	Time I/W (GMT)	00:39
Lon	009° 37.799' W	Water Depth (m)	643	Time bottom (GMT)	01:08
Filename	D376_11.hex	Cast Depth (m)	628	Time O/W (GMT)	01:57
Weather	Wind Force 4				
Comments					

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	628	01:09		x	x			x			1
2	2	2	628	01:09								x	2
3	3	3	549	01:13	x	x	x			x			3
4	4	4	549	01:13								x	4
5	5	5	449	01:18		x	x			x			5
6	6	6	449	01:18									6
7	7	7	399	01:22	x	x	x			x			7
8	8	8	399	01:22									8
9	9	9	349	01:25		x	x			x			9
10	10	10	349	01:26								x	10
11	11	11	299	01:29		x	x			x			11
12	12	12	299	01:30									12
13	13	13	199	01:35	x	x	x	x		x			13
14	14	14	200	01:36								x	14
15	15	15	100	01:41		x	x	x	x	x			15
16	16	16	100	01:41									16
17	17	17	80	01:44		x	x	x	x	x			17
18	18	18	80	01:44									18
19	19	19	50	01:48		x	x	x	x	x			19
20	20	20	49	01:48									20
21	21	21	30	01:51	x	x	x	x	x	x			21
22	22	22	30	01:52									22
23	23	23	10	01:54		x	x	x	x	x			23
24	24	24	10	01:55								x	24
			Sampler		Hannah Nealy	Hannah Nealy	Hannah Nealy	Juliane	Juliane	Claire		Mark H	

D376 CTD log sheet

Station	A2	CTD No	012	Date	17/06/2012
Lat	48˚ 04.58' N	Event No	026	Time I/W (GMT)	03:22
Lon	009˚ 43.48' W	Water Depth (m)	1337	Time bottom (GMT)	03:55
Filename	D376_12.hex	Cast Depth (m)	1327	Time O/W (GMT)	04:32
Weather	Wind Force 3				
Comments	No bottles were fired on this cast – no samples were required.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	OMG	CTD No	013	Date	18/06/2012
Lat	48˚ 31.445' N	Event No	030	Time I/W (GMT)	14:25
Lon	009˚ 14.924' W	Water Depth (m)	158	Time bottom (GMT)	14:32
Filename	D376_13.hex	Cast Depth (m)	110	Time O/W (GMT)	14:49
Weather	Wind Force 4				
Comments					

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	110	14:34									1
2	2	2	110	14:35								x	2
3	3	3	85	14:38									3
4	4	4	85	14:38								x	4
5	5	5	37	14:44									5
6	6	6	37	14:44								x	6
			Sampler									Estelle	

D376 CTD log sheet

Station	A10	CTD No	014	Date	18/06/2012
Lat	48˚ 49.64' N	Event No	031	Time I/W (GMT)	17:41
Lon	008˚ 54.01' W	Water Depth (m)	168	Time bottom (GMT)	17:50
Filename	D376_14.hex	Cast Depth (m)	158	Time O/W (GMT)	17:58
Weather					
Comments	No water samples collected				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**$\delta^{15}N$**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	A11	CTD No	015	Date	18/06/2012
Lat	49˚ 00.878' N	Event No	032	Time I/W (GMT)	20:06
Lon	008˚ 42.012' W	Water Depth (m)	159	Time bottom (GMT)	20:15
Filename	D376_15.hex	Cast Depth (m)	152	Time O/W (GMT)	20:22
Weather					
Comments	No water samples were collected				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**$\delta^{15}N$**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	A12	CTD No	016	Date	18/06/2012
Lat	49˚ 12.002' N	Event No	033	Time I/W (GMT)	22:16
Lon	008˚ 30.061' W	Water Depth (m)	143	Time bottom (GMT)	22:26
Filename	D376_16.hex	Cast Depth (m)	130	Time O/W (GMT)	22:55
Weather	Wind force 4				
Comments	Start of Station A12 'yo-yo' casts. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	130	22:26		x	x			x	x	x	1
2	2	2	130	22:26									2
3	3	3	66	22:31									3
4	4	4	66	22:31									4
5	5	5	61	22:34									5
6	6	6	61	22:34									6
7	7	7	51	22:36		x	x			x	x		7
8	8	8	51	22:36									8
9	9	9	46	22:38		x	x			x	x		9
10	10	10	46	22:38									10
11	11	11	41	22:40		x	x			x	x		11
12	12	12	41	22:40									12
13	13	13	36	22:42									13
14	14	14	36	22:42									14
15	15	15	31	22:45									15
16	16	16	31	22:45									16
17	17	17	16	22:47		x	x			x	x	x	17
18	18	18	16	22:47									18
			Sampler			Hannah Nealy	Claire			Allan	Jess Terry	Pete	

D376 CTD log sheet

Station	A12	CTD No	017	Date	18/06/2012
Lat	49˚ 12.207' N	Event No	034	Time I/W (GMT)	23:32
Lon	008˚ 30.205' W	Water Depth (m)	145	Time bottom (GMT)	23:40
Filename	D376_17.hex	Cast Depth (m)	122	Time O/W (GMT)	23:54
Weather	Wind Force 4				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	122	23:40		x	x			x	x		1
2	2	2	122	23:41								x	2
3	3	3	70	23:44		x	x			x	x		3
4	4	4	70	23:44									4
5	5	5	60	23:46		x	x			x	x		5
6	6	6	60	23:46									6
7	7	7	52	23:48		x	x			x	x		7
8	8	8	52	23:48									8
9	9	9	15	23:52		x	x			x	x		9
10	10	10	15	23:52								x	10
			Sampler			Hannah Nealy	Claire			Mark H	Jo	Mark H	

D376 CTD log sheet

Station	A12	CTD No	018	Date	19/06/2012
Lat	49.20460˚ N	Event No	035	Time I/W (GMT)	00:32
Lon	8.50411˚ W	Water Depth (m)	148	Time bottom (GMT)	00:39
Filename	D376_18.hex	Cast Depth (m)	100	Time O/W (GMT)	00:53
Weather	Wind Force 4				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	100	00:39		X	X			X	X		1
2	2	2	100	00:39								X	2
3	3	3	65	00:42		X	X			X	X		3
4	4	4	65	00:42									4
5	5	5	60	00:44		X	X			X	X		5
6	6	6	60	00:44									6
7	7	7	56	00:46		X	X			X	X		7
8	8	8	56	00:46									8
9	9	9	15	00:50		X	X			X	X		9
10	10	10	15	00:50								X	10
			Sampler			Hannah Nealy	Claire			Mark H	Jo	Mark H	

D376 CTD log sheet

Station	A12	CTD No	019	Date	19/06/2012
Lat	49˚ 12.309' N	Event No	036	Time I/W (GMT)	01:29
Lon	008˚ 29.648' W	Water Depth (m)	146	Time bottom (GMT)	01:34
Filename	D376_19.hex	Cast Depth (m)	100	Time O/W (GMT)	01:51
Weather	Wind Force 3				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	100	01:35		X	X			X	X		1
2	2	2	100	01:36								X	2
3	3	3	50	01:39		X	X			X	X		3
4	4	4	50	01:39									4
5	5	5	45	01:41		X	X			X	X		5
6	6	6	45	01:41									6
7	7	7	35	01:44		X	X			X	X		7
8	8	8	35	01:44									8
9	9	9	15	01:46		X	X			X	X		9
10	10	10	15	01:47								X	10
			Sampler			Hannah Nealy	Claire			Mark H	Jo	Mark H	

D376 CTD log sheet

Station	A12	CTD No	020	Date	19/06/2012
Lat	49° 11.849' N	Event No	037	Time I/W (GMT)	02:31
Lon	008° 29.897' W	Water Depth (m)	148	Time bottom (GMT)	02:37
Filename	D376_20.hex	Cast Depth (m)	100	Time O/W (GMT)	02:53
Weather	Wind Force 4				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	100	02:38		x	x			x	x		1
2	2	2	100	02:38								x	2
3	3	3	45	02:42		x	x			x	x		3
4	4	4	45	02:42									4
5	5	5	40	02:44		x	x			x	x		5
6	6	6	40	02:45									6
7	7	7	35	02:47		x	x			x	x		7
8	8	8	35	02:48									8
9	9	9	15	02:51		x	x			x	x		9
10	10	10	15	02:51								x	10
			Sampler			Hannah Nealy	Claire			Mark H	Jo	Mark H	

D376 CTD log sheet

Station	A12	CTD No	021	Date	19/06/2012
Lat	49.20116° N	Event No	038	Time I/W (GMT)	03:34
Lon	8.49633° W	Water Depth (m)	150	Time bottom (GMT)	03:41
Filename	D376_21.hex	Cast Depth (m)	102	Time O/W (GMT)	03:53
Weather	Wind Force 4				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	102	03:41		x	x			x	x		1
2	2	2	102	03:41								x	2
3	3	3	52	03:45		x	x			x	x		3
4	4	4	52	03:45								x	4
5	5	5	47	03:46		x	x			x	x		5
6	6	6	47	03:47									6
7	7	7	42	03:48		x	x			x	x		7
8	8	8	42	03:48									8
9	9	9	17	03:51		x	x			x	x		9
10	10	10	17	03:51								x	10
			Sampler			Nealy Andy	Claire			Donal	Marie	Sam	

D376 CTD log sheet

Station	A12	CTD No	022	Date	19/06/2012
Lat	49.20044˚ N	Event No	039	Time I/W (GMT)	04:30
Lon	8.49820˚ W	Water Depth (m)	150	Time bottom (GMT)	04:37
Filename	D376_22.hex	Cast Depth (m)	102	Time O/W (GMT)	04:58
Weather	Wind Force 3				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	102	04:38		x	x			x	x		1
2	2	2	101	04:38								x	2
3	3	3	44	04:41		x	x			x	x		3
4	4	4	44	04:42									4
5	5	5	38	04:49		x	x			x	x		5
6	6	6	38	04:49									6
7	7	7	33	04:51		x	x			x	x		7
8	8	8	33	04:51								x	8
9	9	9	17	04:55		x	x			x	x		9
10	10	10	17	04:55								x	10
			Sampler			Nealy Andy	Claire			Donal	Marie	Sam	

D376 CTD log sheet

Station	A12	CTD No	023	Date	19/06/2012
Lat	49.19990˚ N	Event No	040	Time I/W (GMT)	05:31
Lon	8.49795˚ W	Water Depth (m)	150	Time bottom (GMT)	05:38
Filename	D376_23.hex	Cast Depth (m)	101	Time O/W (GMT)	05:55
Weather	Wind Force 4				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	101	05:39		x	x			x	x		1
2	2	2	101	05:39								x	2
3	3	3	47	05:45		x	x			x	x		3
4	4	4	47	05:45									4
5	5	5	43	05:47		x	x			x	x		5
6	6	6	43	05:47									6
7	7	7	38	05:50		x	x			x	x		7
8	8	8	39	05:50									8
9	9	9	17	05:53		x	x			x	x		9
10	10	10	17	05:53								x	10
			Sampler			Nealy Andy	Claire			Donal	Marie	Sam	

D376 CTD log sheet

Station	A12	CTD No	024	Date	19/06/2012
Lat	49.19852˚ N	Event No	041	Time I/W (GMT)	06:37
Lon	8.49976˚ W	Water Depth (m)	147	Time bottom (GMT)	06:37
Filename	D376_24.hex	Cast Depth (m)	102	Time O/W (GMT)	06:56
Weather	Wind Force 3				
Comments	Station A12 ‘yo-yo’ cast. Organic nuts – DOM only.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	δ^{15}N	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	102	06:38		x	x			x	x		1
2	2	2	102	06:39								x	2
3	3	3	56	06:43		x	x			x	x		3
4	4	4	56	06:43									4
5	5	5	50	06:45		x	x			x	x		5
6	6	6	50	06:46									6
7	7	7	45	06:49		x	x			x	x		7
8	8	8	45	06:50									8
9	9	9	17	06:54		x	x			x	x		9
10	10	10	17	06:54								x	10
			Sampler			Nealy Andy	Claire			Donal	Marie	Sam	

D376 CTD log sheet

Station	A12	CTD No	025	Date	19/06/2012
Lat	49˚ 11.860’ N	Event No	042	Time I/W (GMT)	07:38
Lon	008˚ 29.947’ W	Water Depth (m)	148	Time bottom (GMT)	07:56
Filename	D376_25.hex	Cast Depth (m)	100	Time O/W (GMT)	08:10
Weather	Wind Force 3. Sunny day.				
Comments	Station A12 ‘yo-yo’ cast. Organic nuts – DOM only. Bottles 8, 9 and 10 did not fire.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	δ^{15}N	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	100	07:57		x	x			x	x	x	1
2	2	2	100	07:57									2
3	3	3	53	08:00		x	x			x	x		3
4	4	4	53	08:00									4
5	5	5	48	08:02		x	x			x	x		5
6	6	6	48	08:02									6
7	7	7	43	08:04		x	x			x	x		7
8	8	8	43	08:04									8
9	9	9	40	08:05									9
10	10	10	40	08:05									10
11	11	11	15	08:08		x	x			x	x		11
12	12	12	15	08:08								x	12
			Sampler			?	?			?	?	?	

D376 CTD log sheet

Station	A12	CTD No	026	Date	19/06/2012
Lat	49° 11.983' N	Event No	043	Time I/W (GMT)	08:32
Lon	008° 29.956' W	Water Depth (m)	147	Time bottom (GMT)	08:42
Filename	D376_26.hex	Cast Depth (m)	100	Time O/W (GMT)	08:59
Weather	Wind Force 3				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only. Bottles 2, 10, 11 and 12 did not fire.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	100	08:42		x	x			x	x	x	1
2	2	2	100	08:42									2
3	3	3	54	08:47		x	x			x	x		3
4	4	4	54	08:47									4
5	5	5	48	08:49		x	x			x	x		5
6	6	6	48	08:49									6
7	7	7	44	08:50		x	x			x	x		7
8	8	8	44	08:50									8
9	9	9	40	08:52		x	x			x	x		9
10	10	10	40	08:52									10
11	11	11	15	08:54									11
12	12	12	15	08:54									12
			Sampler			?	?			?	?	?	

D376 CTD log sheet

Station	A12	CTD No	027	Date	19/06/2012
Lat	49° 11.968' N	Event No	044	Time I/W (GMT)	09:32
Lon	008° 30.067' W	Water Depth (m)	147	Time bottom (GMT)	09:40
Filename	D376_27.hex	Cast Depth (m)	100	Time O/W (GMT)	09:56
Weather	Wind Force 4				
Comments	Station A12 'yo-yo' cast. Organic nuts – DOM only. Bottles 1, 12 and 13 did not fire.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	100	09:41									1
2	2	2	100	09:41		x	x			x	x	x	2
3	3	3	100	09:41									3
4	4	4	100	09:41									4
5	5	5	52	09:44		x	x			x	x		5
6	6	6	52	09:44									6
7	7	7	52	09:44									7
8	8	8	52	09:44									8
9	9	9	48	09:46		x	x			x	x		9
10	10	10	48	09:46									10
11	11	11	48	09:46									11
12	12	12	48	09:46									12
13	13	13	44	09:47									13
14	14	14	44	09:47		x	x			x	x		14
15	15	15	44	09:47									15
16	16	16	44	09:47									16
17	17	17	30	09:50									17
18	18	18	30	09:50									18
19	19	19	30	09:50									19
20	20	20	30	09:50									20
21	21	21	15	09:51		x	x			x	x		21
22	22	22	15	09:51									22
23	23	23	15	09:51									23
24	24	24	15	09:51									24
			Sampler			?	?			?	?		

D376 CTD log sheet

Station	A1	CTD No	028	Date	22/06/2012
Lat	48° 01.7746' N	Event No	050	Time I/W (GMT)	19:05
Lon	009° 47.762' W	Water Depth (m)	2588	Time bottom (GMT)	20:03
Filename	D376_28.hex	Cast Depth (m)	2585	Time O/W (GMT)	21:18
Weather	Wind Force 4				
Comments	No signal from altimeter. Depth jumps around a lot. Bottle 18 did not fire.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	2585	20:04									1
2	2	2	2585	20:05	X	X	X	X					2
3	3	3	2000	20:16	X		X	X					3
4	4	4	2000	20:17									4
5	5	5	1396	20:28	X		X	X					5
6	6	6	1396	20:29									6
7	7	7	1003	20:37	X	X	X	X					7
8	8	8	1003	20:38									8
9	9	9	702	20:44	X	X	X	X					9
10	10	10	702	20:45									10
11	11	11	502	20:49	X		X	X					11
12	12	12	502	20:50									12
13	13	13	300	20:55	X	X	X	X	X				13
14	14	14	300	20:56									14
15	15	15	149	21:00	X		X	X	X				15
16	16	16	149	21:01								X	16
17	17	17	91	21:07	X		X	X	X				17
18	18	18	91	21:08									18
19	19	19	50	21:10	X	X	X	X	X				19
20	20	20	50	21:10								X	20
21	21	21	30	21:12	X		X	X	X				21
22	22	22	30	21:13									22
23	23	23	0	21:16	X	X	X	X	X				23
24	24	24	0	21:16									24
			Sampler		Claire Hannah Pete	Mattias	Claire	Allan	Mattias			Colin	

D376 CTD log sheet

Station	A2	CTD No	029	Date	22/06/2012
Lat	48° 04.537' N	Event No	051	Time I/W (GMT)	22:07
Lon	009° 43.169' W	Water Depth (m)	1278	Time bottom (GMT)	22:40
Filename	D376_29.hex	Cast Depth (m)	1277	Time O/W (GMT)	23:44
Weather	Wind Force 5				
Comments	Bottles 2, 8 and14 leaking. Dubious firing of bottle 7. Ran out of bottle 23– used 24 for plankton.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	1277	22:41	X	X	X	X				X	1
2	2	2	1277	22:41									2
3	3	3	1002	22:48	X	X	X	X					3
4	4	4	1002	22:49								X	4
5	5	5	753	22:56	X	X	X	X					5
6	6	6	753	22:57								X	6
7	7	7	504	23:04									7
8	8	8	502	23:06									8
9	9	9	254	23:14	X	X	X	X					9
10	10	10	254	23:15								X	10
11	11	11	204	23:18	X	X	X	X	X				11
12	12	12	204	23:19									12
13	13	13	154	23:22	X	X	X	X	X				13
14	14	14	154	23:23									14
15	15	15	104	23:26	X	X	X	X	X				15
16	16	16	104	23:27									16
17	17	17	84	23:29	X	X	X	X	X				17
18	18	18	84	23:30									18
19	19	19	64	23:32	X	X	X	X	X				19
20	20	20	64	23:33									20
21	21	21	38	23:36	X	X	X	X	X				21
22	22	22	38	23:36									22
23	23	23	8	23:39	X	X	X	X					23
24	24	24	8	23:39					X			X	24
			Sampler		Hannah Nealy Claire	Jo	Claire	Estelle	Mark H			Jo	

D376 CTD log sheet

Station	A3	CTD No	030	Date	23/06/2012
Lat	48° 09.25462' N	Event No	052	Time I/W (GMT)	01:04
Lon	009° 37.06' W	Water Depth (m)	613	Time bottom (GMT)	01:23
Filename	D376_30.hex	Cast Depth (m)	610	Time O/W (GMT)	02:10
Weather	Wind Force 4/5				
Comments					

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	610	01:24									1
2	2	2	610	01:24	X	X	X	X					2
3	3	3	550	01:28	X	X	X	X					3
4	4	4	550	01:29								X	4
5	5	5	449	01:33	X	X	X	X					5
6	6	6	449	01:33									6
7	7	7	400	01:37	X	X	X	X					7
8	8	8	400	01:37								X	8
9	9	9	350	01:40	X	X	X	X					9
10	10	10	350	01:40									10
11	11	11	299	01:43	X	X	X	X					11
12	12	12	299	01:44									12
13	13	13	202	01:48	X	X	X	X	X				13
14	14	14	202	01:48								X	14
15	15	15	102	01:53	X	X	X	X	X				15
16	16	16	102	01:53									16
17	17	17	80	01:55	X	X	X	X	X				17
18	18	18	80	01:56									18
19	19	19	50	01:58	X	X	X	X	X				19
20	20	20	50	01:59									20
21	21	21	30	02:01	X	X	X	X	X				21
22	22	22	30	02:01									22
23	23	23	10	02:04	X	X	X	X	X				23
24	24	24	10	02:04									24
			Sampler		Hannah Nealy Mark H	Jo	Claire	Estelle	Mark H			Estelle	

D376 CTD log sheet

Station	A4	CTD No	031	Date	23/06/2012
Lat	48° 14.25' N	Event No	053	Time I/W (GMT)	03:15
Lon	009° 32.77' W	Water Depth (m)	188	Time bottom (GMT)	03:25
Filename	D376_31.hex	Cast Depth (m)	176	Time O/W (GMT)	03:53
Weather	Wind Force 4				
Comments					

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	176	03:26									1
2	2	2	176	03:26		X	X	X				X	2
3	3	3	143	03:29		X	X	X					3
4	4	4	143	03:29									4
5	5	5	123	03:32		X	X	X					5
6	6	6	123	03:32									6
7	7	7	103	03:34		X	X	X					7
8	8	8	102	03:35									8
9	9	9	83	03:37		X	X	X					9
10	10	10	83	03:37								X	10
11	11	11	63	03:40		X	X	X	X				11
12	12	12	63	03:40									12
13	13	13	53	03:42		X	X	X	X				13
14	14	14	53	03:42									14
15	15	15	43	03:44		X	X	X	X				15
16	16	16	43	03:44									16
17	17	17	33	03:46		X	X	X	X				17
18	18	18	33	03:46									18
19	19	19	23	03:48		X	X	X	X				19
20	20	20	23	03:48									20
21	21	21	13	03:50		X	X	X	X				21
22	22	22	13	03:50									22
23	23	23	9	03:52		X	X	X	X				23
24	24	24	9	03:52								X	24
			Sampler			?	?	?	?			Dima	

D376 CTD log sheet

Station	A0	CTD No	032	Date	17/06/2012
Lat	47° 55.638' N	Event No	056	Time I/W (GMT)	00:39
Lon	009° 53.911' W	Water Depth (m)	3150	Time bottom (GMT)	01:08
Filename	D376_32.hex	Cast Depth (m)	3140	Time O/W (GMT)	01:57
Weather	Wind Force 6				
Comments					

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	3140	07:04	x	x	x			x			1
2	2	2	3140	07:05								x	2
3	3	3	3003	07:10	x	x	x			x			3
4	4	4	3003	07:11									4
5	5	5	2504	07:23	x	x	x			x			5
6	6	6	2304	07:29	x	x	x			x			6
7	7	7	2304	07:29									7
8	8	8	2003	07:36	x	x	x			x			8
9	9	9	2003	07:36								x	9
10	10	10	1803	07:42	x	x	x			x			10
11	11	11	1802	07:42									11
12	12	12	1505	07:49	x	x	x			x			12
13	13	13	1505	07:49								x	13
14	14	14	1205	07:56			x			x			14
15	15	15	1004	08:01	x	x	x			x			15
16	16	16	1004	08:02									16
17	17	17	804	08:07	x	x	x			x			17
18	18	18	804	08:07									18
19	19	19	504	08:14	x	x	x	x		x			19
20	20	20	300	08:19			x	x		x			20
21	21	21	100	08:25	x	x	x	x		x			21
22	22	22	81	08:27			x	x					22
23	23	23	40	08:30			x	x					23
24	24	24	2	08:32	x	x	x	x				x	24
			Sampler		?	?	?	?		?		?	

D376 CTD log sheet

Station	A5	CTD No	033	Date	24/06/2012
Lat	48° 19.317' N	Event No	057	Time I/W (GMT)	11:47
Lon	009° 26.312' W	Water Depth (m)	142	Time bottom (GMT)	12:01
Filename	D376_33.hex	Cast Depth (m)	135	Time O/W (GMT)	12:34
Weather	Wind Force 2, calm.				
Comments	Problem with winch screen – long stop @ ~ 90m on way down. Bottle 12 leaked.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	135	12:02		x	x	x					1
2	2	2	135	12:02								x	2
3	3	3	121	12:05		x	x	x					3
4	4	4	121	12:05									4
5	5	5	100	12:08		x	x	x					5
6	6	6	100	12:08								x	6
7	7	7	90	12:10		x	x	x					7
8	8	8	90	12:10									8
9	9	9	80	12:13		x	x	x					9
10	10	10	80	12:13									10
11	11	11	70	12:16		x	x	x	x				11
12	12	12	70	12:16									12
13	13	13	60	12:18		x	x	x	x				13
14	14	14	60	12:19									14
15	15	15	50	12:21		x	x	x	x				15
16	16	16	50	12:22									16
17	17	17	40	12:24		x	x	x	x				17
18	18	18	40	12:24									18
19	19	19	30	12:26		x	x	x	x				19
20	20	20	30	12:26									20
21	21	21	20	12:29		x	x	x	x				21
22	22	22	20	12:30									22
23	23	23	10	12:32		x	x	x	x				23
24	24	24	10	12:32								x	24
			Sampler			Hannah Nealy	Claire	Juliane	Mark H			Mark H Estelle	

D376 CTD log sheet

Station	A6	CTD No	034	Date	24/06/2012
Lat	48˚ 23.734’ N	Event No	058	Time I/W (GMT)	14:10
Lon	009˚ 22.411’ W	Water Depth (m)	138	Time bottom (GMT)	14:19
Filename	D376_34.hex	Cast Depth (m)	127	Time O/W (GMT)	14:53
Weather	Wind Force 2. Rain during cast and subsequent sampling.				
Comments	Bottles 15 and 16 leaked. Oxygen temp measurements taken, no samples.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	127	14:20		x	x	x					1
2	2	2	127	14:21								x	2
3	3	3	108	14:23		x	x	x					3
4	4	4	108	14:23									4
5	5	5	90	14:26		x	x	x					5
6	6	6	90	14:27									6
7	7	7	80	14:29		x	x	x					7
8	8	8	80	14:30									8
9	9	9	70	14:32		x	x	x					9
10	10	10	70	14:32									10
11	11	11	60	14:35		x	x	x					11
12	12	12	60	14:35									12
13	13	13	50	14:37		x	x	x					13
14	14	14	50	14:38								x	14
15	15	15	40	14:40									15
16	16	16	40	14:40									16
17	17	17	30	14:42		x	x	x					17
18	18	18	30	14:43									18
19	19	19	25	14:45		x	x	x					19
20	20	20	25	14:45								x	20
21	21	21	15	14:47		x	x	x					21
22	22	22	15	14:47									22
23	23	23	5	14:50		x	x	x					23
24	24	24	5	14:51								x	24
			Sampler			**Mark H Andy**	**Claire**	**Donal**				**Estelle**	

D376 CTD log sheet

Station	A7	CTD No	035	Date	24/06/2012
Lat	48˚ 27.52’ N	Event No	059	Time I/W (GMT)	15:50
Lon	009˚ 19.11’ W	Water Depth (m)	155	Time bottom (GMT)	16:00
Filename	D376_35.hex	Cast Depth (m)	144	Time O/W (GMT)	16:28
Weather	Wind Force 3 – raining whilst sampling.				
Comments	Oxygen temp measurements taken, no samples.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	144	16:01		x	x	x					1
2	2	2	144	16:01								x	2
3	3	3	122	16:04		x	x	x					3
4	4	4	122	16:04									4
5	5	5	102	16:07		x	x	x					5
6	6	6	103	16:07									6
7	7	7	93	16:08		x	x	x					7
8	8	8	92	16:08									8
9	9	9	82	16:12		x	x	x					9
10	10	10	82	16:12								x	10
11	11	11	72	16:14		x	x	x	x				11
12	12	12	72	16:14									12
13	13	13	63	16:16		x	x	x	x				13
14	14	14	62	16:16									14
15	15	15	53	16:18		x	x	x	x				15
16	16	16	52	16:18									16
17	17	17	42	16:20		x	x	x	x				17
18	18	18	42	16:20									18
19	19	19	32	16:22		x	x	x	x				19
20	20	20	32	16:22									20
21	21	21	73	16:24		x	x	x	x				21
22	22	22	22	16:24									22
23	23	23	12	16:26		x	x	x	x				23
24	24	24	12	16:26								x	24
			Sampler			**Andy**	**Claire**	**Donal**	**Hannah**			**Dima**	

D376 CTD log sheet

Station	A8	CTD No	036	Date	24/06/2012
Lat	48° 30.82' N	Event No	060	Time I/W (GMT)	17:21
Lon	009° 14.90' W	Water Depth (m)	158	Time bottom (GMT)	17:30
Filename	D376_36.hex	Cast Depth (m)	146	Time O/W (GMT)	17:55
Weather	Wind Force 3. Very light rain whilst sampling.				
Comments					

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	145	17:31		X	X	X					1
2	2	2	146	17:31								X	2
3	3	3	126	17:34		X	X	X					3
4	4	4	126	17:34									4
5	5	5	102	17:37		X	X	X					5
6	6	6	102	17:37									6
7	7	7	92	17:39		X	X	X					7
8	8	8	92	17:39									8
9	9	9	82	17:40		X	X	X					9
10	10	10	81	17:40									10
11	11	11	71	17:42		X	X	X					11
12	12	12	71	17:42									12
13	13	13	61	17:44		X	X	X					13
14	14	14	61	17:44									14
15	15	15	51	17:46		X	X	X					15
16	16	16	51	17:46									16
17	17	17	41	17:47		X	X	X					17
18	18	18	41	17:47								X	18
19	19	19	32	17:49		X	X	X					19
20	20	20	32	17:49									20
21	21	21	21	17:51		X	X	X					21
22	22	22	21	17:51									22
23	23	23	12	17:53		X	X	X					23
24	24	24	10	17:54									24
			Sampler			Neally Hannah	Claire	Andy/Donal				Marie	

D376 CTD log sheet

Station	A9	CTD No	037	Date	24/06/2012
Lat	48° 34.44' N	Event No	061	Time I/W (GMT)	18:40
Lon	009° 10.08' W	Water Depth (m)	156	Time bottom (GMT)	18:50
Filename	D376_37.hex	Cast Depth (m)	147	Time O/W (GMT)	19:17
Weather	Wind Force 2				
Comments	Oxygen temp measurements taken, no samples.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	147	18:51		X	X	X					1
2	2	2	146	18:51									2
3	3	3	137	18:53		X	X	X					3
4	4	4	136	18:53									4
5	5	5	122	18:56		X	X	X					5
6	6	6	122	18:56									6
7	7	7	101	18:58		X	X	X					7
8	8	8	101	18:58									8
9	9	9	81	19:01		X	X	X					9
10	10	10	81	19:01									10
11	11	11	71	19:04		X	X	X	X				11
12	12	12	71	19:04									12
13	13	13	61	19:06		X	X	X	X				13
14	14	14	61	19:06									14
15	15	15	51	19:08		X	X	X	X				15
16	16	16	51	19:08									16
17	17	17	41	19:10		X	X	X	X				17
18	18	18	41	19:10									18
19	19	19	31	19:12		X	X	X	X				19
20	20	20	31	19:12									20
21	21	21	21	19:14		X	X	X	X				21
22	22	22	21	19:14									22
23	23	23	11	19:15		X	X	X	X				23
24	24	24	11	19:15									24
			Sampler			?	?	?	?				

D376 CTD log sheet

Station	C1	CTD No	038	Date	24/06/2012
Lat	48° 26.226' N	Event No	062	Time I/W (GMT)	21:03
Lon	009° 26.303' W	Water Depth (m)	190	Time bottom (GMT)	21:13
Filename	D376_38.hex	Cast Depth (m)	180	Time O/W (GMT)	21:37
Weather	Wind Force 3				
Comments					

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	180	21:13			X						1
2	2	2	180	21:13									2
3	3	3	160	21:15			X						3
4	4	4	160	21:15									4
5	5	5	140	21:17			X						5
6	6	6	140	21:17									6
7	7	7	120	21:19			X						7
8	8	8	120	21:19									8
9	9	9	100	21:21			X						9
10	10	10	100	21:21									10
11	11	11	80	21:23			X						11
12	12	12	80	21:23									12
13	13	13	60	21:25			X						13
14	14	14	60	21:25									14
15	15	15	50	21:27			X						15
16	16	16	50	21:27									16
17	17	17	40	21:29			X						17
18	18	18	40	21:29									18
19	19	19	30	21:30			X						19
20	20	20	30	21:30									20
21	21	21	20	21:32			X						21
22	22	22	20	21:32									22
23	23	23	10	21:34			X						23
24	24	24	10	21:34									24
			Sampler				?						

D376 CTD log sheet

Station	C2	CTD No	039	Date	24/06/2012
Lat	48° 24.386' N	Event No	063	Time I/W (GMT)	22:22
Lon	009° 32.366' W	Water Depth (m)	657	Time bottom (GMT)	22:47
Filename	D376_39.hex	Cast Depth (m)	647	Time O/W (GMT)	23:30
Weather	Wind Force 4. Fog.				
Comments	Bottles 4, 5 and 11 leaked.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	647	22:48			X						1
2	2	2	647	22:48								X	2
3	3	3	600	22:51			X						3
4	4	4	600	22:51									4
5	5	5	500	22:55									5
6	6	6	500	22:55			X					X	6
7	7	7	400	22:59			X						7
8	8	8	400	22:59									8
9	9	9	350	23:03			X						9
10	10	10	350	23:03								X	10
11	11	11	300	23:07									11
12	12	12	300	23:07			X					X	12
13	13	13	250	23:10			X						13
14	14	14	250	23:10									14
15	15	15	200	23:14			X						15
16	16	16	200	23:14								X	16
17	17	17	150	23:17			X						17
18	18	18	150	23:17									18
19	19	19	100	23:21			X						19
20	20	20	100	23:21									20
21	21	21	50	23:24			X						21
22	22	22	50	23:24									22
23	23	23	10	23:27			X						23
24	24	24	10	23:27									24
			Sampler				Claire Mark H					Mark H Estelle	

D376 CTD log sheet

Station	C3	CTD No	040	Date	25/06/2012
Lat	48° 22.155' N	Event No	064	Time I/W (GMT)	00:38
Lon	009° 36.650' W	Water Depth (m)	787	Time bottom (GMT)	01:01
Filename	D376_40.hex	Cast Depth (m)	768	Time O/W (GMT)	01:53
Weather	Wind Force 4. Fog.				
Comments	Questionable if we've sampled close to the bottom – water depth varying greatly.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	768	01:03			X						1
2	2	2	768	01:03								X	2
3	3	3	698	01:06			X						3
4	4	4	698	01:07								X	4
5	5	5	674	01:10			X						5
6	6	6	673	01:10									6
7	7	7	589	01:14			X						7
8	8	8	589	01:15								X	8
9	9	9	499	01:19			X						9
10	10	10	499	01:19								X	10
11	11	11	348	01:23			X						11
12	12	12	349	01:23								X	12
13	13	13	213	01:30			X						13
14	14	14	214	01:31									14
15	15	15	149	01:35			X						15
16	16	16	149	01:36									16
17	17	17	64	01:41			X						17
18	18	18	64	01:41									18
19	19	19	49	01:43			X						19
20	20	20	49	01:43									20
21	21	21	29	01:46			X						21
22	22	22	29	01:46									22
23	23	23	19	01:48			X						23
24	24	24	19	01:48									24
			Sampler				Mark H					Mark H	

D376 CTD log sheet

Station	C4	CTD No	041	Date	25/06/2012
Lat	48° 20.530' N	Event No	065	Time I/W (GMT)	03:14
Lon	009° 42.910' W	Water Depth (m)	1373(?)	Time bottom (GMT)	03:49
Filename	D376_41.hex	Cast Depth (m)	1363	Time O/W (GMT)	04:43
Weather	Wind Force 4				
Comments	May not have reached bottom.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	1363	03:50			X					X	1
2	2	2	1364	03:51									2
3	3	3	1201	03:56			X						3
4	4	4	1201	03:56									4
5	5	5	1080	04:01			X						5
6	6	6	1080	04:01								X	6
7	7	7	1001	04:05			X						7
8	8	8	1002	04:05									8
9	9	9	802	04:11			X						9
10	10	10	802	04:11								X	10
11	11	11	722	04:15			X						11
12	12	12	722	04:15									12
13	13	13	502	04:21			X						13
14	14	14	502	04:21								X	14
15	15	15	303	04:27			X						15
16	16	16	302	04:27								X	16
17	17	17	202	04:32			X						17
18	18	18	203	04:32									18
19	19	19	93	04:36			X						19
20	20	20	93	04:36									20
21	21	21	52	04:39			X						21
22	22	22	53	04:39									22
23	23	23	12	04:42			X						23
24	24	24	12	04:42									24
			Sampler				Donal					Marie	

D376 CTD log sheet

Station	LT1	CTD No	042	Date	25/06/2012
Lat	48° 05.409' N	Event No	066	Time I/W (GMT)	06:27
Lon	009° 43.519' W	Water Depth (m)	1295	Time bottom (GMT)	06:58
Filename	D376_42.hex	Cast Depth (m)	1282	Time O/W (GMT)	
Weather	Wind Force 5				
Comments					

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	δ^{15}N	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	1282	06:59								x	1
2	2	2	1282	06:59								x	2
			Sampler									Colin	

D376 CTD log sheet

Station		CTD No	043	Date	26/06/2012
Lat	48° 29.965' N	Event No	070	Time I/W (GMT)	09:44
Lon	009° 20.168' W	Water Depth (m)	156	Time bottom (GMT)	09:53
Filename	D376_43.hex	Cast Depth (m)	148	Time O/W (GMT)	09:59
Weather					
Comments	Calibration dip prior to VMP session. No Niskins attached. Drifted outside of VMP box during cast.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	δ^{15}N	Phyco-erythrin	Salinity	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C5	CTD No	044	Date	27/06/2012
Lat	48° 18.214' N	Event No	081	Time I/W (GMT)	21:32
Lon	009° 48.048' W	Water Depth (m)	1652(?)	Time bottom (GMT)	22:11
Filename	D376_44.hex	Cast Depth (m)	1620	Time O/W (GMT)	23:20
Weather	Wind Force 4				
Comments	Bottle 2 leaked				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	1620	22:12			X					X	1
2	2	2	1620	22:13									2
3	3	3	1495	22:17			X						3
4	4	4	1495	22:17									4
5	5	5	1402	22:20			X						5
6	6	6	1402	22:20									6
7	7	7	999	22:29			X						7
8	8	8	999	22:29								X	8
9	9	9	802	22:35			X						9
10	10	10	802	22:35									10
11	11	11	753	22:38			X						11
12	12	12	753	22:38									12
13	13	13	694	22:40			X						13
14	14	14	694	22:40									14
15	15	15	620	22:44			X						15
16	16	16	620	22:44									16
17	17	17	500	22:48			X						17
18	18	18	500	22:48									18
19	19	19	400	22:51			X					X	19
20	20	20	300	22:55			X						20
21	21	21	202	23:00			X						21
22	22	22	102	23:05			X						22
23	23	23	52	23:08			X						23
24	24	24	12	23:12			X					X	24
			Sampler				**Claire**					**Mark H**	

D376 CTD log sheet

Station	ST1	CTD No	045	Date	28/06/2012
Lat	48° 08.75' N	Event No	082	Time I/W (GMT)	01:18
Lon	009° 37.87' W	Water Depth (m)	699	Time bottom (GMT)	01:37
Filename	D376_45.hex	Cast Depth (m)	691	Time O/W (GMT)	02:31
Weather	Wind Force 4				
Comments	Bottled 12 leaked.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	628	01:41		X							1
2	2	2	628	01:41								X	2
3	3	3	550	01:45		X							3
4	4	4	550	01:46									4
5	5	5	450	01:50		X							5
6	6	6	450	01:51									6
7	7	7	400	01:55		X							7
8	8	8	400	01:55									8
9	9	9	350	01:58		X							9
10	10	10	350	01:59								X	10
11	11	11	300	02:03		X						X	11
12	12	12	300	02:03									12
13	13	13	200	02:08		X						X	13
14	14	14	100	02:16									14
15	15	15	100	02:16		X							15
16	16	16	100	02:16								X	16
17	17	17	80	02:19		X							17
18	18	18	80	02:19									18
19	19	19	50	02:22		X							19
20	20	20	50	02:22									20
21	21	21	20	02:26		X							21
22	22	22	20	02:26									22
23	23	23	10	02:28		X							23
24	24	24	10	02:28									24
			Sampler			**Claire**						**Mark H** **Estelle**	

D376 CTD log sheet

Station	C3	CTD No	046	Date	29/06/2012
Lat	48.37624° N	Event No	090	Time I/W (GMT)	13:01
Lon	9.61200° W	Water Depth (m)	825	Time bottom (GMT)	13:25
Filename	D376_46.hex	Cast Depth (m)	818	Time O/W (GMT)	13:43
Weather	Wind Force 4				
Comments	Start of 'yo-yo' casts. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**$\delta^{15}N$**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	047	Date	29/06/2012
Lat	48° 22.60' N	Event No	091	Time I/W (GMT)	14:13
Lon	009° 37.15' W	Water Depth (m)	753	Time bottom (GMT)	14:35
Filename	D376_47.hex	Cast Depth (m)	743	Time O/W (GMT)	14:53
Weather	Wind Force 4				
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**$\delta^{15}N$**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	048	Date	29/06/2012
Lat	48.37216° N	Event No	092	Time I/W (GMT)	15:23
Lon	9.61234° W	Water Depth (m)	?	Time bottom (GMT)	15:49
Filename	D376_48.hex	Cast Depth (m)	943	Time O/W (GMT)	16:08
Weather					
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**δ^{15}N**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	049	Date	29/06/2012
Lat	48° 22.31' N	Event No	093	Time I/W (GMT)	16:35
Lon	009° 37.20' W	Water Depth (m)	909	Time bottom (GMT)	17:04
Filename	D376_49.hex	Cast Depth (m)	900	Time O/W (GMT)	17:23
Weather					
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**δ^{15}N**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	050	Date	29/06/2012
Lat	48° 22.36' N	Event No	094	Time I/W (GMT)	17:47
Lon	009° 37.17' W	Water Depth (m)	941	Time bottom (GMT)	18:11
Filename	D376_50.hex	Cast Depth (m)	926	Time O/W (GMT)	18:31
Weather					
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**δ^{15}N**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	051	Date	29/06/2012
Lat	48.37546° N	Event No	095	Time I/W (GMT)	18:53
Lon	9.61680° W	Water Depth (m)	830	Time bottom (GMT)	19:15
Filename	D376_51.hex	Cast Depth (m)	820	Time O/W (GMT)	19:35
Weather	Wind Force 5				
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**δ^{15}N**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	052	Date	29/06/2012
Lat	48° 22.634' N	Event No	096	Time I/W (GMT)	20:02
Lon	009° 36.694' W	Water Depth (m)	803	Time bottom (GMT)	20:22
Filename	D376_52.hex	Cast Depth (m)	797	Time O/W (GMT)	20:39
Weather	Wind Force 5				
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	053	Date	29/06/2012
Lat	48° 22.731' N	Event No	097	Time I/W (GMT)	21:03
Lon	009° 36.411' W	Water Depth (m)	730	Time bottom (GMT)	21:25
Filename	D376_52.hex	Cast Depth (m)	720	Time O/W (GMT)	21:41
Weather	Wind Force 5				
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	$\delta^{15}N$	Phyco-erythrin	Salinity	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	054	Date	29/06/2012
Lat	48° 22.726' N	Event No	098	Time I/W (GMT)	22:04
Lon	009° 36.420' W	Water Depth (m)	735	Time bottom (GMT)	22:28
Filename	D376_54.hex	Cast Depth (m)	729	Time O/W (GMT)	22:44
Weather					
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	$\delta^{15}N$	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	055	Date	29/06/2012
Lat	48° 27.67' N	Event No	099	Time I/W (GMT)	23:07
Lon	009° 36.407' W	Water Depth (m)	785	Time bottom (GMT)	23:29
Filename	D376_55.hex	Cast Depth (m)	780	Time O/W (GMT)	23:45
Weather	Wind Force 5				
Comments	'Yo-yo' cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	$\delta^{15}N$	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	056	Date	30/06/2012
Lat	48˚ 22.850’ N	Event No	100	Time I/W (GMT)	00:02
Lon	009˚ 36.656’ W	Water Depth (m)	728	Time bottom (GMT)	00:38
Filename	D376_56.hex	Cast Depth (m)	724	Time O/W (GMT)	00:57
Weather	Wind Force 6				
Comments	‘Yo-yo’ cast. No bottles fired.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**δ^{15}N**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	057	Date	30/06/2012
Lat	48˚ 22.4548’ N	Event No	101	Time I/W (GMT)	01:18
Lon	009˚ 37.0678’ W	Water Depth (m)	847	Time bottom (GMT)	01:49
Filename	D376_57.hex	Cast Depth (m)	842	Time O/W (GMT)	02:09
Weather	Wind Force 6				
Comments	‘Yo-yo’ cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**δ^{15}N**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	058	Date	30/06/2012
Lat	48° 22.22’ N	Event No	102	Time I/W (GMT)	02:33
Lon	009° 37.09’ W	Water Depth (m)	1015	Time bottom (GMT)	03:08
Filename	D376_58.hex	Cast Depth (m)	1005	Time O/W (GMT)	03:31
Weather	Wind Force 6				
Comments	‘Yo-yo’ cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**$\delta^{15}N$**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	C3	CTD No	059	Date	30/06/2012
Lat	48° 21.93’ N	Event No	103	Time I/W (GMT)	03:40
Lon	009° 37.08’ W	Water Depth (m)	1171	Time bottom (GMT)	04:14
Filename	D376_59.hex	Cast Depth (m)	1159	Time O/W (GMT)	04:41
Weather					
Comments	‘Yo yo’ cast. No bottles on frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	**Dissolved oxygen**	**Organic nutrients**	**Inorganic nutrients**	**Chlorophyll**	**Phytoplankton composition**	**$\delta^{15}N$**	**Phyco-erythrin**	**Salinity**	*Bot. No.*
			Sampler										

D376 CTD log sheet

Station	ST3	CTD No	060	Date	30/06/2012
Lat	48° 19.80' N	Event No	104	Time I/W (GMT)	06:13
Lon	009° 26.00' W	Water Depth (m)	131	Time bottom (GMT)	06:20
Filename	D376_60.hex	Cast Depth (m)	83	Time O/W (GMT)	06:53
Weather					
Comments	Instrument calibration dip. Bottles 16-21 removed from frame. Bottle 11 leaked.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	δ^{15} N	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	93	06:23		x	x	x				X (2)	1
2	2	2	93	06:23									2
3	3	3	82	06:26		x	x	x				X (2)	3
4	4	4	82	06:26									4
5	5	5	73	06:28		x	x	x					5
6	6	6	62	06:33		x	x	x					6
7	7	7	63	06:33									7
8	8	8	50	06:36		x	x	x					8
9	9	9	50	06:36									9
10	10	10	40	06:38		x	x	x				x	10
11	11	11	40	06:38									11
12	12	12	30	06:43		x	x	x				X (2)	12
13	13	13	30	06:43									13
14	14	14	19	06:45		x	x	x					14
15	15	15	15	06:49		x	x	x				x	15
16	22	22	15	06:49									22
17	23	23	3	06:51		x	x	x					23
18	24	24	4	06:51									24
			Sampler			?	?	?				?	

D376 CTD log sheet

Station	ST3	CTD No	061	Date	30/06/2012
Lat	48° 19.588' N	Event No	105	Time I/W (GMT)	07:33
Lon	009° 25.818' W	Water Depth (m)	137	Time bottom (GMT)	07:44
Filename	D376_61.hex	Cast Depth (m)	89	Time O/W (GMT)	08:06
Weather	Wind Force 5				
Comments	Instrument calibration dip. Bottles 16-21 removed from frame.				

Fire Seq.	*Bot. No.*	*Rosette Pos.*	*Depth (m)*	*Time (GMT)*	Dissolved oxygen	Organic nutrients	Inorganic nutrients	Chlorophyll	Phytoplankton composition	δ^{15} N	Phyco-erythrin	Salinity	*Bot. No.*
1	1	1	92	07:44	x	x	x	x				X (2)	1
2	2	2	92	07:44									2
3	3	3	82	07:46	x	x	x	x				X (2)	3
4	4	4	82	07:46									4
5	5	5	72	07:48	x	x	x	x				X (2)	5
6	6	6	72	07:48									6
7	7	7	62	07:50	x	x	x	x					7
8	8	8	52	07:53	x	x	x	x					8
9	9	9	52	07:53									9
10	10	10	42	07:53	x	x	x	x				X (2)	10
11	11	11	42	07:55									11
12	12	12	32	07:57	x	x	x	x				x	12
13	13	13	22	07:59	x	x	x	x					13
14	14	14	22	07:59									14
15	15	15	12	08:03	x	x	x	x				X (2)	15
16	22	22	12	08:04									22
17	23	23	surface	08:07	x	x	x	x					23
18	24	24	surface	08:07									24
			Sampler										