RRS Discovery Cruise D340b :

Inall, Mark

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RRS Discovery

Cruise D340b

Dunstaffnage to Govan
via Barra Head and the Surrounding Shelf

26th June to 4th July 2009

M.E. Inall

An Oceans2025 Cruise led by
the Scottish Association for Marine Science

SCOTTISH ASSOCIATION *for* MARINE SCIENCE

Internal Report No. 265

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3	John Beaton	SAMS	Tech	Mark Inall
4	Emily Venables *	SAMS	PO	Mark Inall
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6	Clare Johnston*	SAMS	Oxygen	Mark Inall
7	Alexandra Petersen §	SAMS	Phytoplankton	Keith Davisdon
8	Lewis Miller §	SAMS	Phytoplankton	Keith Davisdon
9	Andy Mogg *	SAMS	DMS	Angela Hatton
10	Natalie Wager	Heriot Watt Uni	DMS	Angela Hatton
11	Mike Smithson	POL	T/Fl Chain	Mark Inall
12	David O'Leary	Marine Institute, Ireland	Observer	Mark Inall
13	Mark Hebden	BODC	Data	Mark Hebden
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16	Keith Davisdon	SAMS	PP	Keith Davisdon
17	Linda Gilpin	Napier	PP	Eric Achterberg
18	Murray Roberts	SAMS	Coral	Murray Roberts
19	Kim Last	SAMS	Coral	Murray Roberts
20	Mélanie Duran*	SAMS	Coral	Murray Roberts
21	Sharon McNeil	SAMS	Nutrients	Keith Davisdon
22	Debbi Brennan	SAMS		Keith Davisdon

* PhD student

§ Undergraduate student

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Jon Short	Technical liaison officer
Chris Barnard	IT and CTD
Richie Phipps	Mechanical
Dave Teare	Scanfish

Ship's crew:

Antonio Gatti	Master
Nick Jones	Chief Officer
Phil Thomas	2nd Officer
Liam MsClintock	3rd Officer
David Hartshorne	Purser Catering Officer
Richard Coe	Chief Engineer
Stephen Bell	2nd Engineer
John Harnett	3rd Engineer
Edin Silajdzic	3rd Engineer
Robert Masters	ETO
Michael Drayton	CPO (Deck)
Martin Harrison	CPO (Scientific)
Stuart Cook	POD
Gary Crabb	SG1A
Ian Mills	SG1A
Peter Smith	SG1A
Nathan Gregory	SG1A
Duncan Lawes	MM1A
John Haughton	Head Chef
Wally Link	Chef
Jeff Orsborn	Steward

Summary

Sailing 14:00UTC on Thursday 25th from Dunstaffnage Point D340b was a 10 day Oceans2025 Theme 3 funded cruise. D340b followed on directly from D340a after a boat transfer at Dunstaffnage from SAMS laboratory on the Dunstaffnage peninsular.

The scientific aims for D340 Leg B were: 1) to study the physical response of tidal flows to topographic features of the shelf seas to the west of Scotland, in terms of stratification and turbulent mixing; 2) to study the consequent response of the water column chemistry and phytoplankton community structures; and 3) to study the benthic response of the hard coral reefs systems commonly found in this area.

Zero downtime through either weather or ship-side equipment failure lead to a fully completed programme and a highly successful cruise.

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1 Introduction

1.1 *Chronology*

Date	Julian Day		Location	Activity
25-Jun-09	176	Thur	Dunstaffnage	Under way
26-Jun-09	177	Fri	Outer shelf section	Science
27-Jun-09	178	Sat	Barra Head	Science
28-Jun-09	179	Sun	Mingulay Reefs	Science
29-Jun-09	180	Mon	Shelf Station	Science
30-Jun-09	181	Tue	Station W	Science
01-Jul-09	182	Wed	Inner shelf section	Science
02-Jul-09	183	Thur	Barra Head	Science
03-Jul-09	184	Fri	NS mid-shelf section	Science
04-Jul-09	185	Sat	Govan	Under way

1.2 Cruise track

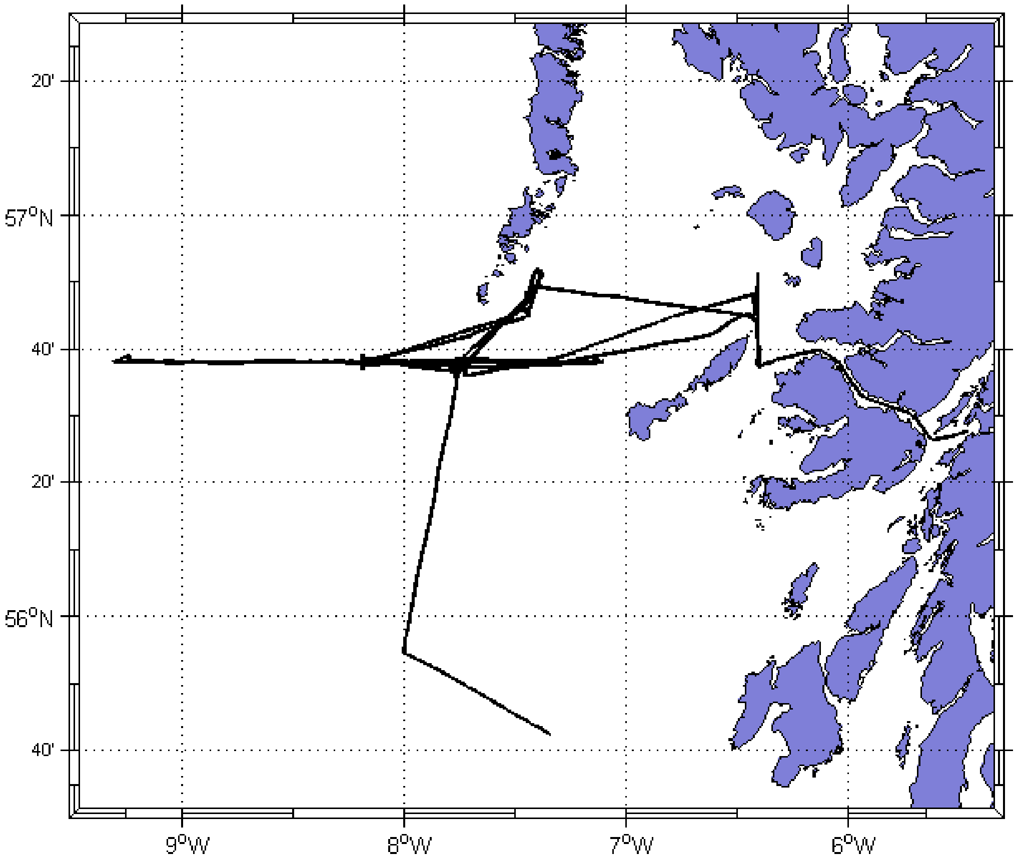


Figure 1.1. The cruise track.

1.3 Sea surface temperature field

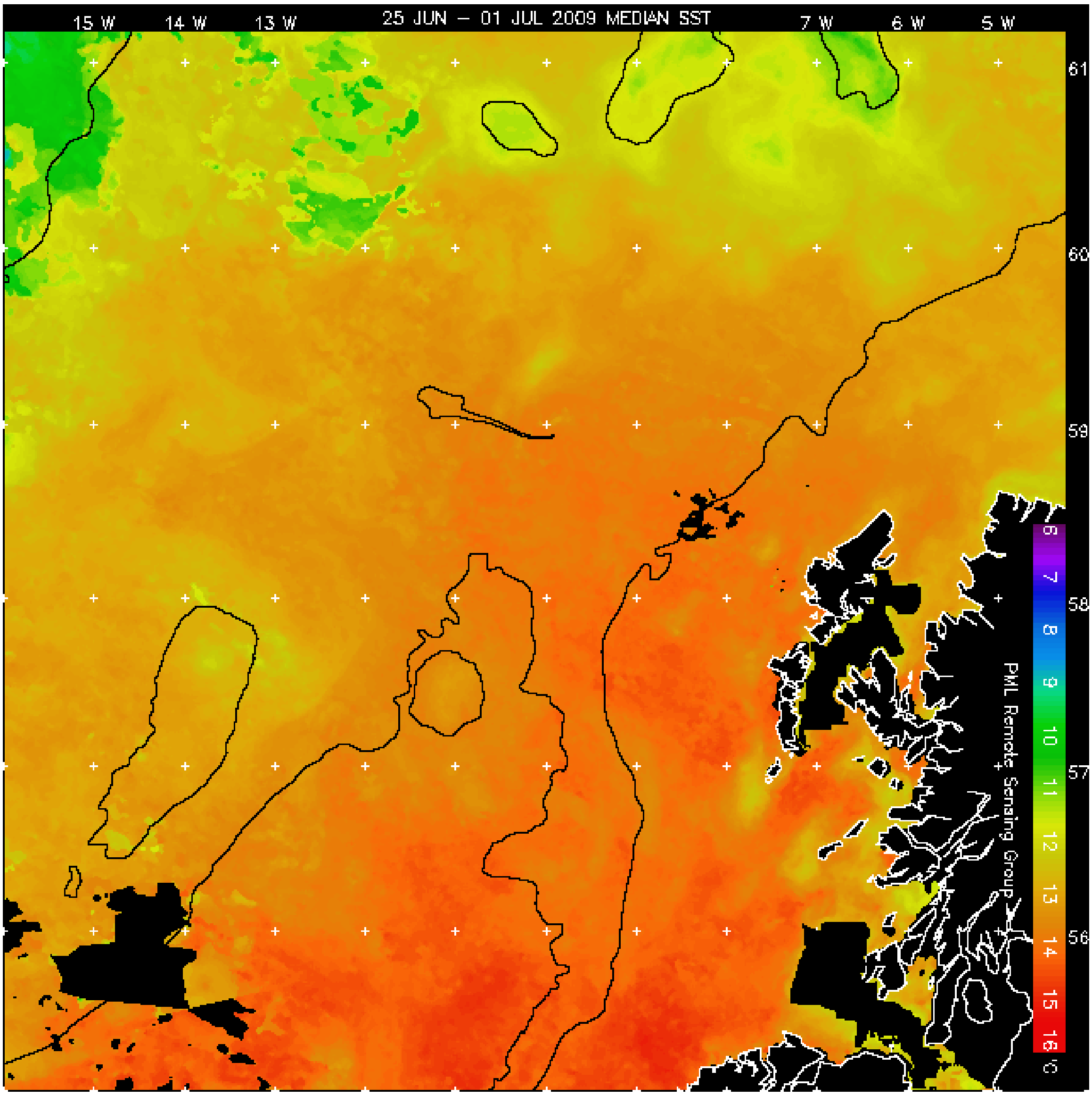


Figure 1.2. AVHRR image of the North East Atlantic showing a composite of sea surface temperature for the 7 day period to 1 July 2009. Satellite data were received and processed in near real time by the NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) at Dundee University and Plymouth Marine Laboratory (www.neodaas.ac.uk)

1.4 Sea surface chlorophyll concentrations

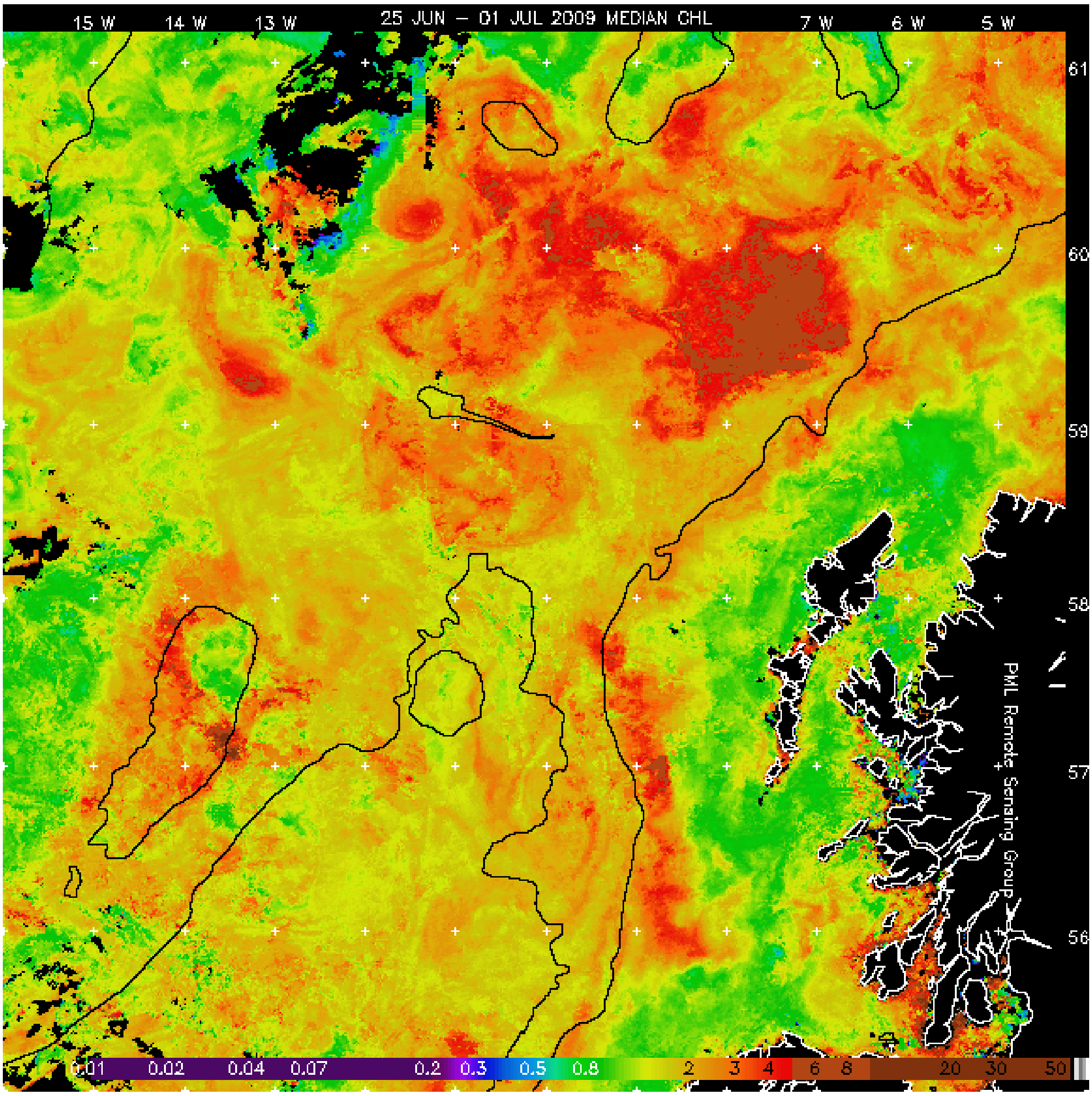


Figure 1.3. MODIS image of the North East Atlantic showing the sea surface chlorophyll *a* from a composite of the 7 day period to 1 July. Courtesy of PML Remote Sensing Group

1.5 Meteorological measurements

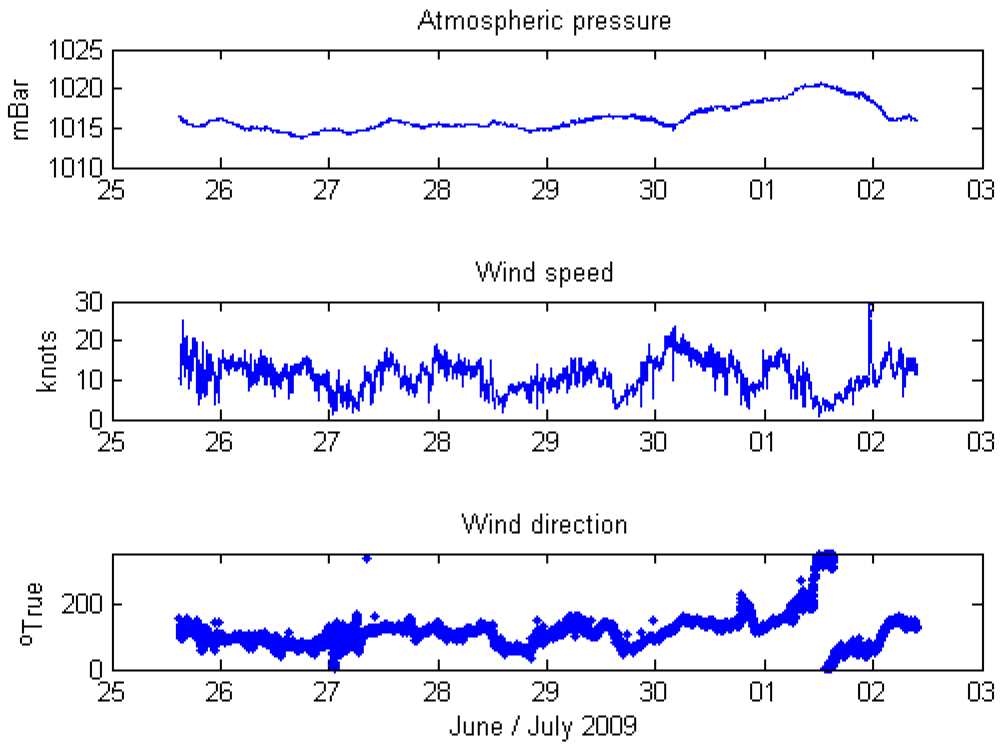


Figure 1.4 A summary of the meteorological measurements from the Surfmet logging system.

1.6 Sea surface observations

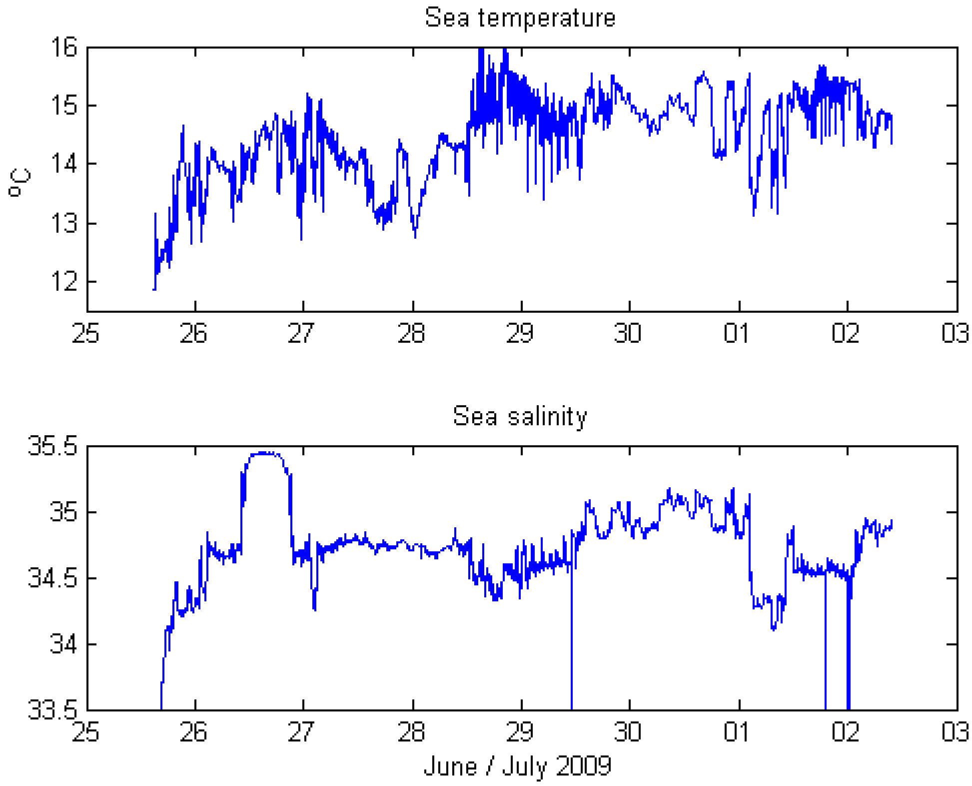


Figure 1.5. A summary of the oceanographic measurements from the Surfmet logging system. Gaps in the depth data are due to spike removal.

2 Narrative

Mark Inall, SAMS, PS

2.1 Thursday 25th June (Julian day 176)

Day 1. Dunstaffnage; Wind light; sea state slight

10:30 Calanus departs Dunstaffnage with first load of scientists and equipment to meet with Discovery off Dunstaffnage Point. Breezy and sunny.

12:30 Second Calanus boat transfer

14:30: Transfer complete, Discovery sets course for Tiree Passage mooring via Sound of Mull

18:30: Visual inspection of Tiree Passage mooring reveals spar intact but toroid missing. Subsurface pellets visible on closer inspection.

19:00: Set course for Barr Head. Slow passage as moorings are prepared for deployment at first light the next morning

2.2 Friday 26th June (day 177)

Day 2. Barra Head; Wind light SE, sea state slight;

5:30: CTD at Barra Head (~110m water depth). Slight delay to fit PAR sensors to CTD frame. ARs for moorings tested.

06:20: Manoeuvring to find exactly 85m WD for BH single point mooring. Mooring successfully deployed.

09:00: CTD at W station. Weather sunny, wind light.

10:00: Steam to Shelf Break 1000m contour.

CTD in 1000m, then 16:15 Muster and boat stations prior to scanfish launch. Scanfish flying superbly - so fish and chips for tea! 10 hour scanfish run in from 1000m, onto the shelf, past station W, past Barra Head and ending at E, between Tiree and Barra.

2.3 Saturday 27th June (day 178)

Day 3. Iceland Basin; Barra Head; Wind calm, sunny.

Another dry, fine, if overcast, day after some light rain overnight. Early CTD, followed by T/fl chain deployment. After sighting the BH pellets close to the surface we decided to recover the T/fl chain, and then recover, shorten, and then redeploy the BH thermistor mooring. Luckily there was spare anchor ballast on board. T/Fl chain redeployed with extra weight to keep it vertical. 10am and the MSS#1 25 hour station got underway.

7pm, weather sunny calm – wonderful!

2.4 Sunday 28th June (day 179)

Day 4. Barra Head and Mingulay Reef complex; Wind slight SE, sea state flat.

More fine weather. Turbulence profiling continued at station BH through until 11am. We then steamed for 2 hours to the cold coral reef sites of Mingulay to begin CTD work and video grab sampling of Lophelia at station M1. With perfect conditions of glassy seas and sunshine live coral was successfully sampled from station M1 on the Mingulay Reef system.

Activities had to be curtailed after some short circuiting in the camera lights and the CTDs resumed over the reef. By 10pm scanfish was in the water for a 12.5 hour repeat circuit survey over several of the reef complexes.

2.5 Monday 29th June (day 180)

Day 5. Mingulay ; Wind F3-4 S, overcast.

Scan fish survey continued through the night and into the morning. South-westerly wind freshening slightly Beaufort 2-3 with 5's forecast later, remaining dry. Steamed back out to station W for a CTD station followed by our second 25 hour MSS turbulence profiler marathon. Wind freshening all the time

2.6 Tuesday 30th June (day 181)

Day 6. Station W; Wind F4-5 SSW, rain showers, then sunny, then overcast with wind dropping.

MSS90 survey#2 completed successfully mid-afternoon. On advice from the Hebrides Range Control we then moved out of the live firing exclusion zone! A successful camera/grab test was undertaken at 8W (56 38N). We returned to the very edge of the exclusion zone to begin our overnight scanfish tow back towards, and over Barra Head and on towards the Cairns of Coll. After recovery to replace a problem magnet for one of the control surfaces, we repositioned and scanfished through the night to arrive by the Cairns of Coll at first light.

2.7 Wednesday 1st July (day 182)

Day 7. Tiree Passage; Wind light, overcast

Short steam around the top of Coll to arrive at the Tiree Passage mooring for a 07:30 low water slack. Pellet floats visible and grapnelled. Some confusion with ropes and mooring layout left the floats on the deck and the pick-up line sinking to the bed. The decision was quickly made that the mooring could be dragged for at a later date by the SAMS vessel Calanus, and D340b science programme continued. Mingulay coral reefs were our next stop. We arrived on station M1 for a CTD at mid-day, then successfully grabbed for corals from 1pm through the afternoon and evening until our break off at 1am Thursday to recover the single point mooring at station W.

2.8 Thursday 2nd July (day 183)

Day 8. Station W to Barra Head to Mingulay reef; Misty, calm. Sunny later.

Surface visibility sufficiently good for first-light recovery of single point mooring at station W. All instruments successfully recovered and underway to Barra Head by 6am. Final turbulence profiling station at BH – 12.5 hours – to investigate interesting signals measured during the first MSS session at BH. Profiling ended at 19:45, three shear sensors had to be replaced during the station – rocky bottom. T/Fl chain recovered then straight into mooring recovery; ADCP lander first, then single point. All instruments recovered. With all the moorings now on board we steamed back north to the reef sites for some final coral sampling through until first light.

2.9 Friday 3rd July (day 184)

Day 9. Barra Head to Stanton Banks; SW3-4, Rain.

Final science activity: scanfish line southwards from Barra Head and over the Stanton Banks. Challenging terrain for scanfish, with shallow and poorly charted rocky reefs in the Stanton Banks area. Science activities ended at 14:00 when we broke off to head for the Clyde and King George V dock.

2.10 Saturday 4th July (day 185)

Day 10.

Pilot on board off Kempock Point, slowly up the Clyde River, under the Erskine Bridge and alongside Shield Hall Riverside Quay at 08:30.

2.11 Watch keepers

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

8 - 12	12 – 4	4 - 8
Emily Venables*	Estelle Dumont*	Valdimir Ivanov*
Dmitry Aleynik	Mark Hebden	Julia Calderwood
David O'Leary**	Mike Smithson** Mark Inall**	John Beaton**

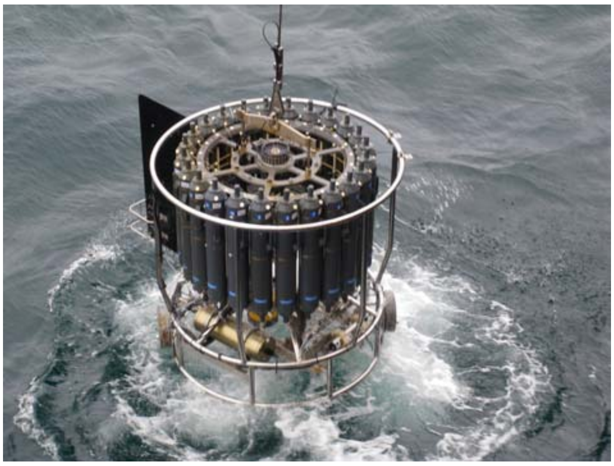
* Watch leader

** Additional watch keepers during MSS90 operations

The NMF technicians (TLO Jon Short, Dave Teare, Chris Bernard and Ritchie Phipps) worked variable shifts depending on work plan.

3 CTD report

Estelle Dumont, SAMS



3.1 Introduction

3.1.1 Methodology

The CTD system used during the cruise (standard stainless steel housing) was equipped with dual T and C sensors, SBE43 oxygen sensor, Chelsea Aqua 3 fluorometer, altimeter, Chelsea/Seatech/Wetlab CStar transmissometer and dual Biospherical/Licor PAR/irradiance sensors (except for cast #089 for which the depth was greater than the PAR sensors pressure-rating). Twenty-four Niskin 10 litres bottles were fitted on the carousel.

The T and C sensors located on the vane should be used as primary sensors, however appear labelled as secondary in the dataset (t1, cond1, sal1, etc). Similarly the sensors inside the frame, which should be treated as secondary, are labelled as primary (t0, cond0, sal0, etc).

The CTD was operated by trained NMFSS technicians throughout the cruise who oversaw all aspects of CTD operations from preparing the bottles to monitoring its performance during a cast to maintaining it on deck. Regular watch keepers from the scientific staff collected samples for salinity.

3.1.2 Dataset

In total, fifteen casts were completed (details in Appendix X). The numbering carried on from the previous cruise D340a and therefore started at cast number 087.

Casts #098 and 099 were done for water collection purposes only, and the data recorded on those two casts may not be fully usable (the CTD pumps were not always on, and the data seemed rather noisy).

3.2 Data processing

The CTD data were processed according the common standards, using Seabird Data Processing version 7.17 (part of the Seasoft-Win32 suite) and Matlab R2007a. 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, Loop Edit, Bin Average (2db-bins), Bin Average (1s-bins, for LADCP processing purposes only) 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).

3.2.1 Raw data processing (SBEDataProcessing)

Data Conversion converted raw data from engineering units to binary .cnv files and produced the .btl files. Variables exported were scan number, pump status, Julian day, latitude [deg], longitude [deg], pressure [db], temperature1 [ITS-90, deg C], conductivity1 [mS/cm], temperature0 [ITS-90, deg C], conductivity0 [mS/cm], oxygen [mg/l], beam attenuation [1/m], altimeter [m], fluorescence on [ug/l], beam transmission [%], PAR, PAR1 and depth [m].

Please note:

The primary TC sensors were labelled 1, secondary 0.

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 the oxygen sensor response delay, relative to pressure (+3s applied here). This 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 ran to remove conductivity cell thermal mass effects from the measured conductivity. The constants used were the ones given 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 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 density sigma-theta (kg/m3), twin salinities (psu) 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) 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).

3.2.2 Despiking (Matlab)

The pressure, oxygen, temperature (primary and secondary) and salinity (primary and secondary) data were manually despiked (using the function Scrollingplot). 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, temperature or 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).

3.2.3 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. Some 1s-bin averaged were also produced (up and downcast data), used for the LADCP processing.

Ascii Out output the bin-averaged data files as ASCII (with a simplified header).

3.2.4 Plotting (Matlab)

Plots of the 24Hz raw data, 24Hz despiked data and 2db-bins despiked data were produced for the following variables: temperature, conductivity, salinity, density, oxygen, fluorescence, PAR vs pressure; and salinity difference*, conductivity difference* and salinity difference* vs scan or time (* between primary and secondary sensors).

For the 2db-bin averaged data, the following plots were also produced: potential temperature vs pressure and salinity vs potential temperature.

3.2.5 Comments:

The dual temperature and conductivity measurements were in agreement during the downcast but showed a noticeable difference during the upcast (or part of the upcast). There were some "noisy" sections of data, generally during the upcast, during bottle firings and in the thermocline zone.

The PAR sensor data on casts #096 to 099 seemed questionable. The cause of the problem was not determined and has not been investigated further as the PAR data appeared reasonable again for the following casts.

3.3 Salinity calibration

Salinity samples were taken from the Niskin bottles on most casts throughout the cruise and were analysed onboard using an Autosal salinometer. Calibration of the CTD salinity data will be determined post-cruise, and will also include the data from samples obtained during the first leg of the cruise on the Scottish Shelf.

4 Dissolved Oxygen Calibration

Clare Johnson, SAMS

4.1 Introduction

Bottle oxygen samples were taken to calibrate the oxygen sensor mounted on the stainless steel rosette used during D340b. Samples were taken in triplicate from between two and five depths on the majority of CTD casts (see Table 4.1) and measured using the Winkler technique on a Radiometer autoburette system (ABU91). Samples were taken from a variety of depths and dissolved oxygen concentrations.

4.2 Data collection and analysis

Sample collection

Samples for dissolved oxygen were collected first to decrease the risk of oxygen concentrations in the rosette bottles changing before sampling. Samples were collected in glass bottles of a known volume using silicon tubing attached to the rosette bottle spigot. This tubing was flushed with water between each rosette bottle and care was taken to ensure no bubbles were in the tube. The tubing was placed at the bottom of the sample bottle and the bottle rinsed with sample whilst inverted before sample collection. Flow speed was adjusted to ensure a gentle, non-turbulent flow of water and that no bubbles entered the sample. Water was allowed to overflow the bottle before the tubing was carefully withdrawn and 1 ml of manganese chloride (60 w/v %) and 1 ml of alkaline iodide solution (32 w/v % sodium hydroxide mixed with 60 w/v % sodium iodide) were added on deck with automated dispensers. Samples were carefully capped and shaken to ensure all dissolved oxygen reacted to form a manganese hydroxide precipitate. Samples were shaken again approximately one hour after sampling and stored at room temperature for between seven and 48 hours before further analysis.

Sample analysis

The manganese hydroxide precipitate was redissolved by the addition of 1 ml sulphuric acid (5M) releasing iodide ions. A magnetic stirrer was used ensure all the precipitate was dissolved before the titration with sodium thiosulphate solution (0.23 M) using the autoburette. The sodium thiosulphate was standardised during D340a and immediately on return to the Scottish Association for Marine Science. The end point of the sample titration was determined spectrophotometrically, the titre value recorded and subsequently converted to dissolved oxygen concentration. Triplicate samples were averaged and any outlying values discarded from the calibration. Precision of triplicate samples ranged from 0.06 % to 2.11 %.

4.3 Calibration

Sensor oxygen concentrations for the time when the rosette bottles were fired on each cast were obtained from processed bottle files. These were plotted against bottle oxygen values (see Fig. 4.1) allowing the following regression relationship to be determined:

corrected sensor oxygen (mg/l) = 0.9326 raw sensor oxygen (mg/l) + 0.8173

The regression correlation coefficient was 0.998.

The corrected sensor oxygen's were subtracted from bottle oxygen values obtaining residuals. These were plotted against sample number (Fig. 4.2) and depth (Fig. 4.3). A small trend from more positive to negative residuals can be seen with time throughout the cruise, and a possible positive bias with depth for the only station below 1000 m. However all residuals are within ±0.07 mg/l from the bottle oxygen concentrations.

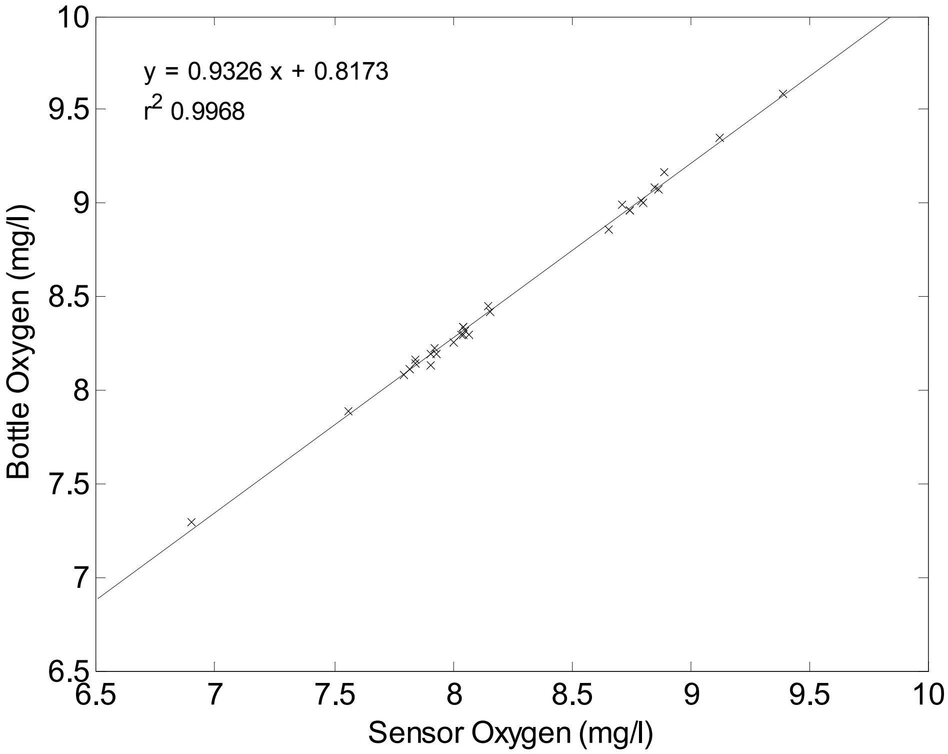


Figure 4.1 Dissolved oxygen calibration for D340b.

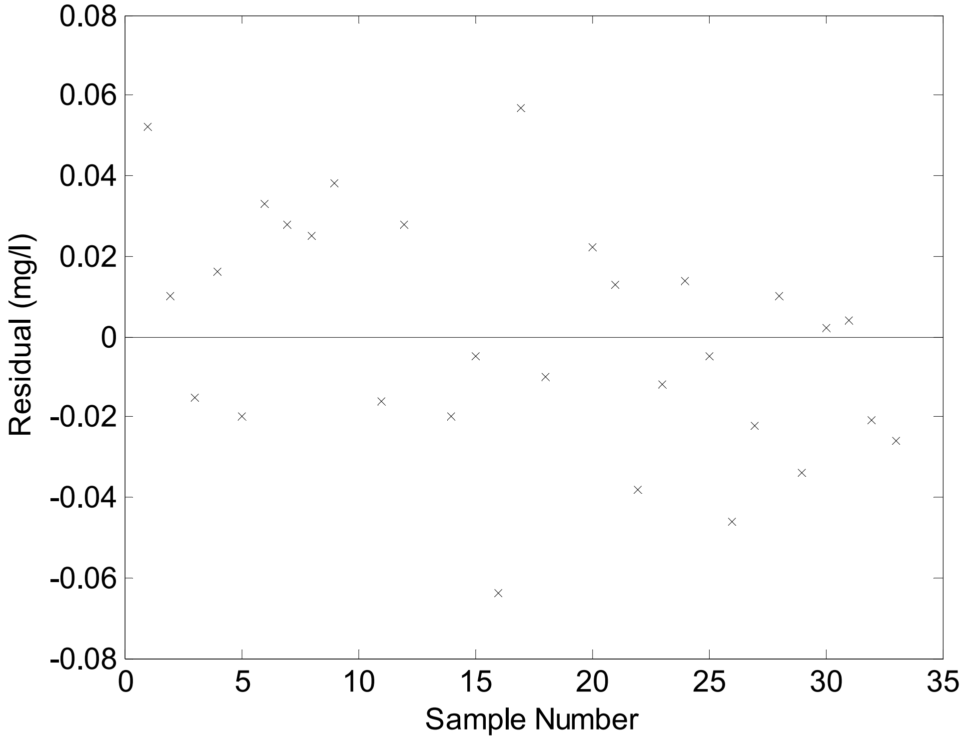


Figure 4.2 Dissolved oxygen residuals (bottle minus corrected sensor oxygen) against sample number.

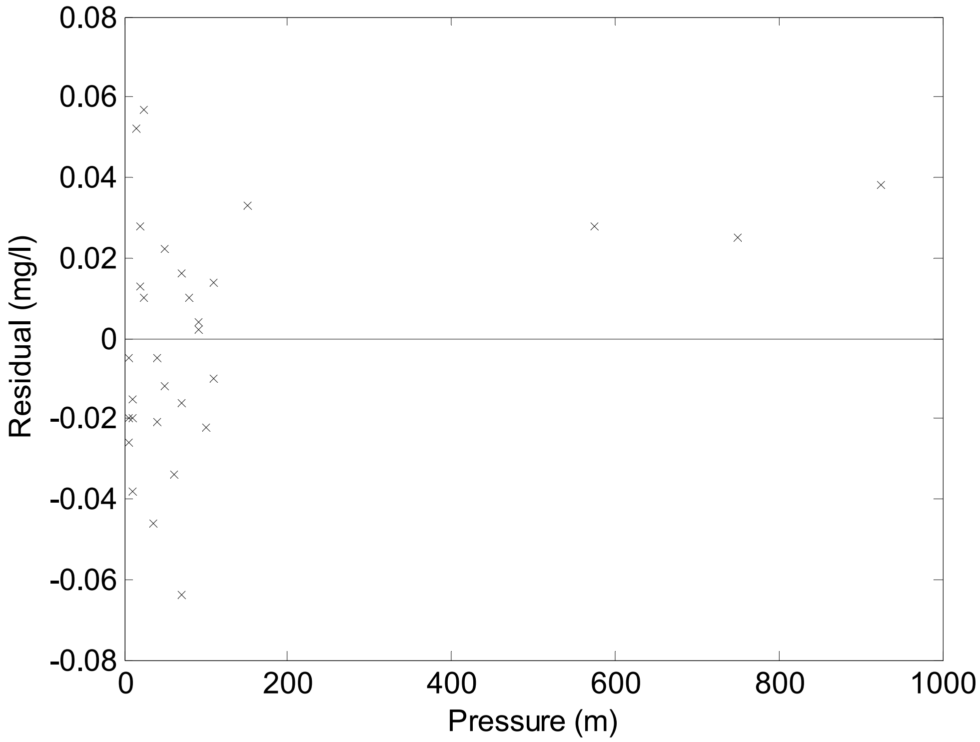


Figure 4.3. Dissolved oxygen residuals (bottle minus corrected sensor oxygen) against depth(m).

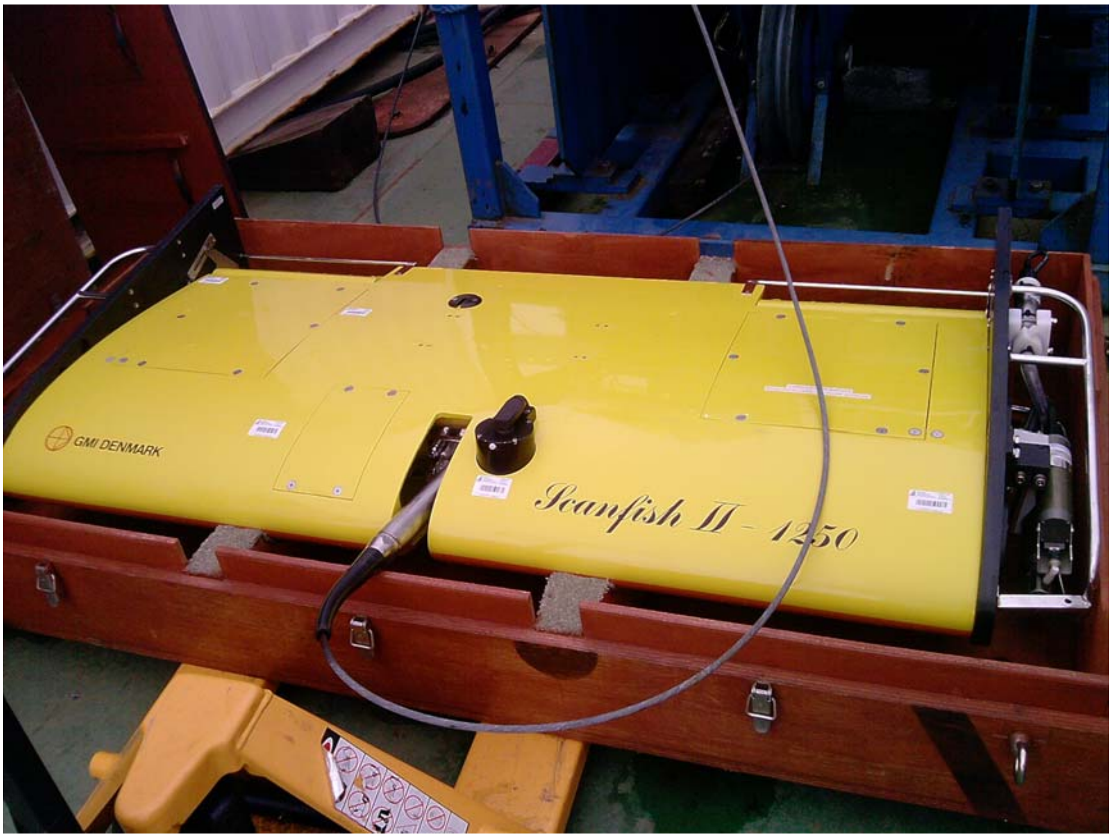
Date	Event	Sample Depths (m)
26/06/2009	CTD087	15, 80
26/06/2009	CTD088	10, 70
26/06/2009	CTD089	5, 150, 575, 750, 925
27/06/2009	CTD091	10, 40, 70
28/06/2009	CTD092	25, 110
28/06/2009	CTD094	5,20,70,110
29/06/2009	CTD095	20, 50, 120
30/06/2009	CTD096	10, 50, 110
30/06/2009	CTD097	5, 35, 100
01/07/2009	CTD100	25, 60, 90
02/07/2009	CTD101	5, 40, 90

Table 4.1. Station and sample depths for dissolved oxygen calibration samples.

5 Scanfish Processing

Dr Dmitry Aleynik , SAMS

5.1 Introduction



Scanfish CTD data were obtained from the Seabird 911 CTD unit and a Chelsea Instruments Aquatraka II Fluorometer. The temperature and fluorescence sensors were sited on right side of the Scanfish body and the conductivity cell was in-board. The specification details of the Scanfish are given in the manual technical report, this section describes data processing. All profiles were processed by the end of the cruise using SBE Data Processing Version 3.57e software and the batch ".psa" scripts recently adapted to the cruise conditions. The original CTD data were 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.

5.2 Processing

Raw Scanfish CTD data were processed following standard way used in hydrographic cruises. After each series of tow-yo of Scanfish CTD casts were completed the data were saved to the deck unit PC and transferred over the ship network to the Unix data disk. The Seabird logging software (SeasaveV7) writes 3 files per each series of tow-yo: *"D340_scf_station_name*" with the following extensions: .*HEX* (raw data file), .*CON* (data configuration file), and .*HDR* (a header file). SBE Seasave Win32 V 5.37e software was used to perform all processing steps. Processed data were loaded into Matlab R2007a for plotting.

Instrument type: 911plus/917 plus CTD. Calibration parameters from .CON files for each sensor are in the **Tables.5-5.4**

Table.5.1. Temperature Sensor calibration parameters

Sensor ID	**55**
SB_ConfigCTD_FileVersion	**7.18.0.0**
SerialNumber	**4137**
CalibrationDate	**01/05/08**
UseG_J	**1**
A	**0.00000000e+000**
B	**0.00000000e+000**
C	**0.00000000e+000**
D	**0.00000000e+000**
F0_Old	**0.000**
G	**4.39961690e-003**
H	**6.49957646e-004**
I	**2.34787962e-005**
J	**2.10053145e-006**
F0	**1000.000**
Slope	**1.00000000**
Offset	**0.0000**

Table.5.2. Pressure Sensor calibration parameters

Sensor ID	**45**
SB_ConfigCTD_FileVersion	**7.18.0.0**
SerialNumber	**44933**
CalibrationDate	**06-14-1991**
C1	**-2.488575e+004**
C2	**2.188450e-001**
C3	**6.713940e-003**
D1	**3.742900e-002**
D2	**0.000000e+000**
T1	**3.041345e+001**
T2	**-1.138620e-004**
T3	**4.058200e-006**

T4	**1.686970e-009**
Slope	**1.00000000**
Offset	**0.84000**
T5	**0.000000e+000**
AD590M	**1.288659e-002**
AD590B	**-8.925773e+000**

Table.5.3. Conductivity Sensor calibration parameters

Sensor ID	**3**
SB_ConfigCTD_FileVersion	**7.18.0.0**
SerialNumber	**2801**
CalibrationDate	**09/05/08**
UseG_J	**1**
SeriesR	**0.0000**
CellConst	**2000.0000**
Coefficients equation	**"0"**
A	**0.00000000e+000**
B	**0.00000000e+000**
C	**0.00000000e+000**
D	**0.00000000e+000**
M	**0.0**
CPcor	**0.00000000e+000**
Coefficients equation	**"1"**
G	**-9.74220744e+000**
H	**1.45503800e+000**
I	**-1.38526959e-003**
J	**1.75466421e-004**
CPcor	**-9.57000000e-008**
CTcor	**3.2500e-006**
Coefficients	
Slope	**1.00000000**
Offset	**0.00000**

Table.5.4. Fluorometer ChelseaAqua3 Sensor calibration parameters

Sensor ID	**5**
SB_ConfigCTD_FileVersion	**7.18.0.0**
SerialNumber	**088126**
CalibrationDate	**2 Jan 2007**
VB	**0.257700**
V1	**2.140400**
Vacetone	**0.300700**
ScaleFactor	**1.000000**
Slope	**1.000000**
Offset	**0.000000**

Scanfish Seabird Data processing routine descriptions

The list of routines applied to the raw Scanfish CTD data is in the file *c:\D340\D340_scanfish\psa_files\D340_scan_v1b.txt* which was invoked by program *sbebatch* within the script files, prepared for each Scanfish transects respectively:

- *D340_batch_L1.bat* for SB-E (from the Shelf Break toward station E, between Tiree and Barra)
- *D340_batch_L2.bat* for M1-B1 (*Mingulay and Banana Reefs* repeat circuit survey)
- *D340_batch_L3.bat* for WE-CC (*Station W* south west of Barra Head towards *Station E* and the *Cairns of Coll*)

DatCnv: converted raw CTD data in the .dat file from engineering units using the calibration information provided in the configuration file (.CON). Files output consisted of binary .CNVfiles containing the 24hz down and up casts.

FilterFilter runs a low-pass filter on each column of data. A low-pass filter smoothes high frequency (rapidly changing) data. To produce zero phase (no time shift), the filter is first run forward through the data and then run backward through the data. This removes any delays caused by the filter. The pressure channel was filtered with a time constant of 0.5 seconds.

AlignCTD: usually used to shift the dissolved oxygen sensor output (if it presents) relative to the pressure data by 5 seconds to compensate for lags in the sensor response time. This routine was not applied to Scanfish CTD oxygen in D340 cruise because the oxygen sensor was not installed. But the shifts equal 0.5 seconds were applied to the temperature and Conductivity sensors output, due to the fast horizontal movement of the instrument during tow-yo with the average speed 8 knots (~ 4.1 m/s).

CellTM: removes the effect of thermal 'inertia' on the conductivity cells using the algorithm:

a = 2 * alpha / (sample interval * beta + 2)

b = 1 - (2 * a / alpha)

dc/dt = 0.1 * (1 + 0.006 * [temperature - 20])

dt = temperature - previous temperature

ctm [S/m] = -1.0 * b * previous ctm + a * (dc/dt) * dt

The sample interval is measured in seconds and temperature in °C, and ctm is calculated in S/m. The thermal anomaly amplitude (alpha), was set at 0.03 and the thermal anomaly time constant (1/beta) was set at 7 (the SeaBird recommended values for SBE911). The sample interval is 1/24 second, dt is the temperature (t) difference taken at a lag of 7 sample intervals, ctm is the corrected conductivity at the current data cycle.

Corrected conductivity = c + ctm

Bin average averages data, using averaging intervals based on pressure, depth, time or scan number. In the D340 cruise we used pressure with 1m bin size for both up- and downcasts.

Derive subroutine were used for calculation of depth (m), potential temperature (ITS-90), salinity (PSU) and Specific Volume Anomaly (1o^-8 m^3/Kg)

AsciiOut: converts the binary .cnv files into ASCII format .cnv and ascii files for reading into other packages, for example Matlab in the same format as was used in several previous cruises for data-post processing.

Time series of EA500 Echo-Sounder data, provided by Christopher Bernard , were aligned with the ship GPS navigation data to produce the bottom relief profiles during the scan-fish tow-yo transects.

Scanfish ASCII data post-processing.

In Second part of D340 cruise Scanfish was generally ‘flown’ at a tow speed of 8.0 knots, from 1-5 m below the surface to the depth 100-110 m in the deeper areas and within 10 m above the sea bed in the shallower parts of the transects. Cycling every 2 minutes this gives an effective horizontal resolution of approximately 400 m. 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=2m and a search radius defined by sx=300/86400seconds and sz=4m. and / or
b) distance along longitude/latitude weighting, with Δx=470 m (443) m, Δz=2m and a search radius defined by sx=3*Δx and sz=4m.

For post-processing of the Scanfish data several Matlab scripts, stored in the folder *c:\D340\D340_scanfish\code*, were modified.

5.3 Results from the Shelf Break – Exact Line (SB-E)

(Figures. 5.1-5.3)

The SB-E transect was fulfilled between the 26th June 16:44 GMT and the 27th June 2009 02:20, along latitude 56º 38’N from 9º18’W with depth around 1100 m and finish on 7º 06’W (*Fig. 5.1*) with depth 127 m. The line was approximately perpendicular to the Shelf Break isobaths. In the first half of the Scanfish transect the sea bottom is flattened with the characteristic depth just a few meters above 150. In the centre of our transect across the rise – the underwater extension of the Barra Head - with depths 100 and even shallower 50m, which abruptly falls to 240 m on the Sea of Hebrides. In the eastern and central parts of this transect low saline waters (34.5-34.8 psu) were dominated in the upper layers of the water column, and these freshened waters were extended to the bottom over the rise. The colder waters (12-13ºC) were exposed to the surface over the both topographic obstacles – Shelf Break and over the underwater Barra Head extension. The thickness of pycnocline was much narrower over the Shelf Break and extended to the bottom over the underwater rise (*Fig. 5.2*).

The calculated anomalies of the vertical position of isopycnal surface σ_θ =26.8 kg m^3 related to its depth, averaged along the whole transect, revealed the oscillations with horizontal scale about 30 km (*Fig. 5.3*).

The maximums in the vertical distribution of the signal from Fluorometer were observed above the Shelf Break and in the eastern edge of the transect SB-E, while over the rise the signal from Fluorometer was low and close to the background values. In addition to the last need to be mentioned that the SB-E transect went over the rise at near mid-night time.

Results from the Mingulay – Banana reefs survey (M1-B1)

(Figures. 5.4-5.7)

This survey was fulfilled from the 28th June, 22:41 until the 29th June 11:32 in the series of clockwise circulations over Mingulay – Banana reefs. The whole data set was spited on two lines North-western and South-eastern. The data for each leg were gridded separately against the time, and the southern legs are shown in a reverse order for representing the data in same geographical orientation as the northern legs *(Fig. 5.4-5.7).* Most interesting feature was observed on the northern legs in the direction from the south-west toward the north-east. There were observed a sample of development and decay of irregularity in potential density field, as well as in salinity and temperature, located exactly over the underwater rock at depths between 20 and 80 m. The whole observed process occupied about 7 hours from 01:15 until 8:10.

5.4 Results from the transect West –East of Barra Head toward Cairns of Coll (WE-CC)

(Figure. 5.8)

This Scanfish transect was carried out between the 30th June 22:06 and the 1st July at 05:57 from the station W (56º 38'N, 8º 11'W) South West of the Barra Head, continued over the underwater rise toward the station E on its North-eastern edge and extended further East over the deep basin and finished at station CC (56º 42.7'N 6º 34'W). The Eastern part of the transect were filled with freshened shelf waters with salinity lower 34.3 psu at the surface and 34.7 psu near the bottom at the depths 60-80 m. The tongue of waters with lower salinity at depths 20-30 m was observed at the central part of deep basin. Waters with lower salinity (34.8 psu) were found over the underwater rise in the upper 20 m, which could be explained as the southern branch of the coastal current, which could deliver fresh shelf waters toward the open sea. The presence of such recirculation current was previously reported from the drifters data traced in the entrance to the Minch in the April - June 1995 [*Hill, et al. 1997;* Supplementary Figure 6 in *Hill, et al. 2008]*

The vertical distribution of the temperature shows the presence of cold waters (13ºC) on the eastern part of the transect WE-CC and the warm patches (15-16 ºC) in the western and central parts the upper layer (0-15 m). On the plot of the vertical distribution of density filed we can see a series of contractions and expansion of isopycnals, which emphasizes the presence of internal waves. These waves were in the intensive interaction with the steep and complex bottom topography of the area: at least three troughs and ridges are clear visible on the western part of the WE-CC transect.

5.5 Results from the transect from Barra Head toward South Stanton (BH-SS)

(Figure. 5.9)

The last Scanfish transect form Barra Head toward South Stanton (BH-SS) was fulfilled on the 3rd July 2009 from 05:50 until 11:54 in the southward direction from 56º 37.27'N, 7º 44.86' W to 55º 53.48'N, 7º 55.90'W. The disturbances in the vertical distribution of temperature, salinity, density and fluorescence are associated here with the interaction of residual currents flow, tidal circulation and rough topography of the area. The higher signal of Fluorescence in the surface layer were observed above the underwater rises (with depths 60-80 m) in the central part of the transect BH-SS. There were observed also the lower temperature values (13 ºC) near the surface, which were in the contrast to 14 ºC and 15 ºC at the surface in the northern and southern parts of the transect. Fresh, low saline (34.9 psu) waters were observed at both northern and southern parts of transect, while the central part were filled with the waters of higher salinity (>35.3 psu).

References

Hill, A.E., Horsburgh, K.J., Garvine, R.W., Gillibrand, P.A., Slesser, W.R. and R.D. Adams. Observations of a density-driven recirculation of the Scottish Coastal Current in the Minch. Estuarine, Coastal and Shelf Science 45(1997) 473 - 484.

Hill, A. E., J. Brown, L. Fernand, J. Holt, K. J. Horsburgh, R. Proctor, R. Raine, and W. R. Turrell (2008), Thermohaline circulation of shallow tidal seas, *Geophys. Res. Lett.*, 35, L11605, doi:10.1029/2008GL033459

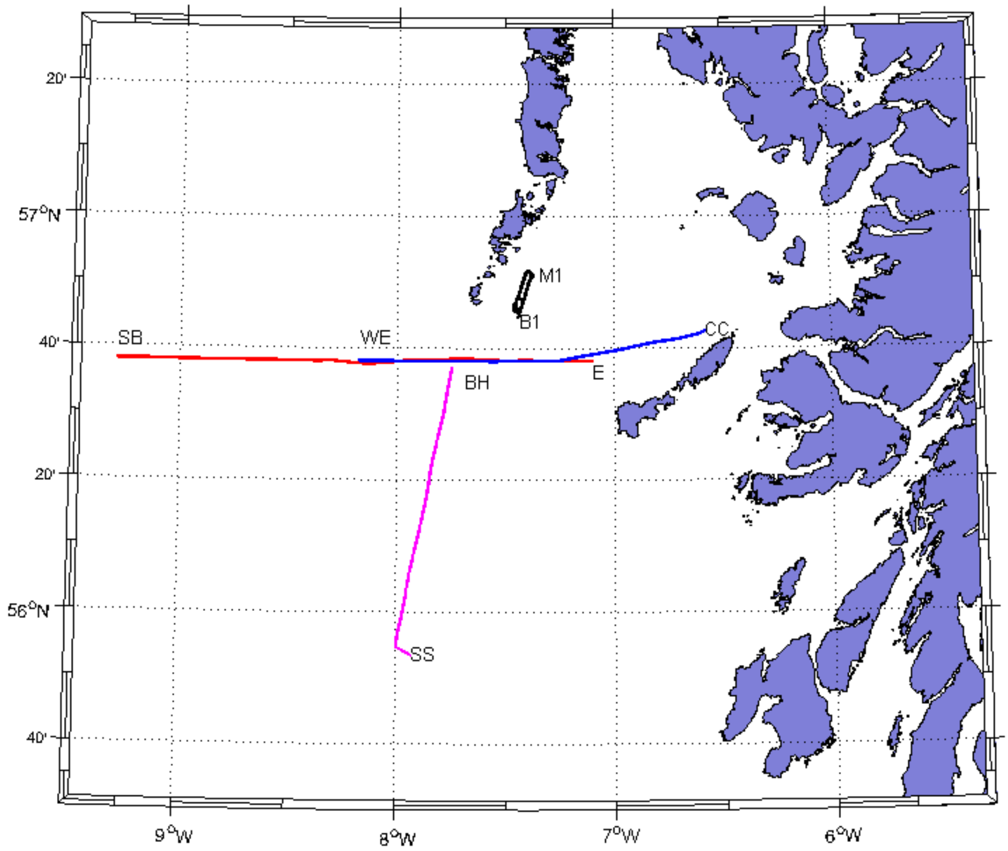


Figure 5.1.

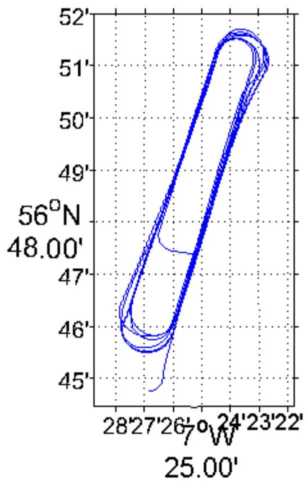
Position of the Scanfish surveys:

1. Transect form Shelf Break to station E (SB-E),

2. Mingulay – Banana reefs survey (M1-B1), right →

3. Transect West of Barra Head toward Cairns of Coll (WE-CC), expanded view is on the right

4. Transect from Barra Head toward South Stanton (BH-SS)



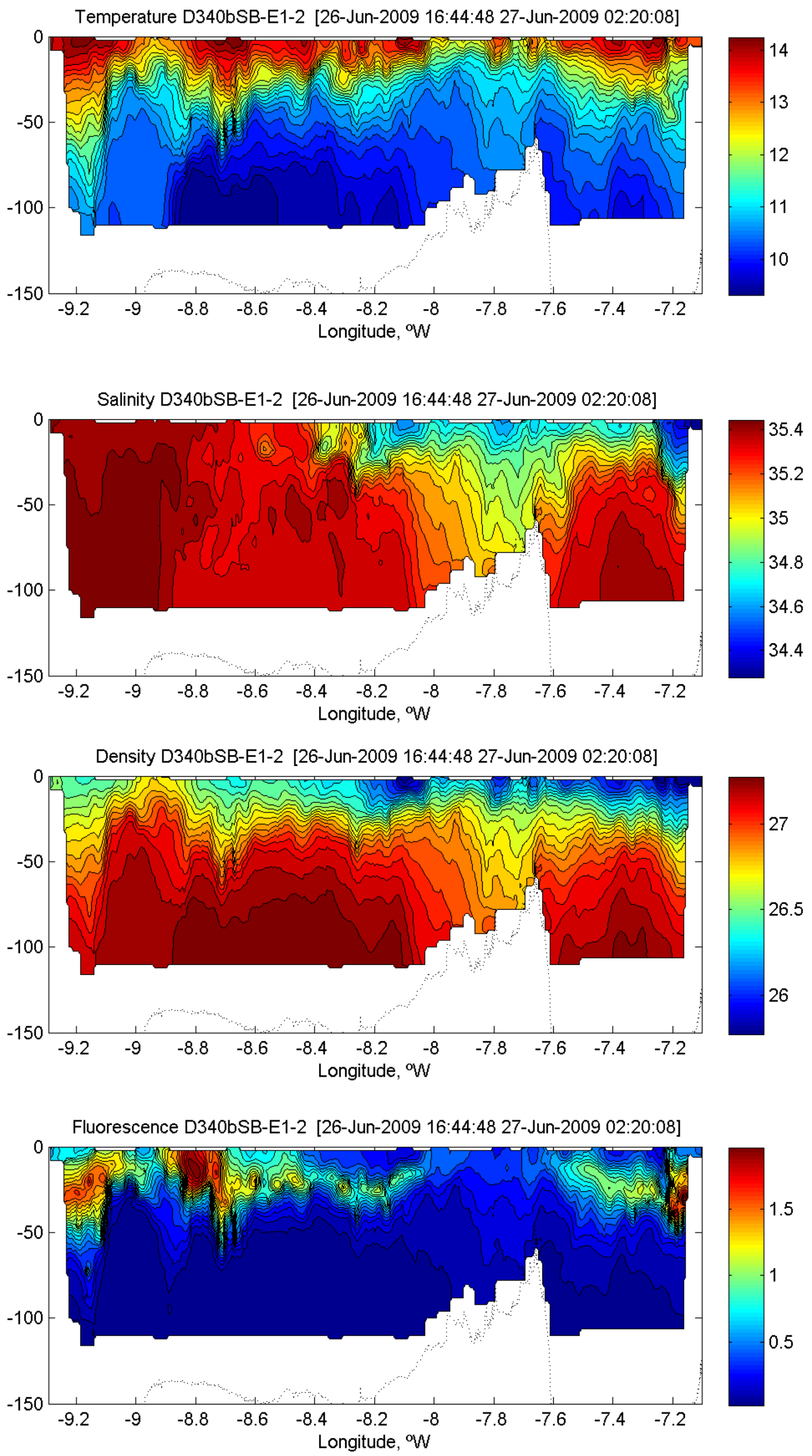


Figure 5.2. Vertical distribution of temperature, salinity, potential density and Fluorescence along the Scanfish transect form Shelf Break to station E (SB-E). Bathymetry is shown by blue dots.

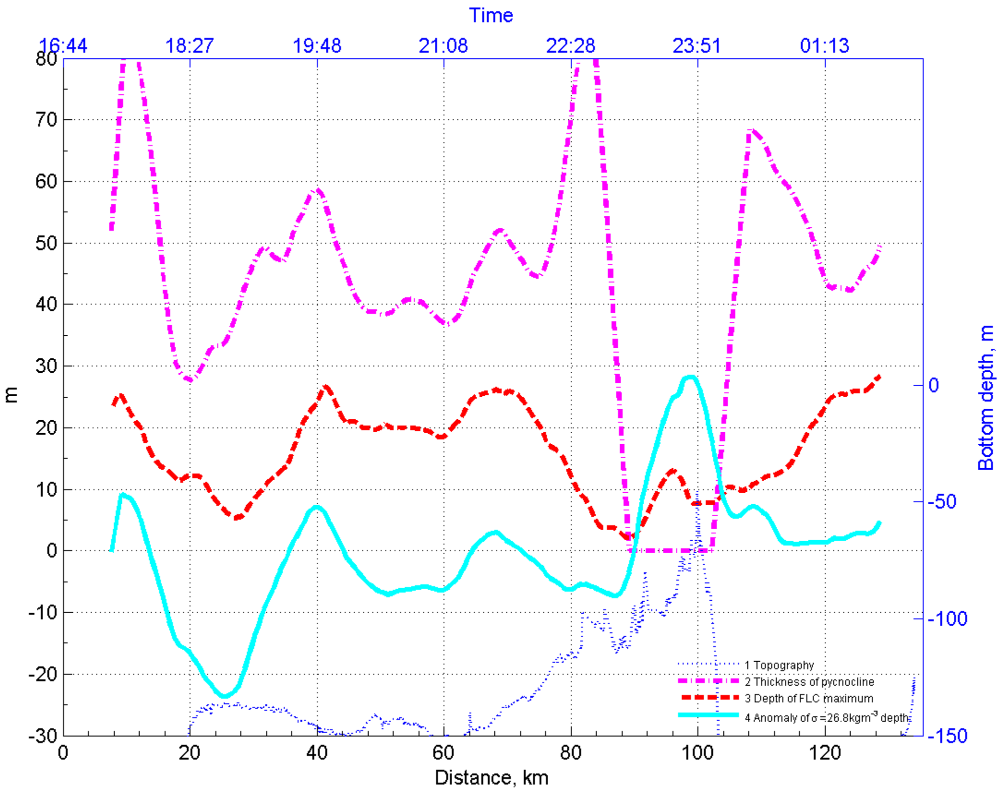


Figure 5.3. Bathymetry from Shelf Break to station E (blue). The thickness of pycnocline between 26.1 and 27.1 kg m^{-3}, (red). Depth of maximum fluorescence (magenta). Depth anomaly of σ_θ =26.8 kg m^{-3} relative to section mean (cyan).

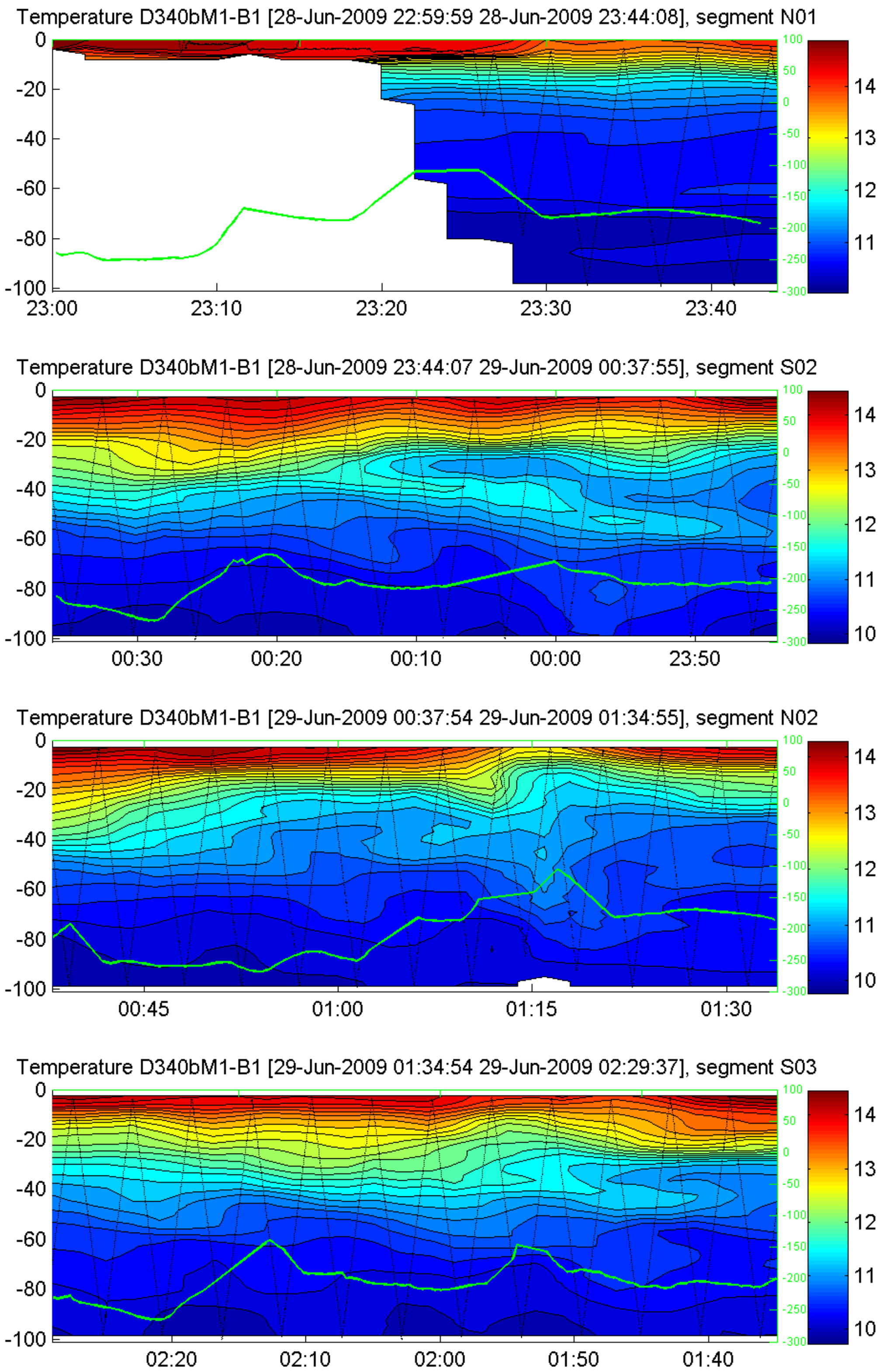


Figure 5.4a. Vertical distribution of temperature along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

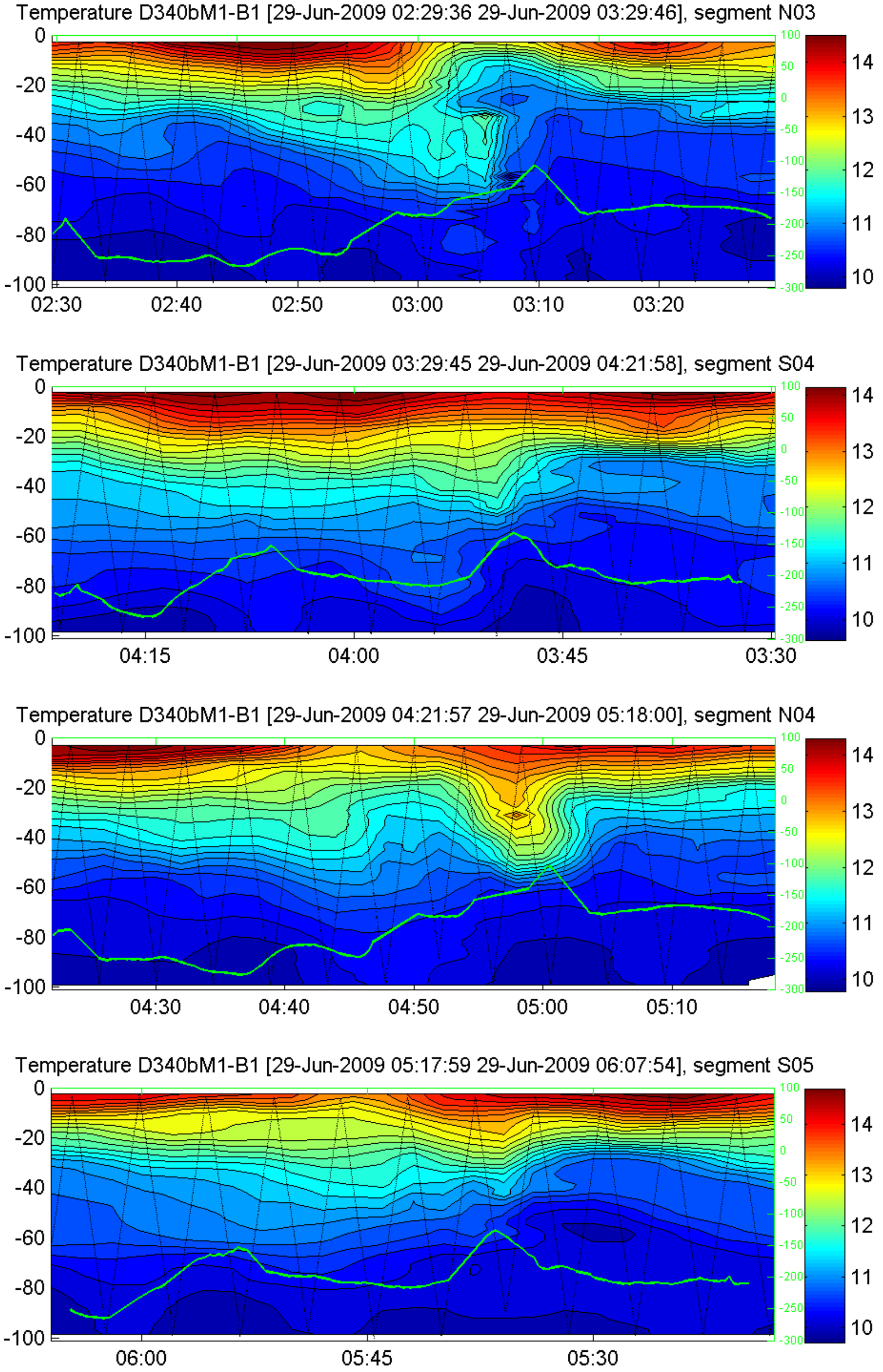


Figure 5.4b.Vertical distribution of temperature along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

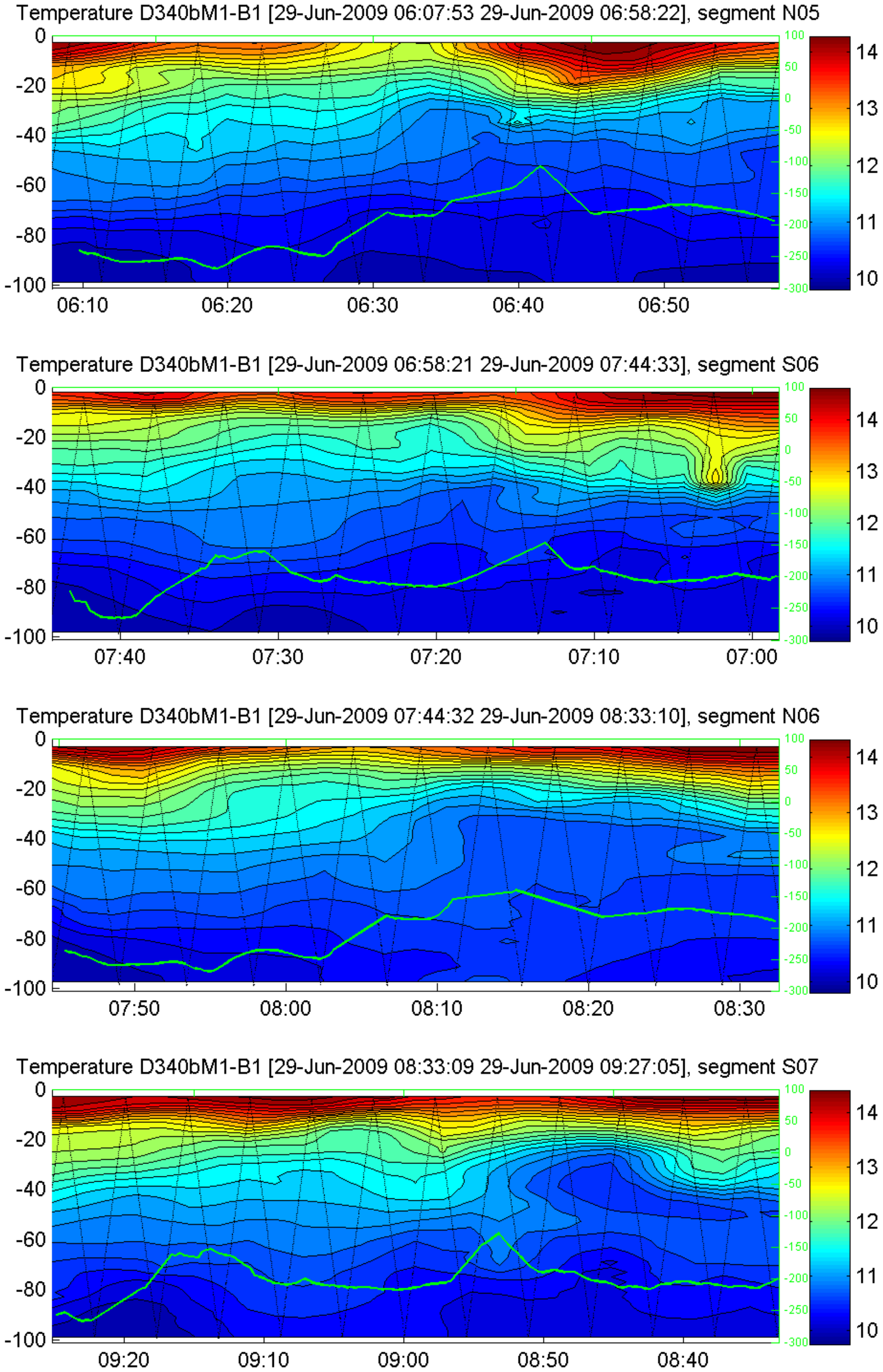


Figure 5.4c.Vertical distribution of temperature along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

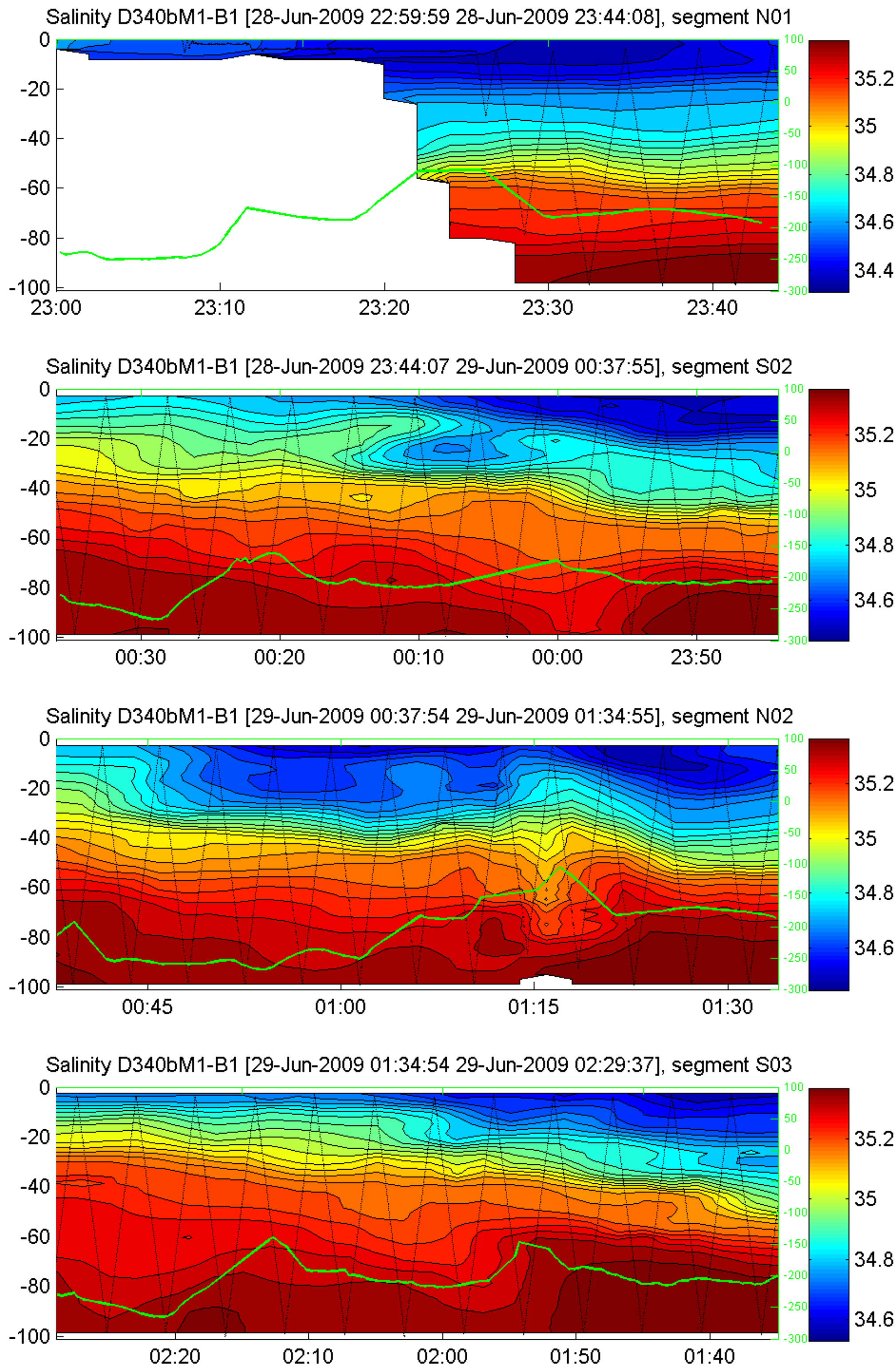


Figure 5.5a. Vertical distribution of salinity along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

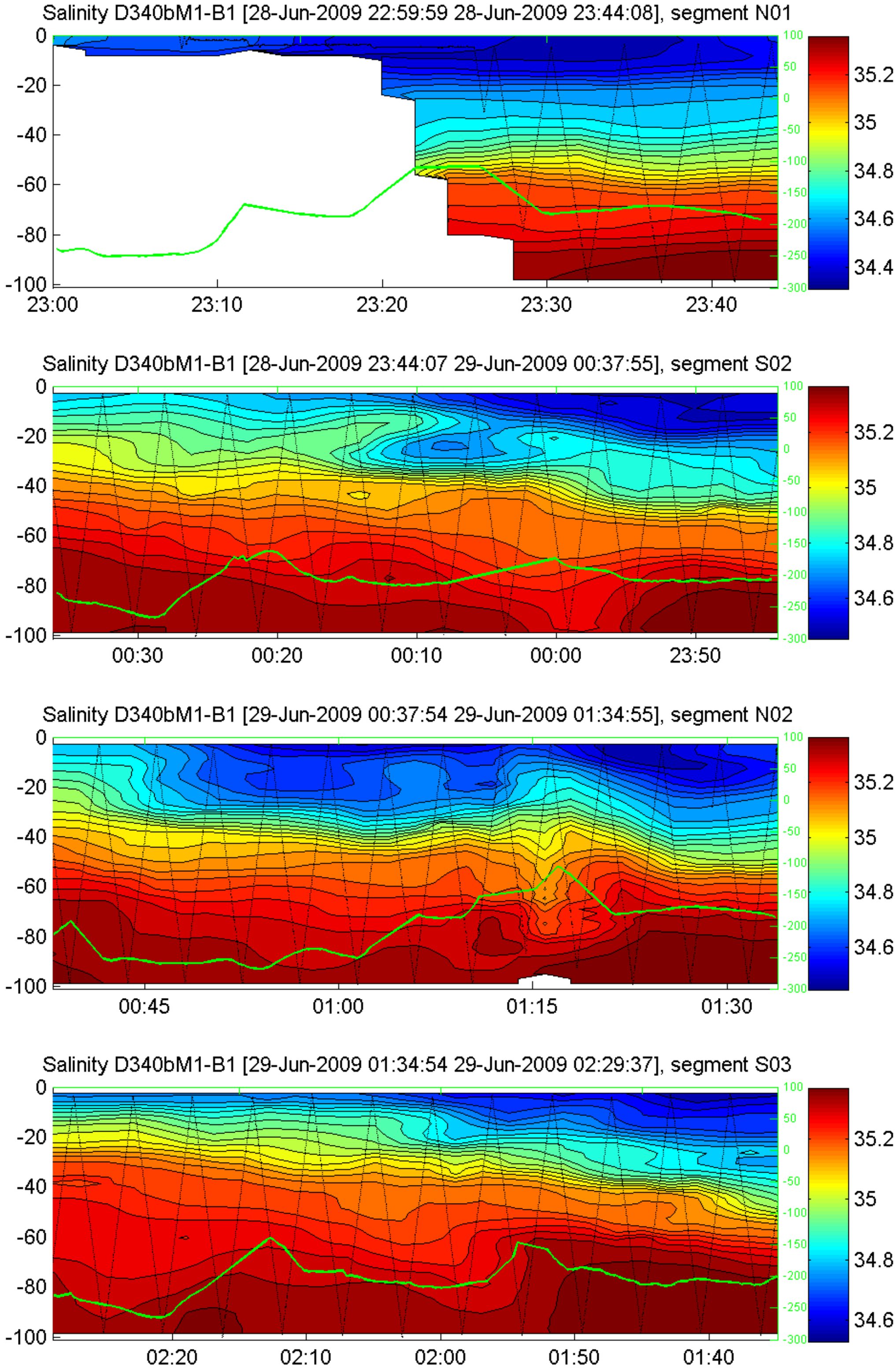


Figure 5.5b. Vertical distribution of salinity along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

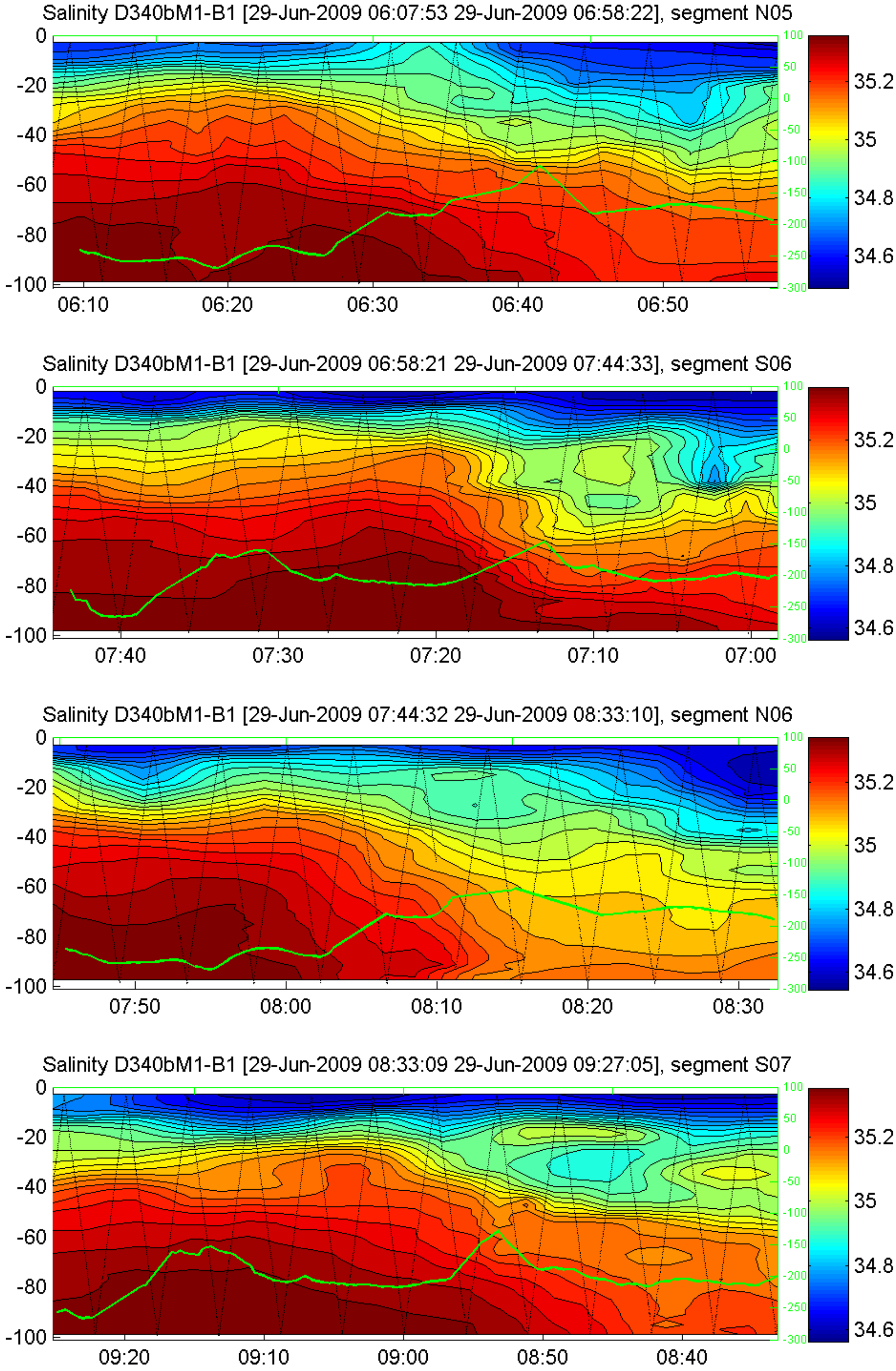


Figure 5.5c. Vertical distribution of salinity along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

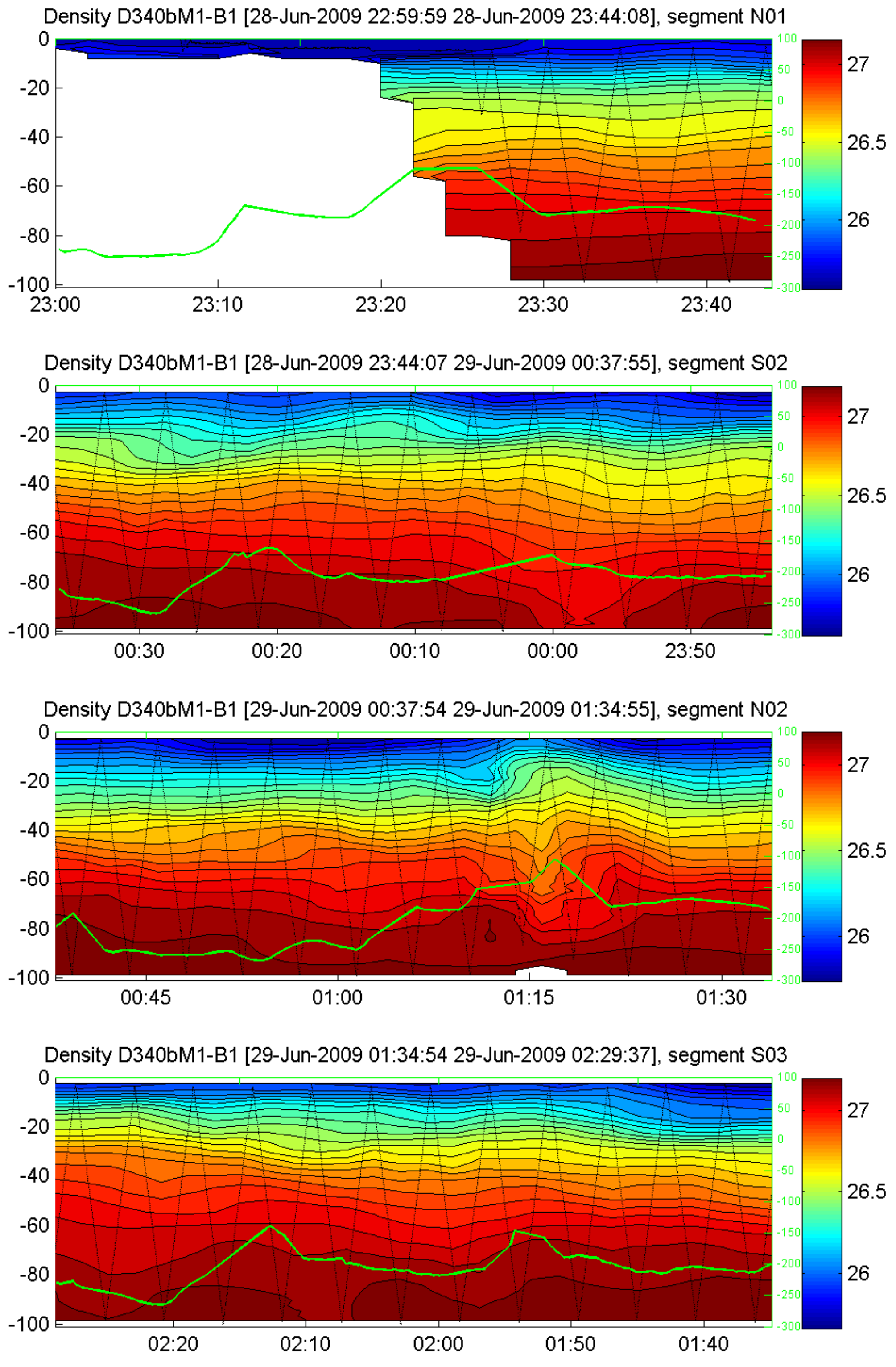


Figure 5.6a. Vertical distribution of potential density and Fluorescence along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

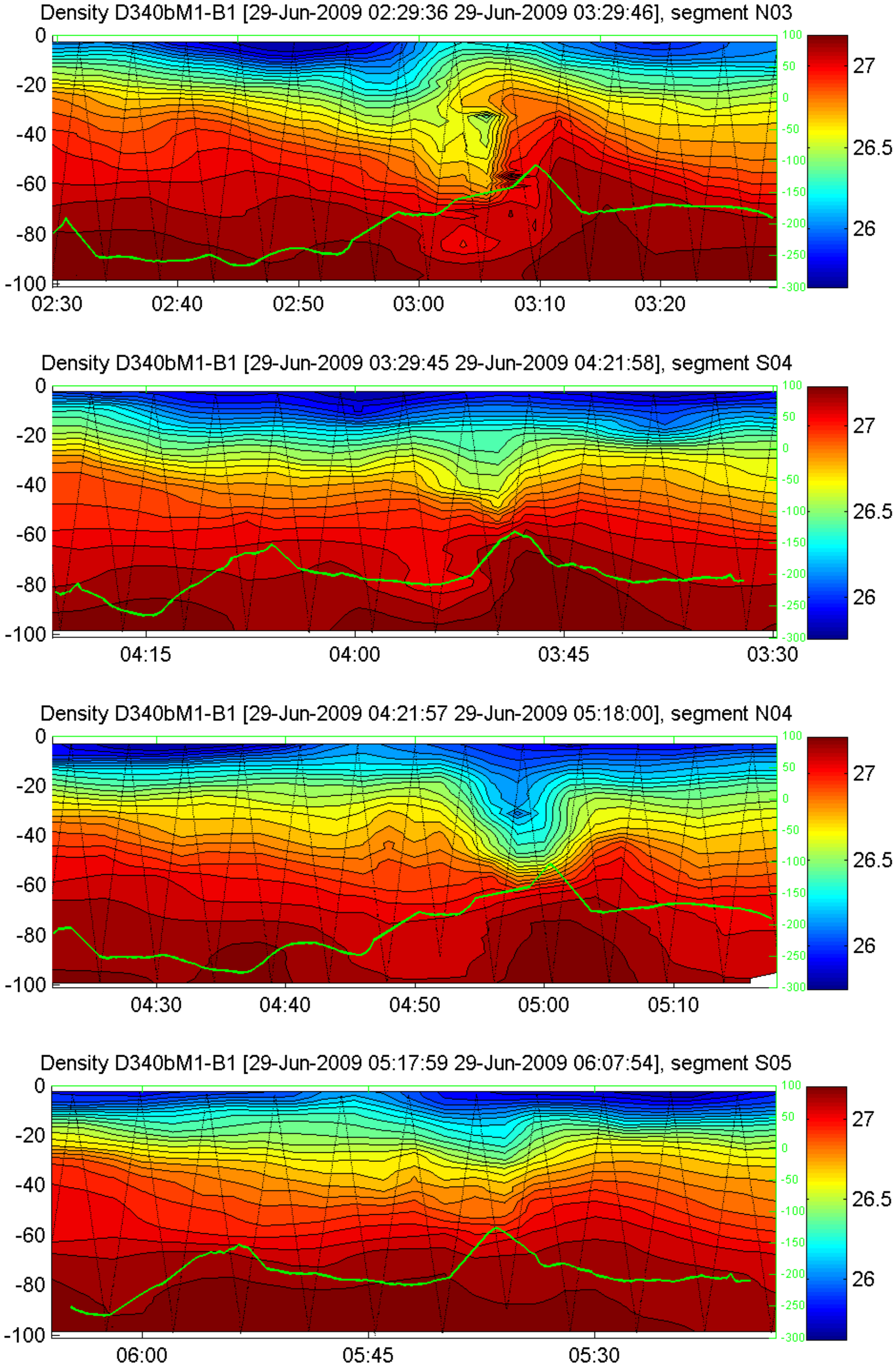


Figure 5.6b.Vertical distribution of potential density and Fluorescence along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

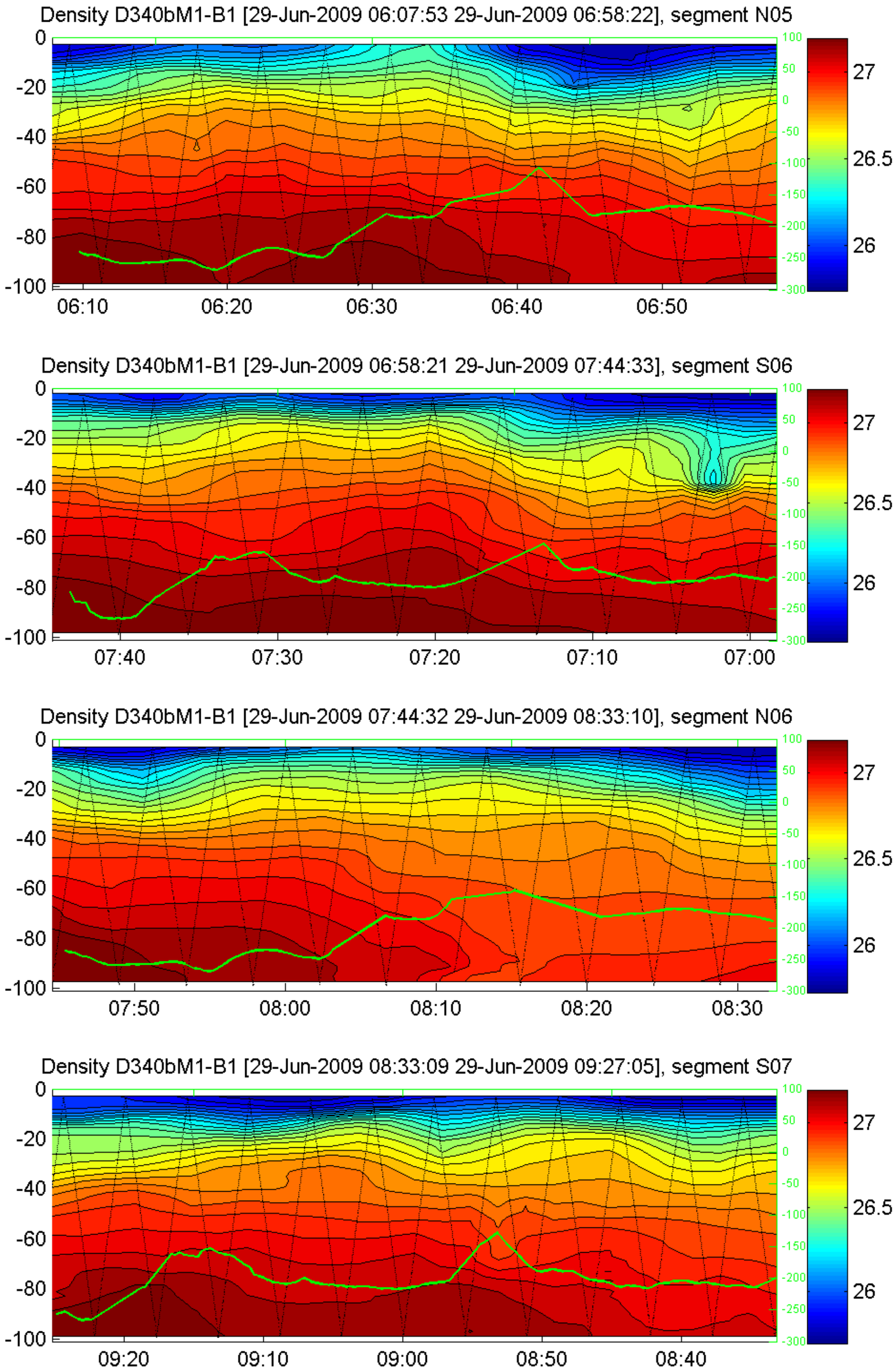


Figure 5.6c. Vertical distribution of potential density and Fluorescence along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

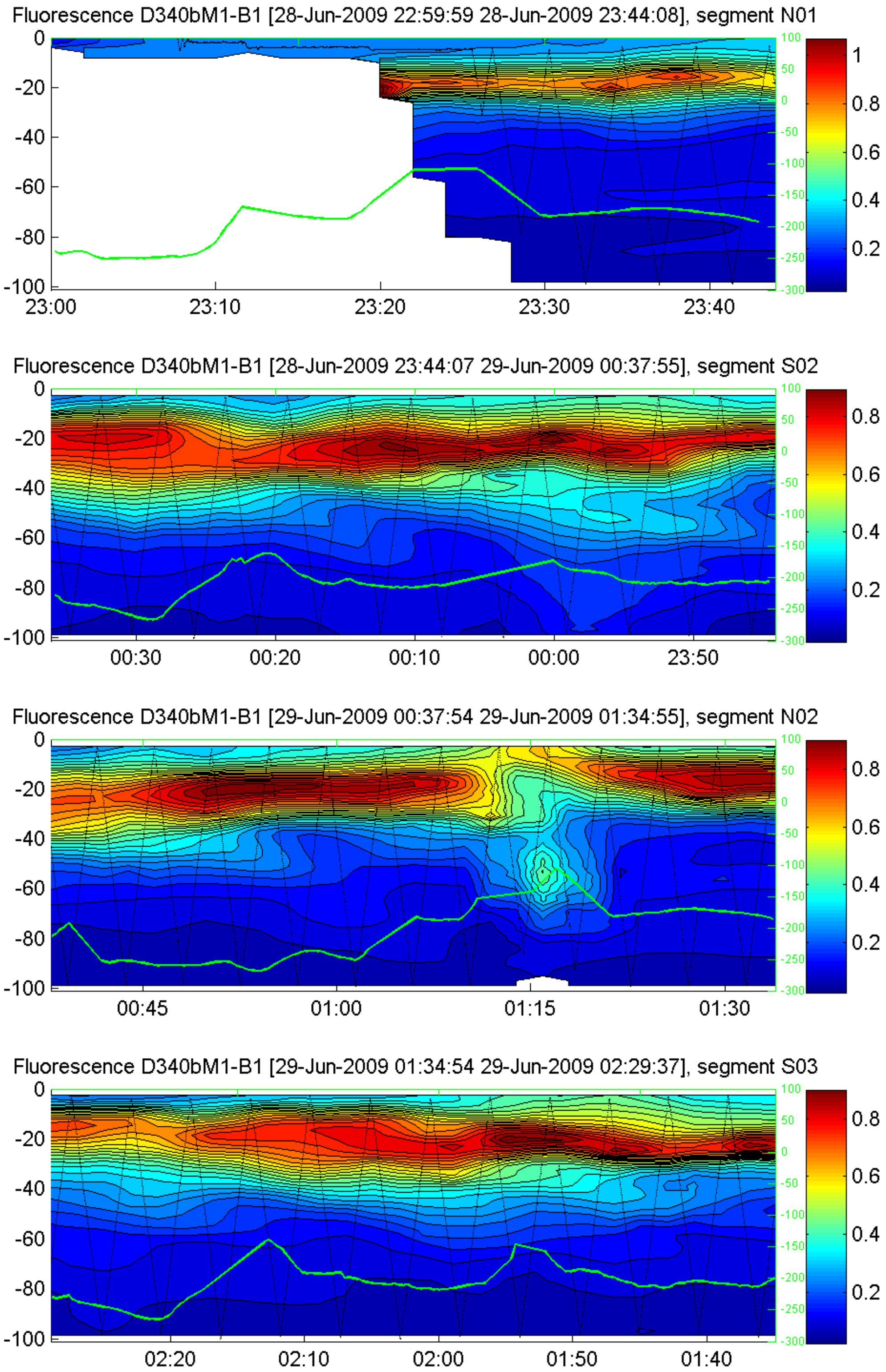


Figure 5.7a. Vertical distribution of Fluorescence along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

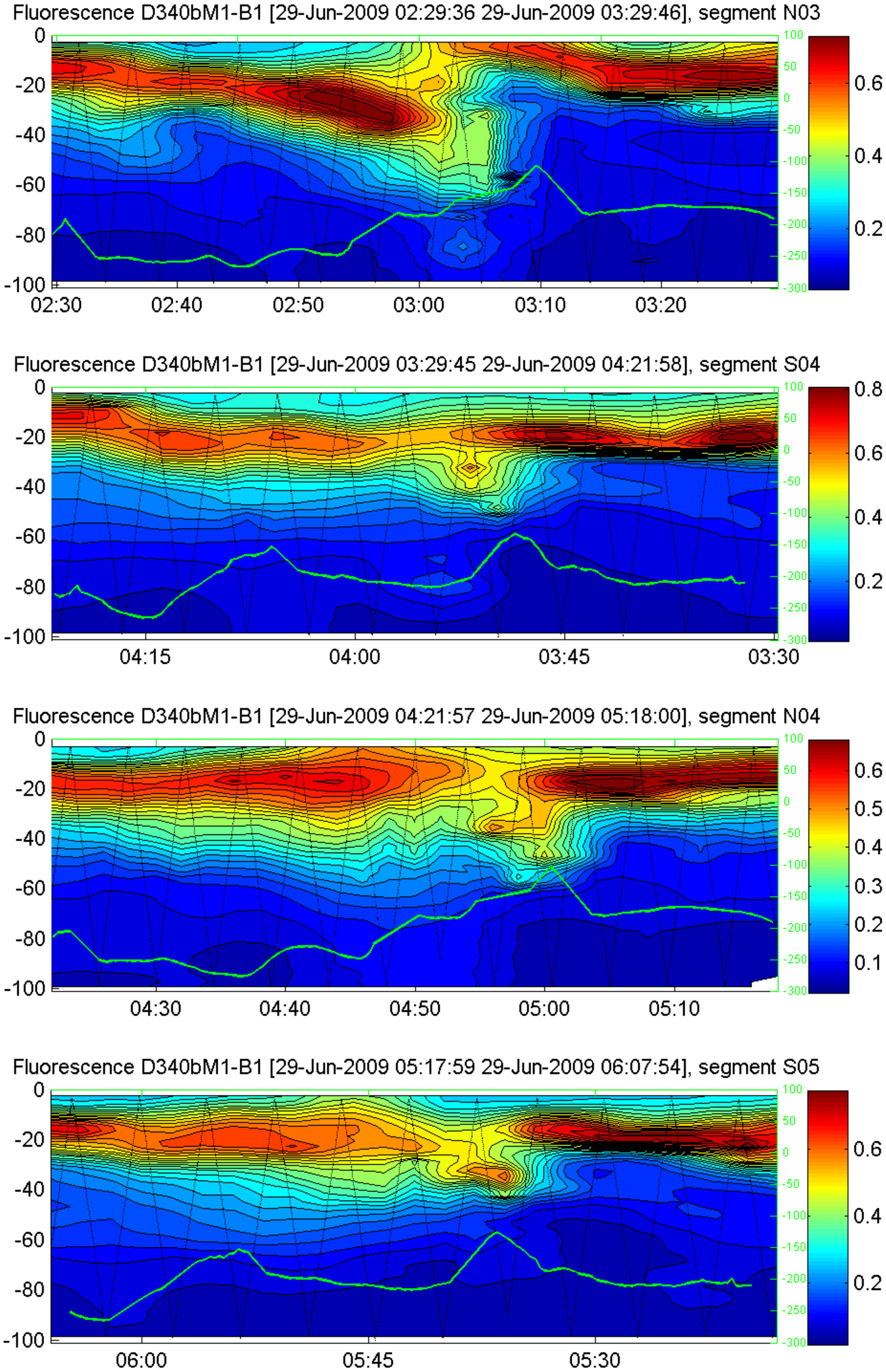


Figure 5.7b. Vertical distribution of Fluorescence along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

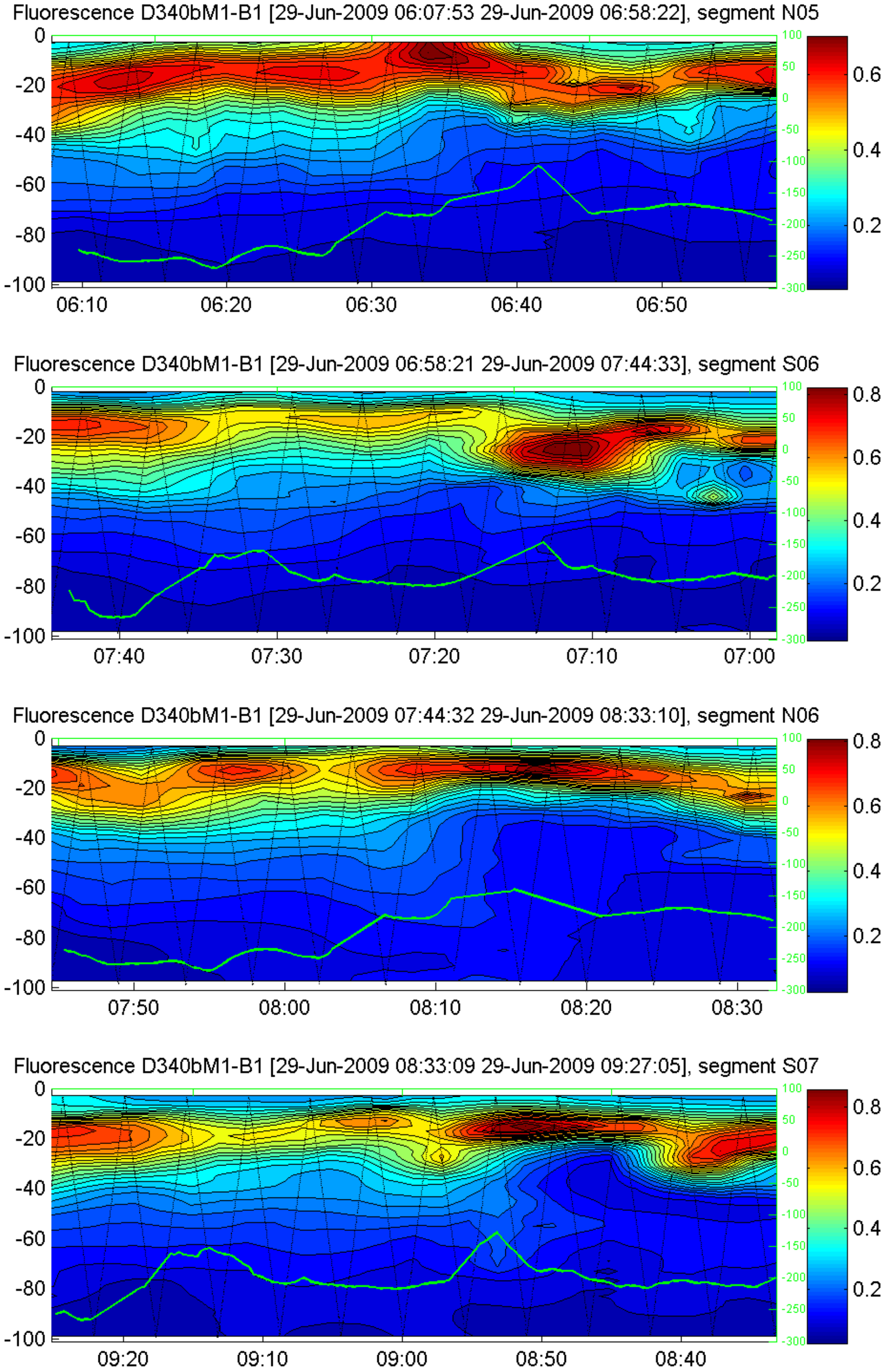


Figure 5.7c. Vertical distribution of Fluorescence along the Scanfish transects form Mingulay – Banana reefs survey (M1-B1). Bathymetry is shown by green line.

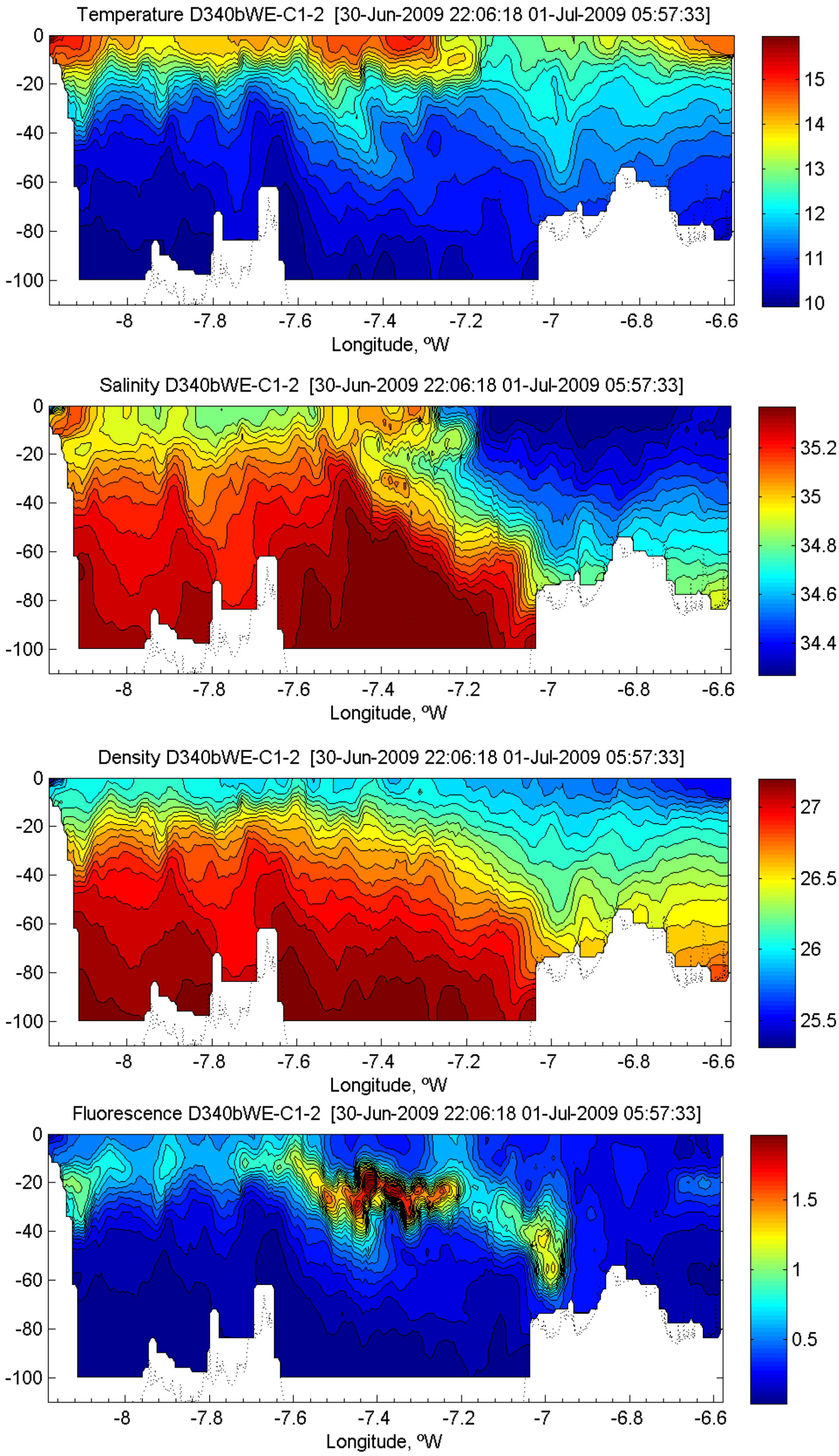


Figure 5.8.Vertical distribution of temperature, salinity, potential density and Fluorescence along the Scanfish transect form West of Barra Head toward Cairns of Coll (WE-CC). Bathymetry is shown by blue dots.

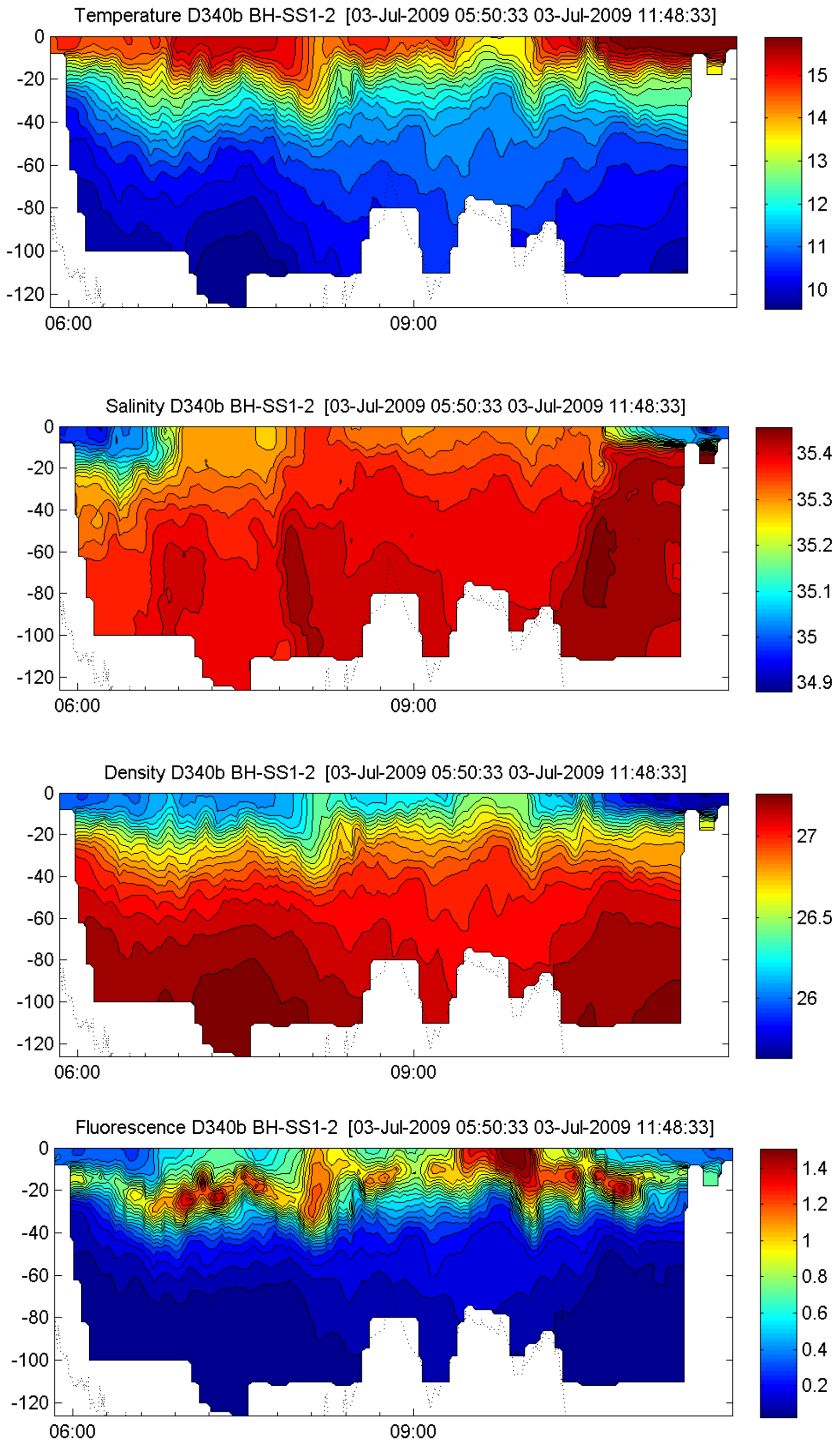


Figure 5.9. Vertical distribution of temperature, salinity, potential density and Fluorescence along the Scanfish transect form Barra Head toward South Stanton (BH-SS). Bathymetry is shown by blue dots.

6 MSS90 Microstructure Profiler

Emily Venables and Mark Inall

6.1 Introduction

A Sea and Sun Technology shear and temperature microstructure profiler was deployed in yo-yo mode for 25 hours at two stations; BH and W. BH was revisited for a second period of 12.5 hours resulting in a grand total of 542 profiles during the cruise. The instrument used was an MSS90 shallow water profiler, serial number 034. The MSS90 measures velocity shear, temperature (fast response, and slow response), conductivity, pressure and package acceleration, all at 417Hz. The shear microstructure measurements provide an estimate of the turbulence kinetic energy dissipation within the water column. We deployed the MSS90 from a gunnel-mounted self-contained electric winch mounted on the starboard quarter (Figure 6.1). One thousand meters of neutrally buoyant Kevlar cored conducting cable was on the winch. The profiler was deployed to a maximum depth of 142m at station W. Profiling at ~0.8 m/s the MSS was allowed to impact the seabed on each profile, providing measurements to with 4cm of the seabed.

Figure 6.1: John and Vladimir operate the winch at the starboard stern quarter

Allowing the profiler to impact the seabed, however, did increase the chances of damaged probes, and on profile 0493 the shear sensors were broken. This was not noticed until 5 profiles later when the instrument was brought onboard to turn the ship. After that a live display of shear was set up on the acquisition computer to ensure that no more data were lost. Sensors were replaced with spares, and all went well until the penultimate profile of the cruise, when a third sensor broke.

6.2 Sensor Configuration: MSS90 SN034

Fast Response Temperature: Thermometrics FP07

Pressure: Keller PA8-50

Temperature: ISW Pt100

Conductivity: ADM 7polig

Acceleration: ADXL203

Casts 0001:0492:

Shear 1: ISW PNS02 SN: D050

Shear 2: ISW PNS02 SN: D051

Casts 0498:0542:

Shear 1: ISW PNS02 SN: D046

Shear 2: ISW PNS02 SN: D047

6.3 Deployment Details (Times in GMT)

Table 6.1: MSS034 Deployment Details.

Start Time	Stop Time	Station Name	Water Depth	File name range	Comments
27/6/09 10:06	28/6/09 11:04	BH	~100m	D3400001 to D3400242	Calm seas, good profiling weather
29/6/09 15:30	30/6/09 16:30	W	~140m	D3400243 to D3400430	Some problems with winch tangling
2/7/09 07:15	2/7/09 19:45	BH	~100m	D3400431 to D3400542	3 broken sensors

6.4 Processing

Data were processed during the cruise using the MSSpro software purchased with the profiler. Processing was carried out in 5 stages using batch files written previously for D321b. Stage 1 consisted of converting the voltages output by the profiler into actual shear measurements from the gradient of velocity as a function of pressure throughout the water column assuming Taylor's frozen fluid hypothesis. At this stage calibration coefficients were applied according to the sensitivity of the shear probes as determined by laboratory calibrations. Calibration coefficients were also applied to account for the spatial response of a PNS shear probe due to its size. Shear spectra were then checked against Nasmyth's universal spectrum of turbulence in the ocean and high frequency noise was filtered out using a low pass filter. Spectral fits were very close to the universal spectra for corresponding levels of dissipation, following them closely from 2 to 50 cpm. Once data had been filtered, an iterative process of integration was used to calculate the dissipation rate of turbulent kinetic energy (epsilon) over the measurable range from the profiler. Frequencies outside of this range were accounted for by spectral fitting with the Nasmyth spectrum. Finally, epsilon values were used to calculate vertical diffusivity and final files (in the kz folder) were produced with 1m binned hydrographic, shear, dissipation and diffusivity data.

6.5 Results

Station BH appeared to have a strong diurnal signal both at depth and at the surface (Figure 6.2). Unfortunately the signal coincided with slightly (10m) shallower sea bed depths, ship turns and watches. For this reason station BH was revisited for a further 12 hour period on July 2nd. Results from the second occupation, however, confirm the deep diurnal signal.

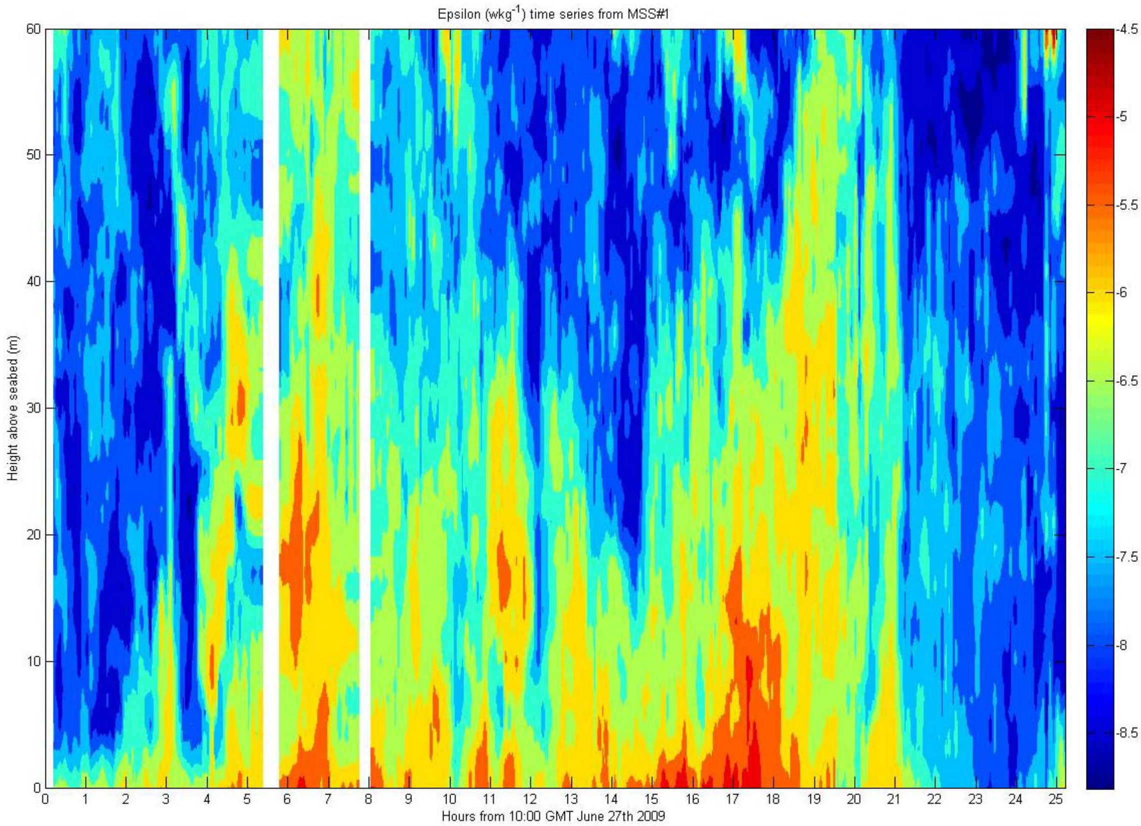


Figure 6.2: Epsilon (W/kg) time series from BH #1 (MSS#1)

Dissipation rates were generally lower at station W, with a pronounced elevation (two orders of magnitude) in the bottom 10m of the water column during hours 11 to 20 of the 25 hour station (Figure 6.3).

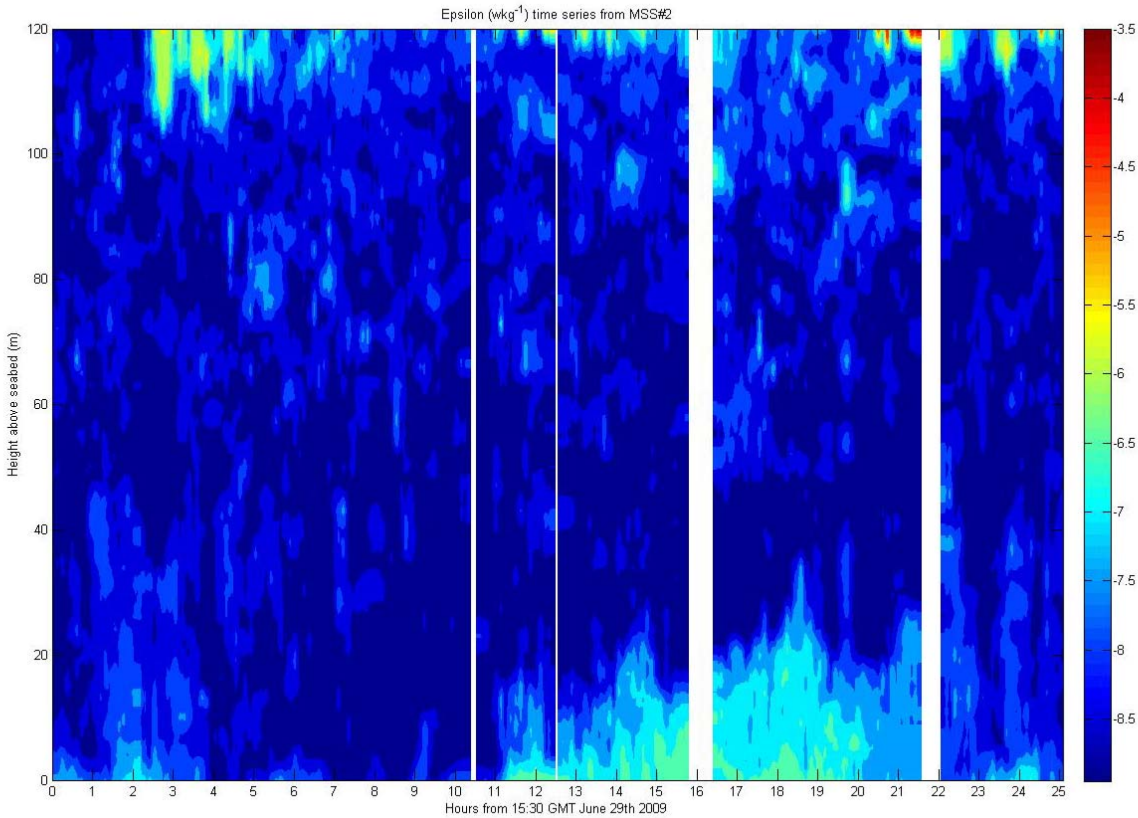


Figure 6.3: Epsilon (W/kg) time series from W (MSS#2).

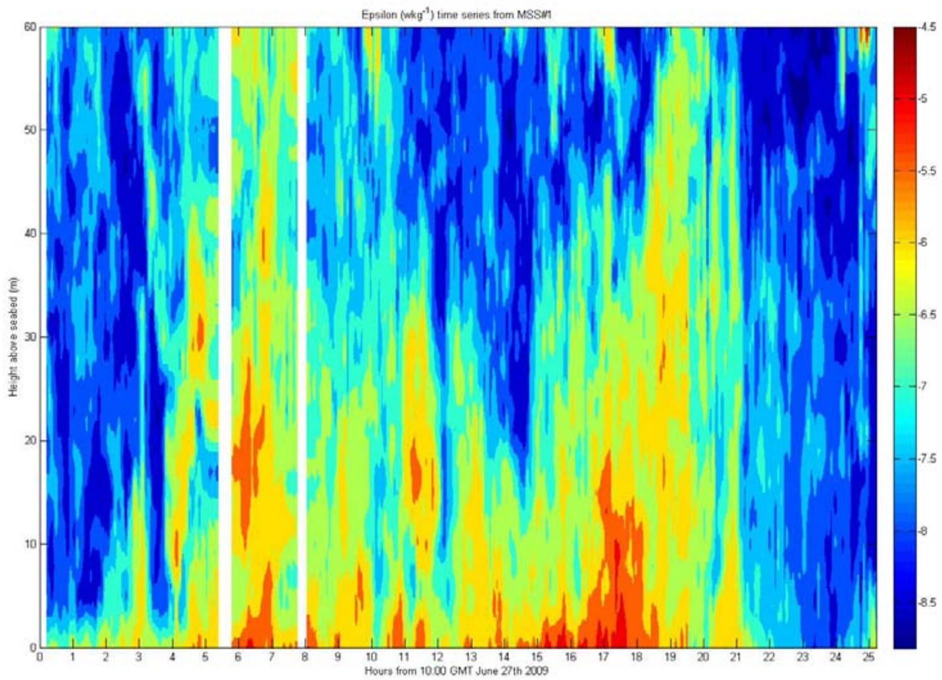


Figure 6.4: Epsilon (W/kg) time series from W (MSS#3).

7 Lowered ADCP (LADCP) Processing

Emily Venables

7.1 Introduction

Lowered Acoustic Doppler Current Profiler (LADCP) data were obtained from all but two of the CTD casts. Casts 098 and 099 were for water collection only. A single downward looking 300 kHz RDI 'Workhorse' LADCP was deployed on the frame Specific details of the LADCP are given elsewhere, this section describes data processing.

7.2 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.

7.3 Results

Figure 7.1 is an example of the Visbeck processing output from the shelf break station, CTD089. East (U) velocity is shown in red and North (V) velocity is shown in green. Flow appears to be northwestward in the upper 800m, reversing to southeastward between 800 and 1000m.

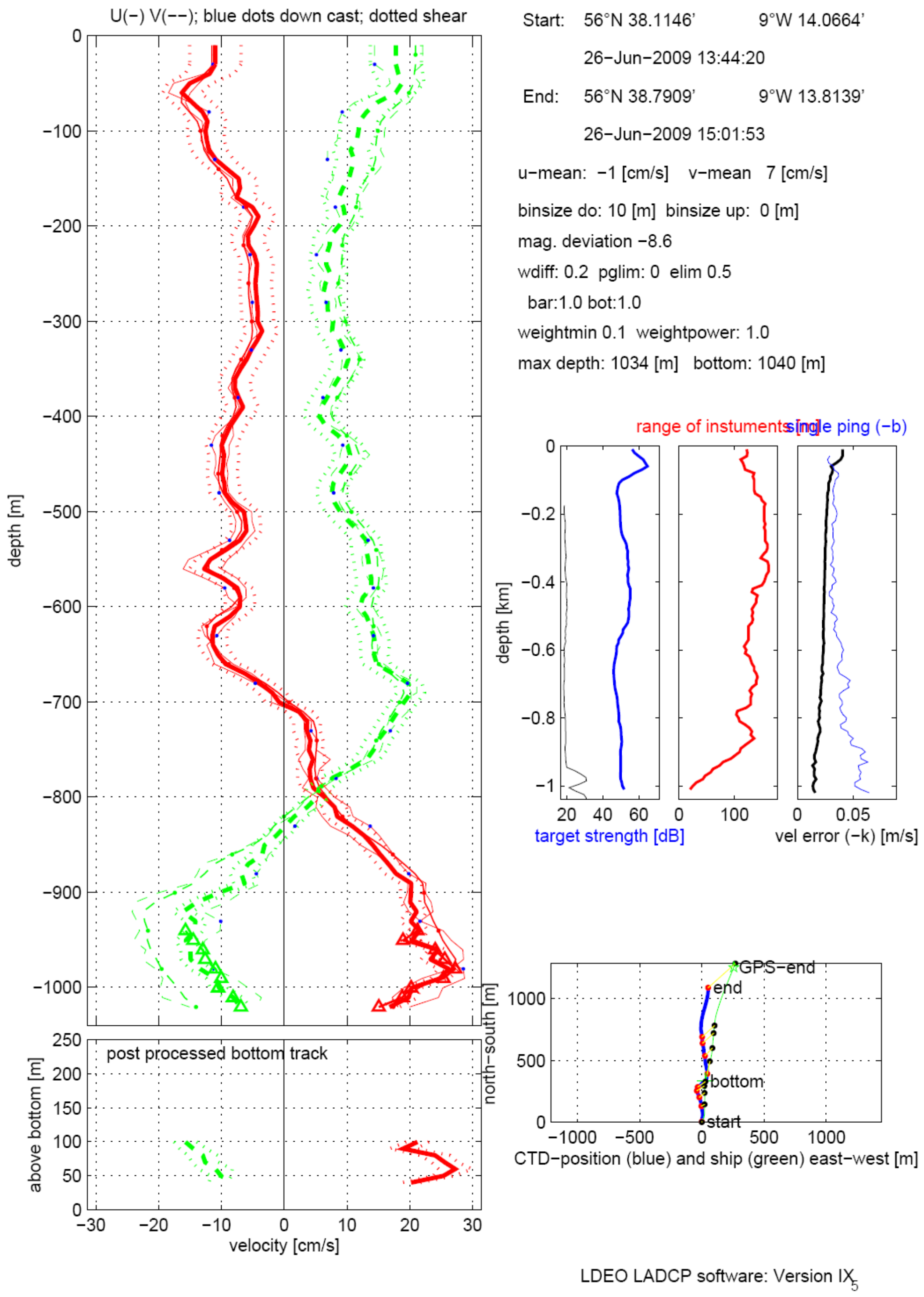


Figure 7.1: LDEO software processing output for CTD 089, shelf break

8 Temperature-Chlorophyll Chain

Mike Smithson (POL)

8.1 Introduction

The temperature-chlorophyll (T-Chl) chain consists of a series of self-contained internally-recording fluorometers and temperature loggers attached to a 10mm diameter galvanised steel wire. The chain is designed to be towed through the water at speeds up to 4kt. When being towed a 380kg lead sphere shackled to the bottom end of the wire acts as a depressor to prevent the line of instruments from streaming out behind the ship. For this cruise the chain was used in conjunction with the MSS90 turbulence profiler with the ship making headway of ~0.5kt and a weight of ~150kg was sufficient. Copper ferrules crimped onto the wire at 1m intervals are used as mounting points to attach the instruments. Specially designed clamps allow for quick attachment and release of instruments at these mounting points. The clamps reduced deployment and recovery times for the chain from an estimated 2 hours or more to about 15 minutes.

The fluorometers used were Wetlabs FLB self-logging, internally-powered fluorometers. Two types of temperature logger were used, both manufactured by Star-Oddi. Mounted at the same position on the wire as the fluorometers were Star-Oddi Centi-T (or Centi-TD) temperature (and depth) loggers. Interspersed were Star-Oddi Starmon-mini temperature loggers. Tables 8.1, 8.2 and 8.3 give the details and specifications of each instrument type.

8.2 Deployment details

Three deployments were carried out during the cruise using the port-side davit and winch: deployment 1, site BH, nominally 25 hours; deployment 2, site W, nominally 25 hours; deployment 3, site BH, nominally 12.5 hours. Immediately after the first deployment at site BH it was noticed that the top of the single-point minilogger temperature mooring was very close to the sea surface and would be in danger of entanglement with either the T-Chl chain or the MSS90 profiler. It was decided to recover and shorten the minilogger mooring. Although this required recovery and redeployment of the T-Chl chain all the instruments remained recording and so for the purposes of this report the original deployment and redeployment are referred to together as deployment 1. Details of each deployment are given in Tables 8.4, 8.5 and 8.6. Instrument positions are counted from the deepest ferrule (i.e. the first instrument attached to the wire during deployment). Start and stop times refer to the start and end of logging for individual instruments. The times for the start and end of useful data (i.e. when the chain was finally in position and when recovery began) are also given.

8.3 Data recovery and initial processing

Data was downloaded from all instruments after each deployment using the proprietary software supplied by the instrument manufacturers. Star-Oddi temperature calibrations are stored in each instrument and are applied automatically when the data is downloaded. No further processing is required. Calibrations for the fluorometers are applied individually to the raw data after downloading. The calibrations are linear across the range of the instrument and the coefficients are just a simple “dark-count” offset and scale factor. These are given in Table 8.1.

Data return for the three deployments was 100%.

Depth data from the Star-Oddi depth sensors show an offset prior to and post deployment. This has been noticed before and is caused mainly by the clamping of the sensors. Experience has shown that subtracting a mean of the prior and post values of the offset from the depth data gives a “true” depth value.

In some instances the depth data from the Star-Oddi sensors show variations comparable with the instrument spacing. In some cases this appears to coincide with periods when the ship was turning at the end of the MSS90 profiling line. Other departures from the nominal depth are for longer periods and are as yet unexplained. This should be taken into account, in conjunction with tidal and ship’s navigation and ADCP data, when analysing the data.

Wetlabs fluorometer FLB 780 has an offset of exactly 16 minutes in the recorded times. 16 minutes needs to be added to the times shown in the data file. This is puzzling as the fluorometers set their internal clocks from the computer when being set up. All the fluorometers were set up in sequence in the space of approximately 40 minutes and those set before and after FLB 780 have correct time information.

Table 8.1. Details and specifications of Wetlabs FLB chlorophyll fluorometers.

Serial number	Calibration date	Calibration coefficients		
		Offset	Scale factor	
775	28-Jun-2007	91	0.0073	Excitation wavelength: 470nm
776	28-Jun-2007	69	0.0077	
777	28-Jun-2007	67	0.0078	Emission wavelength: 695nm
778	28-Jun-2007	78	0.0076	
779	28-Jun-2007	78	0.0076	
780	09-Jul-2007	73	0.0077	Sensitivity: 0.01μg l^{-1}
907	14-Feb-2008	83	0.0076	
937	14-Feb-2008	80	0.0078	Range: 0.01 to 125μg l^{-1}
938	14-Feb-2008	78	0.0077	

Table 8.2. Details and specifications of Star-Oddi Centi-T(D) temperature loggers. *Centi-PR – has pitch and roll sensors in addition to temperature and pressure.

Serial number	Calibration date	Depth range (m)	
3269	29-Jun-2007	100	Temperature accuracy: ±0.1ºC
3270	29-Jun-2007	100	Temperature resolution: 0.032ºC
3604	12-Feb-2008	n/a	Temperature range: –1ºC to +40ºC
3606	12-Feb-2008	n/a	Temperature time constant: 20s
3613	12-Feb-2008	n/a	100m sensor depth accuracy: ±0.4m
3616	12-Feb-2008	n/a	100m sensor depth resolution: 0.03m
3653	17-Mar-2008	240	240m sensor depth accuracy: ±1.0m

3655	17-Mar-2008	240	240m sensor depth resolution: 0.07m
683*	06-Nov-2007	100	

Table 8.3. Details and specifications of Star-Oddi Starmon-mini temperature loggers.

Serial number	Calibration date		Serial number	Calibration date	
2604	30-May-2007		2614	30-May-2007	
2605	30-May-2007		2617	29-Jun-2007	Accuracy: ±0.05ºC
2606	30-May-2007		2618	29-Jun-2007	
2607	30-May-2007		2620	29-Jun-2007	Resolution: 0.013ºC
2608	30-May-2007		2621	29-Jun-2007	
2609	30-May-2007		2622	29-Jun-2007	Range: –2ºC to +40ºC
2610	30-May-2007		2623	29-Jun-2007	
2611	30-May-2007		2624	29-Jun-2007	Time constant: 18s
2612	30-May-2007		2625	29-Jun-2007	
2613	30-May-2007				

Table 8.4: T-Chl chain deployment 1 (Site BH). All data was logged at 30s intervals. Start of useful data: 09:40:00 on 27-Jun-09. End of useful data: 11:07:00 on 28-Jun-09. Instrument types are indicated by: F – Wetlabs FLB fluorometer; T_S – Star-Oddi Starmon-mini temperature logger; T_{P100} – Star-Oddi Centi-TD temperature logger with 100m pressure sensor; T_{P240} – Star-Oddi Centi-TD temperature logger with 240m pressure sensor; T_C – Star-Oddi Centi-T temperature logger.

				27-Jun-09	28-Jun-09
Position	Nominal depth (m)	Instrument type	Serial Number	Start time (GMT)	Stop time (GMT)
1	59	T_S	2621	04:00:00	16:25:43
2	58	T_S	2620	04:00:00	16:29:39
4	56	T_S	2625	04:00:00	16:33:57
6	54	T_S	2606	04:00:00	16:36:42
8	52	F T_{P100}	775 3269	04:01:00 04:00:00	14:10:15 13:39:07

10	50	T_S	2607	04:00:00	16:40:58
12	48	T_S	2614	04:00:00	16:44:17
14	46	F T_C	778 3616	03:57:00 04:00:00	13:48:40 13:36:48
16	44	T_S	2605	04:00:00	16:48:44
18	42	T_S	2609	04:00:00	16:52:5
20	40	F T_{P240}	780 3653	03:52:00 04:00:00	14:01:54 13:26:04
22	38	T_S	2617	04:00:00	16:56:55
24	36	T_S	2608	04:00:00	16:59:36
26	34	F T_C	777 3604	03:41:00 04:00:00	14:24:10 13:23:56
28	32	T_S	2613	04:00:00	17:03:48
30	30	T_S	2604	04:00:00	17:06:25
32	28	F T_{P100}	938 3270	03:34:00 04:00:00	14:32:20 13:19:10
34	26	T_S	2624	04:00:00	17:10:20
36	24	F T_C	776 3606	03:29:00 04:00:00	15:27:20 13:15:14
38	22	T_S	2618	04:00:00	17:12:59
40	20	F T_{P240}	937 3655	03:23:00 04:00:00	15:39:10 13:10:23
42	18	T_S	2610	04:00:00	17:16:57
44	16	T_S	2611	04:00:00	17:19:34
46	14	F T_C	779 3613	03:17:00 04:00:00	15:53:10 12:56:46
48	12	T_S	2612	04:00:00	17:23:30
50	10	T_S	2622	04:00:00	17:26:13
52	8	F T_{P100}	907 683	03:12:00 04:00:00	16:07:10 12:38:11
54	6	T_S	2623	04:00:00	17:31:04

Table 8.5: T-Chl chain deployment 2 (Site W). All data was logged at 30s intervals. Start of useful data: 15:28:00 on 29-Jun-09. End of useful data: 16:44:00 on 30-Jun-09. Instrument

types are indicated by: F – Wetlabs FLB fluorometer; T_S – Star-Oddi Starmon-mini temperature logger; T_{P100} – Star-Oddi Centi-TD temperature logger with 100m pressure sensor; T_{P240} – Star-Oddi Centi-TD temperature logger with 240m pressure sensor; T_C – Star-Oddi Centi-T temperature logger.

Position	Nominal depth (m)	Instrument type	Serial Number	29-Jun-09 Start time (GMT)	30-Jun-09 Stop time (GMT)
1	59	T_S	2621	12:00:00	20:46:09
2	58	T_S	2620	12:00:00	20:01:13
4	56	T_S	2625	12:00:00	21:29:35
6	54	T_S	2606	12:00:00	20:39:03
8	52	F T_{P100}	775 3269	13:03:00 12:00:00	19:45:10 17:16:38
10	50	T_S	2607	12:00:00	20:55:12
12	48	T_S	2614	12:00:00	21:11:30
14	46	F T_C	778 3616	12:52:00 12:00:00	19:39:05 17:22:52
16	44	T_S	2605	12:00:00	21:14:26
18	42	T_S	2609	12:00:00	21:22:15
20	40	F T_{P240}	780 3653	12:49:00 12:00:00	19:12:05 18:26:10
22	38	T_S	2617	12:00:00	21;25:17
24	36	T_S	2608	12:00:00	21:17:14
26	34	F T_C	777 3604	12:42:00 12:00:00	19:33:35 17:20:09
28	32	T_S	2613	12:00:00	20:04:22
30	30	T_S	2604	12:00:00	20:13:10
32	28	F T_{P100}	938 3270	12:38:00 12:00:00	19:02:40 18:29:12
34	26	T_S	2624	12:00:00	20:48:41
36	24	F T_C	776 3606	12:34:00 12:00:00	18:57:00 18:36:32
38	22	T_S	2618	12:00:00	20:15:34
40	20	F	937	12:31:00	18:47:05

		T_{P240}	3655	12:00:00	18:32:06
42	18	T_S	2610	12:00:00	20:34:39
44	16	T_S	2611	12:00:00	21:03:55
46	14	F	779	12:28:00	19:25:35
		T_C	3613	12:00:00	18:34:58
48	12	T_S	2612	12:00:00	20:51:38
50	10	T_S	2622	12:00:00	20:10:16
52	8	F	907	12:25:00	19:18:15
		T_{P100}	683	12:00:00	18:38:21
54	6	T_S	2623	12:00:00	20:07:30

Table 8.6: T-Chl chain deployment 3 (Site BH). All data was logged at 30s intervals. Start of useful data: 07:05:00 on 02-Jul-09. End of useful data: 19:49:00 on 02-Jul-09. Instrument types are indicated by: F – Wetlabs FLB fluorometer; T_S – Star-Oddi Starmon-mini temperature logger; T_{P100} – Star-Oddi Centi-TD temperature logger with 100m pressure sensor; T_{P240} – Star-Oddi Centi-TD temperature logger with 240m pressure sensor; T_C – Star-Oddi Centi-T temperature logger.

				01-Jul-09	02-Jul-09
Position	Nominal depth (m)	Instrument type	Serial Number	Start time (GMT)	Stop time (GMT)
1	59	T_S	2621	01:00:00	21:51:14
2	58	T_S	2620	01:00:00	21:53:33
4	56	T_S	2625	01:00:00	21:55:52
6	54	T_S	2606	01:00:00	21:58:42
8	52	F	775	20:28:00	20:40:10
		T_{P100}	3269	01:00:00	20:24:00
10	50	T_S	2607	01:00:00	22:04:44
12	48	T_S	2614	01:00:00	22:06:57
14	46	F	778	20:24:00	21:07:35
		T_C	3616	01:00:00	20:30:47
16	44	T_S	2605	01:00:00	22:49:14
18	42	T_S	2609	01:00:00	22:59:15
20	40	F	780	20:21:00	20:48:45
		T_{P240}	3653	01:00:00	20:15:23

22	38	T_S	2617	01:00:00	22:13:05
24	36	T_S	2608	01:00:00	22:51:59
26	34	F T_C	777 3604	20:15:00 01:00:00	21:01:35 20:19:17
28	32	T_S	2613	01:00:00	22:44:49
30	30	T_S	2604	01:00:00	22:47:02
32	28	F T_{P100}	938 3270	20:11:00 01:00:00	21:21:10 20:21:56
34	26	T_S	2624	01:00:00	22:39:46
36	24	F T_C	776 3606	20:06:00 01:00:00	21:35:10 20:32:08
38	22	T_S	2618	01:00:00	22:09:27
40	20	F T_{P240}	937 3655	20:02:00 01:00:00	20:53:20 20:26:30
42	18	T_S	2610	01:00:00	22:35:44
44	16	T_S	2611	01:00:00	23:04:09
46	14	F T_C	779 3613	19:58:00 01:00:00	21:14:10 20:28:42
48	12	T_S	2612	01:00:00	23:01:54
50	10	T_S	2622	01:00:00	22:56:33
52	8	F T_{P100}	907 683	19:53:00 01:00:00	21:28:45 20:33:35
54	6	T_S	2623	01:00:00	22:54:31

9 Moorings

Two single-point and one sea-bed lander moorings were deployed and recovered during D340b. Mooring BH1 was a single point temperature minilogger mooring (event 012 Appendix 1); BH2 was a 300 kHz RDI ADCP on a seabed lander frame (event 008 Appendix 1); W1 was a combined ADCP/T-minilogger/RBR thermistor chain single point mooring (Figure 9.2, event 003 in Appendix 1)

Table 9.1: Mooring BH1 instrument details.

Mooring BH1	Deployed: 11:20Z 28/06/09		Recovered: 21:37Z 02/07/09	
56° 37.35’ N		07° 44.93’ W		WD = 87m
Instrument	Serial No.	Height above bed (m)	Sample interval (s)	Comments
Vemco Minilogger	**3268**	66.8	15	
Vemco Minilogger	**1084**	64.3	15	
Vemco Minilogger	**1591**	61.8	15	
Vemco Minilogger	**1592**	59.3	15	
Vemco Minilogger	**1593**	56.8	15	
Vemco Minilogger	**1594**	54.3	15	
Vemco Minilogger	**1626**	53.05	15	
Vemco Minilogger	**1595**	51.8	15	
Vemco Minilogger	**1627**	50.55	15	
Vemco Minilogger	**1596**	49.3	15	
Vemco Minilogger	**1628**	48.05	15	
Vemco Minilogger	**1597**	46.8	15	
Vemco Minilogger	**1629**	45.55	15	
Vemco Minilogger	**1598**	44.3	15	
Vemco Minilogger	**1599**	41.8	15	
Vemco Minilogger	**1600**	39.3	15	
Vemco Minilogger	**1601**	36.8	15	
Vemco Minilogger	**1602**	34.3	15	
Vemco Minilogger	**1619**	31.8	15	
Vemco Minilogger	**1620**	29.3	15	
Vemco Minilogger	**1621**	26.8	15	
Vemco Minilogger	**1622**	24.3	15	
Vemco Minilogger	**1623**	21.8	15	

Vemco Minilogger	**1624**	19.3	15	
Vemco Minilogger	**1625**	16.8	15	

Table 9.2: Mooring BH2 instrument details

Mooring BH2		Deployed: 04:36Z 27/08/09		Recovered: 20:51Z 02/07/09
56° 37.36' N		07° 44.92' W		WD = 90m
Instrument	Serial No.	Height above bed (m)	Sample interval (s)	Comments
RDI 300kHz ADCP	10628	0.3	Bin size = 2m Ensemble = 60s PPE = 80	10142 ensembles recorded

Table 9.3: Mooring W1 instrument details.

Mooring W1		Deployed: 09:05Z 26/06/09		Recovered: 04:20Z 02/07/09
56° 37.35' N		07° 44.93' W		WD = 139m
Instrument	Serial No.	Height above bed (m)	Sample interval (s)	Comments
RBR T-Chain	3278	125.15	5	100m long T-Chain. 10 evenly spaced sensors starting at 125.15 hab
Vemco Minilogger	**6176**	120.9	15	Miniloggers interspersed between T-Chain thermistors
Vemco Minilogger	**6175**	114.4	15	
Vemco Minilogger	**6178**	107.9	15	
Vemco Minilogger	**6177**	101.4	15	
Vemco Minilogger	**1693**	94.9	15	
Vemco Minilogger	**1692**	88.4	15	
Vemco Minilogger	**1691**	81.9	15	
Vemco Minilogger	**1690**	75.4	15	
Vemco Minilogger	**1689**	68.9	15	
Vemco Minilogger	**1688**	62.4	15	
Vemco Minilogger	**1687**	55.9	15	
Vemco Minilogger	**1686**	49.4	15	
Vemco Minilogger	**1685**	42.9	15	

Vemco Minilogger	**1684**	36.4	15	
Vemco Minilogger	**1630**	29.9	15	
Vemco Minilogger	**3278**	23.4	15	
Vemco Minilogger	**3614**	20.15	15	
Vemco Minilogger	**7334**	16.9	15	
Vemco Minilogger	**7337**	13.65	15	
RDI 300kHz ADCP	BC 00 00 03 B5 BD 99 09 (CPU SN)	8.5	Bin size = 2m Ensemble = 60s PPE = 80	9811 ensembles recorded

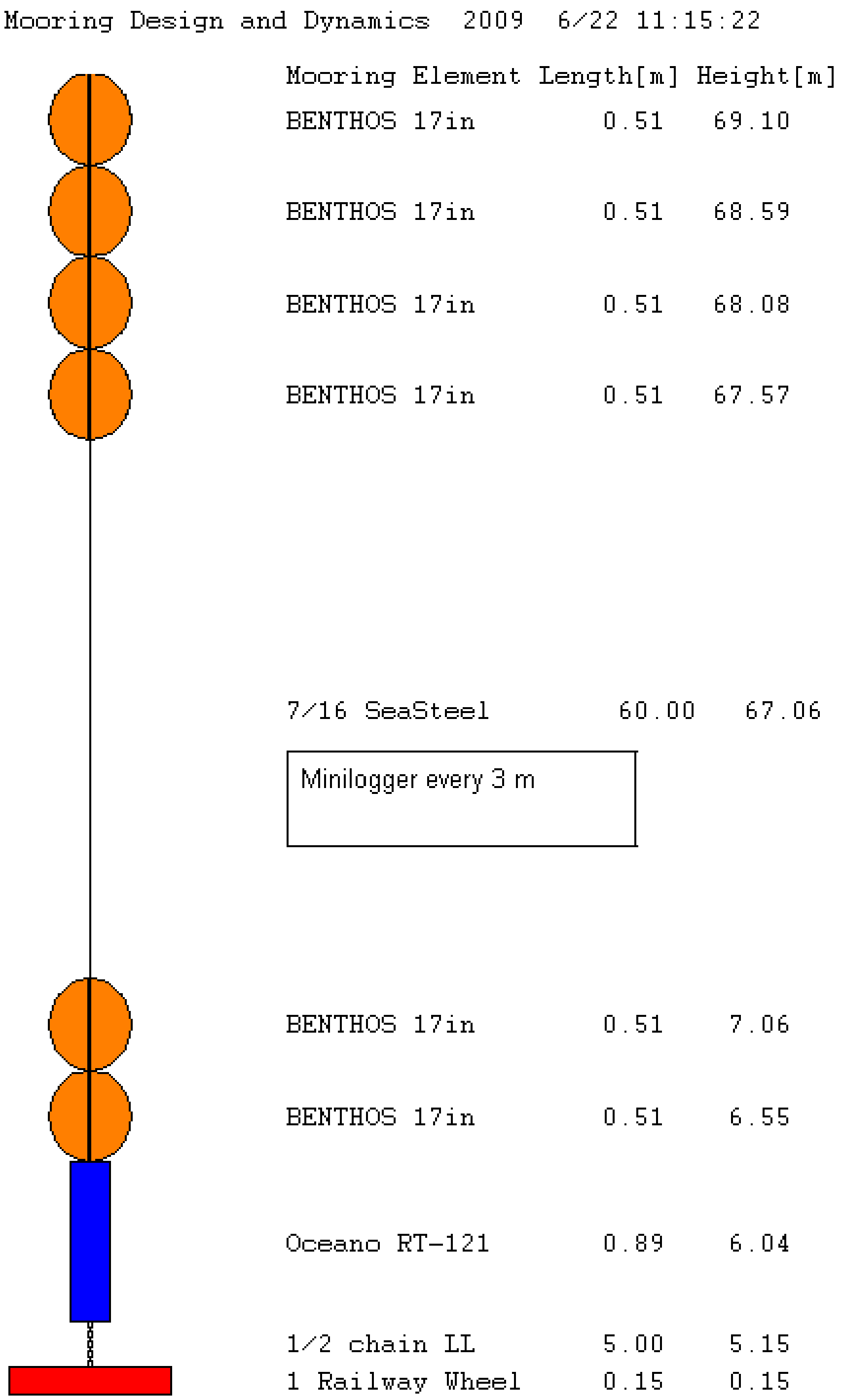


Figure 9.1: Mooring BH1, deployed as event 012 (Appendix 1)

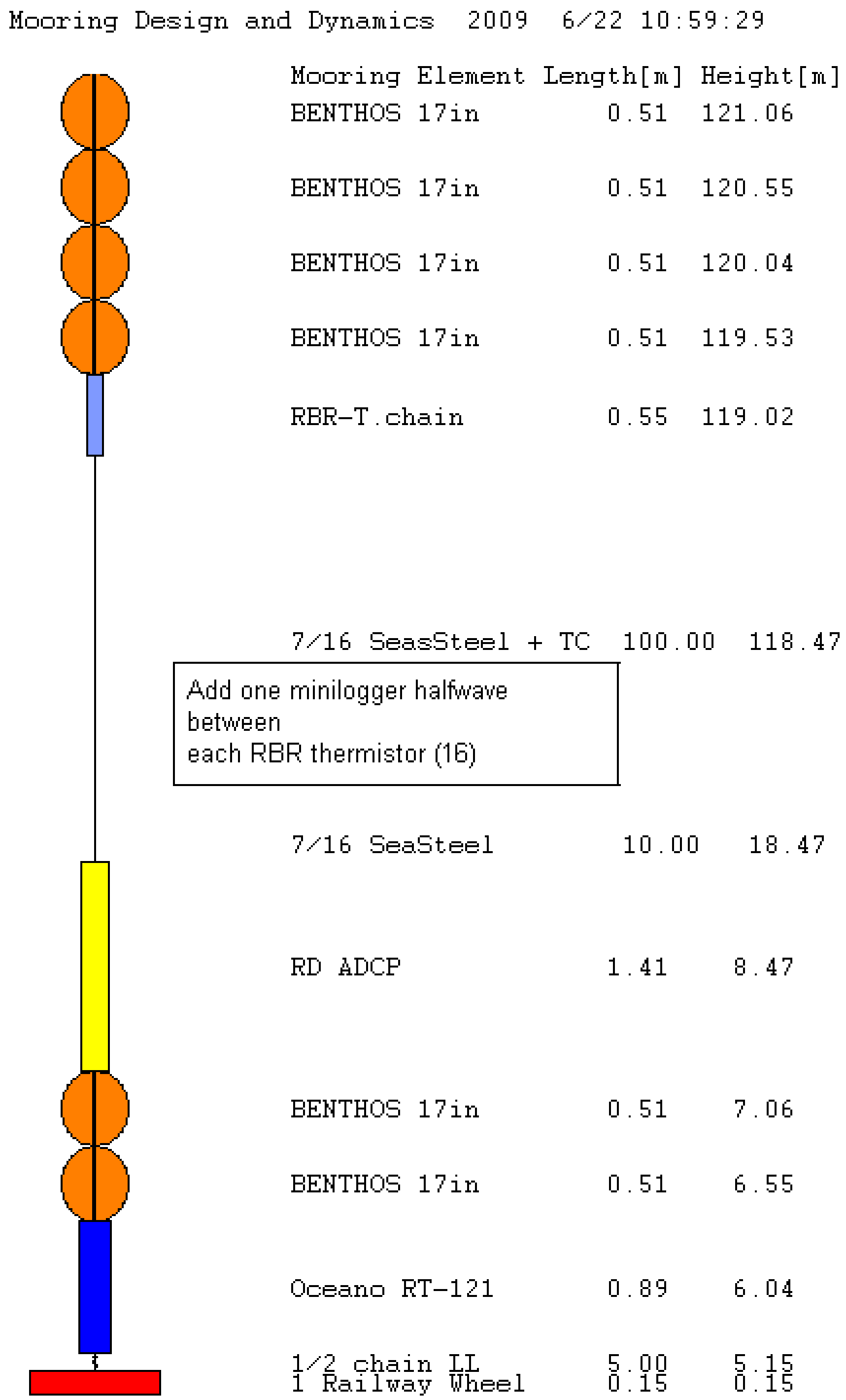


Figure 9.2: Mooring W1, deployed as event 003 (Appendix 1)

10 Dissolved Inorganic Nutrients

Sharon McNeill

PI : Keith Davidson

10.1 Introduction

The basic water column dissolved nutrients, ammonia, phosphate, silicate and nitrate were analyzed from CTD casts along the second leg of the Ellet line (Barra Head, Shelf break and reef sites at Mingulay). Depths for the samples were chosen to correspond with those of the chlorophyll and bioassay studies. Samples were taken from the conventional steel framed CTD. A full list of nutrient samples taken and analysed on board is shown in Table 10.1.

10.2 Processing

Samples were collected in 250mls acid cleaned polythene bottles directly from the CTD spigots without the use of a tube. Samples were always analyzed within 24 hours of collection and stored in a fridge prior to analysis. Measurement was conducted using a Lachat *QuikChem 8500* flow injection autoanalyser using the manufacturers recommended methods: Ammonia, 31-107-06-1-B; Orthophosphate, 31-115-01-1-G; Silicate, 31-114-27-1-A and Nitrate/Nitrite, 31-107-04-1-A.

Samples were measured in triplicate to identify instrument precision. Standards were prepared in deionised water and the samples were run in a carrier stream of dionised water. Salt correction of the result was performed by running a small number of Low Nutrient Sea Water samples (OSIL, http://www.osil.co.uk, Batch LNS 17, Salinity 35) during each sample batch run and the mean result was subtracted from sample results.

A standard reference solution prepared from nutrient standard solutions supplied by OSIL containing 1µMNH_4, 1µMPO_4, 10µMSiO_2 and 10µMNO_3 was run at the start and end of each sample batch.

Table 10.1: Nutrient samples analyzed on D340b

Station	CTD	CTD bottle	Depth (M)		Station	CTD	CTD bottle	Depth(M)
BH	87	15	5		M1	94	13	2
		13	15				12	5
		11	24				11	15
		9	30				10	20
		7	40				9	30
		5	60				8	40
		3	80				7	50
		1	100				6	60
W	88	9	10				4	70
		5	22				3	90
		3	70				2	110
		1	130		W	95	21	5
SB	89	23	5				19	15

		20	15				15	20
		17	20				11	30
		15	30				9	40
		13	40				7	50
		11	60				5	60
		9	68				3	70
		7	80				2	120
		5	100		W	96	21	5
BH	90	11	5				19	10
		10	10				18	15
		5	20				17	20
		4	30				12	21
		3	40				8	35
		2	50				7	40
		1	75				5	50
BH	91	21	5				4	60
		17	10				3	80
		15	15				2	110
		14	20				1	127
		13	25		W	97	14	5
		11	30				12	15
		10	35				10	20
		7	40				8	30
		6	45				5	40
		5	50				3	60
		3	60				1	100
		2	70					
		1	75					

Table 10.1(cont)

Station	CTD	CTD bottle	Depth (M)		Station	CTD	CTD bottle	Depth(M)
M1	92	22	5		M1	100	21	5
		20	15				19	15
		13	25				16	25
		10	30				13	30
		8	40				11	34
		5	60				9	42

		4	70				7	50
M1	93	10	2				6	60
		9	5				3	70
		8	15				2	90
		7	25				1	116
		6	30		BH	101	18	5
		5	40				14	14
		4	50				12	20
		3	60				9	30
		2	70				7	40
		1	130				3	60
							1	90

11 Phytoplankton abundance

Keith Davidson SAMS

11.1 Introduction

Enumeration of phytoplankton is required to investigate how the physical and chemical structure of the water within and outside the mixing zone is related to total abundance, functional group (diatoms/dinoflagellaes) and genus/species composition.

11.2 Method

Phytoplankton samples were collected from CTD casts and depths indicated in tables 11.1 & 11.2. Samples from six depths were obtained based on the fluoresence profile observed. Depths included the chlorophyll maximum if one existed and representative depths from within and below any mixed layer. 100ml samples were fixed with 1% final concentration of Lugol's Iodine and stored in amber bottles for post cruise analysis by microscopy.

Table 11.1: CTDs sampled for microbial parameters

Date	Station	Cast number	Location	Time of deployment (GMT)
26/06/2009	SE	089	56° 38.1' N 9° 14.07' W	13:40
27/6/2009	BH	091	56° 37.2' N 7° 43.8' W	15:13
28/6/2009	M	092	56° 49.3N 7° 23.6W	13;19
29/6/2009	W	095	56° 38.05'N 8° 11.07' W	14:10
30/6/2009	W	097	56° 38.6'N 8° 10.9' W	13:08
1/7/2009	M	100	56° 49.4' N 7° 23.4' W	12:20
2/7/09	BH	101	56° 36.4' N 7° 45.5' W	13:10

Table 11.2 depth in m of CTD sampling for main microbial parameters

CTD	Location	Depth 1	Depth 2	Depth 3	Depth 4	Depth 5	DCM
089	SE	68	40	30	15	5	20
091	BH	60	40	30	15	5	10
092	M	60	40	30	15	5	25

095	W	60	40	30	15	5	20
097	W	60	40	30	15	5	20
100	M	60	42	25	15	5	34
101	BH	60	40	30	20	5	14

Main microbial parameters were: Phytoplankton abundance, bacterial abundance, bacterial production, chlorophyll concentration, 15N uptake, DOC/N concentration, inorganic nutrient concentration, POC/N

12 Chlorophyll concentration

Alexandra Peterson, Keith Davidson SAMS

Collection and analysis of chlorophyll samples provides an estimate of the autotrophic biomass within the water column and allows calibration of fluorometric data collected by CTD.

12.1 Method

Water samples were collected from CTD casts and depths detailed in Tables 11.1 & 11.2 and transferred into one litre pre washed polycarbonate bottles. These bottles were kept in the dark until processing.

Samples were collected for chlorophyll determination at the same six depths at those for microscopy. Depending on the biomass within the water column duplicate sub samples of between 500-1000ml from each depth were filtered under low vacuum through 47mm GFF glass fibre filters (effective pore size 0.7µm). These filters were stored frozen in centrifuge tubes.

Analysis will be conducted by extraction of chlorophyll overnight in the dark at 4^{o}C in 90% acetone. Subsequently samples will be sonicated and then centrifuged to release the pigment into solution. Analysis of pigment concentrations will be conducted using a Turner Designs Trilogy fluorometer.

13 15N Nitrogen uptake

Lewis Miller, Keith Davidson SAMS

13.1 Introduction

To obtain an estimate of contribution of new (nitrate) and regenerated (ammonium) to production determination was made of the rate of uptake of nitrate and ammonium using ^{15}N stable isotopes of nitrogen.

13.2 Method

Water samples were collected from three depths from the CTD casts of Table 13.1. These depths represented surface mixed layer, chlorophyll maximum and sub chlorophyll maximum. Water was stored in thermos flasks until processing. Samples were pre filtered through 200µm mesh to remove large zooplankton grazers.

Table 13.1. Depths sampled for ^{15}N uptake measurements

CTD	Depth 1	Depth 2	Depth 3	Depth 4	Depth 5	DCM
089		√			√	√
091		√			√	√
092		√			√	√
095			√		√	√
097		√			√	√
100	√			√		√
101	√	√				√

From each depth 250ml sub samples were transferred into polycarbonate bottles.

Duplicate bottles received spike additions of ^{15}N Sodium nitrate and duplicate bottles received spike additions of ^{15}N ammonium chloride.

Bottles were then incubated for four hours on deck in tanks with flow through seawater and neutral density screens to approximately simulate the irradiance levels from which the water had been collected. In all cases the concentration of the ^{15}N spike was set as 10% of the known or estimated concentration of nitrate or ammonium (as appropriate) at the particular depth. After incubation, samples were filtered through 25mm pre ashed GFF filters. Filters were stored frozen in eppindorf tubes for post cruise analysis at SAMS. Analysis will be conducted using a PDZ Europa ANCA 20-20 GSL mass spectrometer. Defrosted samples will be oven dried (60^{o}C) for 4 hours and then wrapped in tin disks prior to analysis.

14 POC/N determination

Alexandra Peterson, Keith Davidson SAMS

14.1 Introduction

To obtain an estimate of the particulate organic matter in the water column, samples were collected for the determination of particulate organic carbon (POC) and particulate organic nitrogen (PON).

14.2 Method

Water samples were collected from CTD casts and depths detailed in Tables 11.1 & 11.2 and transferred into one litre pre washed polycarbonate bottles. These bottles were kept in the dark until processing. Depending on the biomass within the water column duplicate sub samples of between 250-5000ml from each depth were filtered under low vacuum through pre ashed 25mm GFF glass fibre filters (effective pore size 0.4µm). Filters were then fumed over HCl and stored frozen in eppindorf tubes. Samples will be transported frozen to SAMS for post cruise analysis. Analysis will be conducted using a PDZ Europa ANCA 20-20 GSL mass spectrometer. Defrosted samples will be oven dried (60^oC) for 4 hours and then wrapped in tin disks prior to analysis.

15 DOC/N determination

Keith Davidson SAMS

15.1 Introduction

To obtain an estimate of the dissolved organic matter in the water column, samples were collected for the determination of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON). This dissolved organic matter is important in fuelling bacterial (and potentially) phytoplankton growth.

15.2 Method

Water samples were collected from CTD casts and depths detailed in Tables 11.1 & 11.2 and transferred into one litre pre washed polycarbonate bottles. These bottles were kept in the dark until processing.

Duplicated sub-samples (20 ml) were drawn from the CTD Niskin bottles and filtered through precombusted (24 h, 450 °C) glass fibre filters (Whatman GF/F 25 mm, 0.7 µm effective cut-off), with a glass syringe and filter cartridge, and using polyethylene gloves. Each filtered sub-samples was collected in a precombusted glass vial, preserved with orthophosphoric acid (35 µl Analar 85 % H_3PO_4 per 10 ml sample), sealed with a screw cap with Teflon liner and refrigerated (4-6 ˚C) in the dark, until post cruise analysis.

DOC will be analysed on a Total Organic Carbon analyzer (Shimadzu TOC-V) with platinium catalyst (0.5% on alumina), carrier gas as O_2 (N5 grade, 150 ml/min), coupled to an NDIR (Non-Dispersive infra-Red) detector. Total Dissolved Nitrogen (TDN) was analysed with a TN unit (Shimadzu) using high temperature oxidation to nitric oxide (NO) and detection by chemiluminescence. Dissolved organic nitrogen (DON) will be obtained by subtraction of total inorganic nitrogen (auotanalyser, Lachat QuickChem 8000) from TDN.

16 Deck board incubations

Keith Davidson, Mark Hart, Sharon McNeill, Debra Brennan, Alexandra Peterson, Lewis Miller SAMS

Linda Gilpin Napier

16.1 Introduction

Different nutrients may limit the growth of phytoplankton. In coastal waters N may be the limiting nutrient for both diatoms and dinoflagellates, while diatoms may also be limited by silicon. In order to assess if either or both of these nutrients were limiting to phytoplankton production and microbial community response we conduced deck board experiments in which N and/or Si were added to natural seawater samples.

16.2 Method

Two, three day experiments were conduced, one at one station within, Bara Head (BH), and one station outside, W, the mixing zone.

Water was collected from the chlorophyll maximum of CTDs 090 and 096 for the BH and W experiments respectively.

40L of collected water was mixed in a polycarbonate tank, with a subsample taken to determine the T=0 values of inorganic nutrients phytoplankton and bacterial abundance, phytoplankton PI response, bacterial production, chlorophyll, POC/N, DOC/N, bacterial community composition and HNAN/PNAN abundance.

The water was then decanted into four carboys that received the nutrient additions detailed in Table 16.1

Table 16.1: Deck board experiment nutrient additions

carboy	addition
control	None
+N	15µM NO3
+Si	15µM Silicate
+N/Si	15µM NO3 and 15µM Silicate

A further sample to verify the inorganic nutrient addition was taken prior to decanting the water from each carboy into 18 1L whirlpack bags, each containing 500ml of water.

These bags were placed in deck board incubation tanks with flow through seawater and neutral density screening allowing 15% of ambient irradiance to pass.

Six bags from each treatment were harvested after 24, 48 and 72 hours to determine duplicate values of the quantities detailed in table 16.2.

Table 16.2: Parameters measured in the deck board experiments at each time point (methods of sample collection and processing are described elsewhere in this report).

Bag	Parameter
1 & 2	Inorganic nutrients & POC/PON
3 & 4	Chlorophyll & DOC/N
5 & 6	Phytoplankton & bacterial abundance Phytoplankton PI response Bacterial production

In addition at the end of the experiments at 72 hours samples were collected for the enumeration of HNAN/PNAN abundance and bacterial functional group composition.

17 Bacterial production:

Mark Hart, Keith Davidson, Linda Gilpin.

17.1 Introduction

Bacterial production was assayed using the micro-centrifuge method (Kirchman, 2001). Working solutions of 500 µCi mL^{-1} Thymidine were made from 5 mCi mL^{-1} [^{3}H]-Thymidine stock solutions (Amersham Life Science, U.K.) and stored in the dark at 2 to 4° C.

17.2 Materials and Methods:

Profiles were determined on 6 depths from surface to 45m for all stations on D340B. For each depth, approximately 250ml samples were drawn in 250 ml dark glass bottles. Similarly, samples were taken from the deckboard incubations detailed above in section 6. Five (10) ml sub-samples was then spiked with 20.4 or 24 µl [^{3}H]-Thymidine (final concentration 20 nM). The 10ml sub-sample was then aliquoted into five 2 ml microcentrifuge tubes, including two killed controles with 89 µl 100% TCA (background) and 3 tubes for incubations. The tubes were incubated in the dark in a thermo-regulated incubator at 10° C for 1 hour. At the end of the incubation, 89 µL of 100% TCA were added to all but the background tubes to terminate bacterial production. The samples were then stored in the fridge ready for further processing at SAMS.

18 Hydrocarbon Bacterial Analysis

Mark Hart, Debra Brennan

18.1 Introduction

The study was aimed at detecting the presence of hydrocarbon degrading bacteria (HDB) within marine pelagic samples and the relationship between their abundance and phytoplankton abundance.

18.2 Materials and Methods

5 litre samples were taken from CTD drops from 3 depths detailed in the table below, generally to cover a range between above DCM, DCM and below DCM. Each sample was then filtered through a 0.8 µm polycarbonate filter to collect particulate associated material (algal cells and attached bacteria). The filtrate was collected and subsequently passed through a 0.2 µm filter to collect the free-living bacterial fraction. Membrane filters were then placed in a 15 ml falcon tube and frozen. In addition a smaller subsample (approx 1000 ml) was filtered onto a 0.8 µm membrane for chlorophyll analysis. All samples will be analysed back at SAMS using molecular methods such as real-time PCR and sequence analysis specifically targeted at members of the HDBsxz community.

Table 18.1: Hydrocarbon bacterial analysis sample details.

CTD Cast	Date	Site	Depths (m)	Bottle No.
089	26/6/09	Shelf Break	15	20
			20	17
			68	9
091	27/6/09	Barra Head1	5	21
			10	18
			30	12
092	28/6/09	Reef1	5	23
			25	14
			40	9
095	29/6/09	West1	5	22
			20	17
			60	6
100	01/7/09	Reef2	5	21

			30	13
			60	5
101	02/7/09	Barra Head2	14	
			30	
			60	

19 Bacteria and Microheterotrophic Enumeration

Debra Brennan

19.1 HNAN/PNAN & CYANOBACTERIA

Sample collection:Samples were collected from CTD casts at 6 depths including chlorophyll maximum

All samples were immediately fixed with 1% (final conc) glutaraldehyde.

19.1.1 HNAN/PNAN

15ml of fixed sample was filtered through a 0.8µm polycarbonate filter with a 0.8µm cellulose nitrate backing filter. The sample was filtered under low vacuum to maintain an even distribution of cells across the filter.

25µl of the fluorescent stain DAPI was added to the final 5ml and incubated for 4 min before re-commencing filtration. Subsequently 5ml of milli-Q water (pre sterilised by 0.2µm filtration) was added to rinse down any remaining sample from the tower.

The filter was then mounted on a microscope slide and frozen at –21 degrees for later analysis.

19.1.2 CYANOBACTERIA

Samples were processed using a similar filtration procedure as for HNAN/PNAN but in this case cells were collected following filtration of 5ml of fixed sample onto a 0.2µm white polycarbonate filter. No stain is required for enumeration as the cyanobacteria auto fluoresce when viewed under ultra violet illumination.

19.2 Sample analysis:

Slides will be kept frozen and transported to SAMS for post cruise enumeration by fluorescent microscopy.

19.3 BACTERIAL ABUNDANCE

5ml of fixed sample placed in a cryovial and snap frozen with liquid nitrogen prior to freezing at –80 degrees. Post cruise, bacterial abundance analysed by flow cytometry

19.4 BACTERIAL FUNCTIONAL GROUP BY FISH (fluorescent in situ hybridisation)

Samples were collected from 3 depths from CTD casts: 40m, 15m & 5m.

A 10ml sub sample from each depth was fixed with paraformaldehyde and incubated for at least 4 hours before filtration.

Samples were filtered onto a 0.2µm white polycarbonate filter with0.8µm cellulose backing filter.

Filters were air dried and place in a petri dish before freezing at -21 degrees for post cruise analysis. Samples will be processed following FISH procedure where specific probes are used to identify specific bacterial types using fluorescence microscopy.

19.5 GRAZING EXPERIMENT

Grazing experiments were performed at all stations. Two dilutions 1% (5 ml of seawater was added to 495 ml of 0.8/0.2 µm (AcroPac 500 capsule, Pall Corporation) filtered seawater – FSW-) and also 50% (250ml unfiltered/250ml filtered) to be compared to 100% (500ml of seawater as sampled). Seawater was sampled from the CTD niskin bottle and kept in the dark (black bin bags) in cold room. 495 ml was measured with a measuring cylinder and the 5 ml with a 5ml pipette. Incubation was carried out for 24 hours, in 1 L whirlpack (VWR) and sampled at T_{zero} and T_{24}. Bags were incubated in tanks on deck at 14°C with running water from non-toxic supply from the ship. 4.5 ml samples were taken for enumeration of bacteria and HNF, stored in 5 ml cryovials 80ul of glutaraldehyde and 25ul of DAPI stain was added before the tubes were plunged into liquid nitrogen and stored at -80°C until enumeration. Enumeration of cell will be done by flow cytometry.

20 Primary Production – PI parameters

Linda Gilpin – Edinburgh Napier University

20.1 Introduction

Phytoplankton cells in a mixed as opposed to a stratified water column may be expected to exhibit different photosynthetic characteristics (α and Pmax) driven by the different light regimes they experience. Since the stations visited during the cruise were anticipated to be in different mixing environments, this study sought to determine the PI characteristics using short term incubations of 1 hr duration using a photosynthetron.

20.2 Materials and Methods

Water was collected from 2 depths; one in the surface mixed layer and the other in the deep chlorophyll maximum. For each PI curve the following procedure was followed. A volume of 80mL was spiked with 16µCi ^{14}C sodium bicarbonate and 5mL aliquots were dispensed into 15 clear glass 20mL Econovials. Twelve of these vials were capped and placed into a photosynthetron which had been set up with a range of 12 irradiances from 0 to ~ 2500 µE /sec m^2. Following incubation for 1 hr, the vials were removed and any unincorporated inorganic ^{14}C was displaced by adding 50µL conc HCl and agitating on an orbital shaker in a fume hood for a minimum of 1hr. The incorporation of ^{14}C into particulate and dissolved components was measured using a RackBetaLKB scintillation counter following the addition of 10ml Optiphase Supermix cocktail. The remaining 3 inoculated vials were not incubated but were immediately acidified and agitated and acted as time zero points. In order to check the activity of the stock used in each incubation, triplicate 200µL volumes of the inoculated sample were added to 10mL of a Supermix/Carbosorb mixture and read in the scintillation counter.

Plots of photosynthesis (mgC/m³/hr) versus irradiance will be standardised to chlorophyll when this becomes available and the characteristics of the curve (α and Pmax) will be determined using literature methods.

Estimates of column integrated production will be derived using these PI characteristics together with light attenuation, chlorophyll depth distribution and masthead PAR data when they become available.

Table 20.1 CTD depths sampled for PI curves (refer to Table 11.2 for actual depths)

CTD	Depth 1	Depth 2	Depth 3	Depth 4	Depth 5	DCM
089					√	√
091					√	√
092					√	√
095					√	√
097					√	√
100				√		√
101					√	√

21 Cold-water coral research

J Murray Roberts, Kim Last, Melanie Douarin (SAMS)

21.1 Introduction

There were two broad objectives to the cold-water coral research carried out during Discovery 340b. The first was to collect samples of live *Lophelia pertusa* and associated fauna and the second was to collect water samples from the reef site to measure trace element and oxygen isotopes. These coral and water samples provide the basis for on-going studies at SAMS. The live samples will be used to study coral growth and physiology under predicted scenarios of ocean acidification (a component of the European Project on Ocean Acidification) over the next two years. Samples of dead coral framework were fixed at sea so the species found can subsequently be separated and identified. Trace elements and oxygen isotopes within the water samples will be used to calibrate and test palaeoceanographic temperature proxies from *L. pertusa* obtained earlier vibro-cores through the Mingulay reef mounds (PhD study M. Douarin). Finally, live corals were placed in a newly-built experimental flume (from A.J. Davies, University of North Wales, Bangor) to examine their behavioural response to controlled laminar flow conditions.

21.2 Methods

21.2.1 Video-grab sampling

Corals were collected from the Mingulay Reef Complex (Roberts et al. 2005, in press) using minimally-invasive video-directed grab sampling (Mortensen et al. 2000). The video grab apparatus consists of a modified van Veen grab deployed beneath a video camera and lights. When lowered from the vessel on a wire, the camera umbilical was taped to the wire at 15 m intervals. As the vessel drifted across the reef site the video image of the seabed beneath the grab was used to target sampling. Since van Veen grabs are designed to trigger when they hit the seabed, the SAMS video-grab includes an electro-magnet to hold the trigger arm in position until the grab is lowered onto the target of interest (on this cruise primarily live *L. pertusa* for flume and future laboratory study). The polarity of the magnet is then reversed, the arm releases and when the deployment wire tightens the grab jaws close. A Geographic Information System (GIS) displaying live vessel GPS position was used on the bridge so the skipper was able to see how the vessel was positioned with respect to the coral reef structures. This GIS displayed a grey-scale shaded bathymetry that clearly shows the coral mounds that make up the reef complexes at Mingulay. Examples of the bathymetry plots used to guide coral sampling are given in figures 21.3 and 21.4 below..

Live cold-water coral samples were transferred immediately after collection to a chilled, stirred, recirculating seawater aquarium filled with bottom water collected from the CTD rosette sampler (9°C, 35.4 psu). Subsamples of live coral (10-20 polyps) were fixed in either 90% ethanol or 10% formalin for future genetic or histological analysis respectively. Samples of dead coral framework and rubble were washed through a 1 mm mesh and fixed in 10% borax-buffered formalin seawater.

21.2.2 Water sampling

Our primary aim was to collect seawater samples according to the tide at several depths over Mingulay Reef Area 1 (Roberts et al. 2005).

When Niskin bottles were on deck:

- Approximately 700 ml seawater were collected from the bottles as soon as possible for trace elements analysis
- Approximately 20 ml seawater were collected from the bottles for oxygen isotopes analysis

In the clean laboratory:

- 25 ml of seawater were filtered through 0.45 μm filters for trace element analysis and 0.5 ml of nitric acid was added
- Approximately 500 ml seawater were filtered through 0.45 μm filter. Both the filter and 250 ml of the filtered water were retained.
- All material was stored in the cold room.

Melanie Douarin's PhD work is based on the study of four British Geological Survey vibro-cores from Mingulay Area 1. This cold-water coral reef framework is composed by *Lophelia pertusa*. Over the last few years, several methods have been proposed that use *L. pertusa* for palaeotemperature reconstructions. Using these BGS vibro-cores provides a great opportunity to put these techniques into practice and test their validity. It is important to note that both isotopes and traces elements used for palaeotemperature reconstructions are affected by both environmental parameters and coral biology (notably 'vital effects' associated with the rate of coral calcification). Since it has proved difficult to quantify how isotopes and traces elements fractionate during coral calcification the in-situ data from this study will help calibrate these temperature proxies and reduce uncertainties in their application as palaeoceanographic archives. Our future work will measure trace elements ratios (e.g. Mg/Ca and Sr/Ca) and oxygen isotopes in the seawater samples collected during the cruise D340b and then to compare these data with trace element ratios and oxygen isotope values from corals collected from the Mingulay reef.

21.3 Equipment report

At the end of its first deployment, after three successful hauls, the video-grab developed a fault that tripped the topside video unit whenever power was applied to the lights. When brought back on deck and dismantled the problem was traced to the extension leads used on the lights which had slightly parted allowing seawater ingress. The camera and light bracket was simplified, removing the extension leads, and strengthened with two additional metal supports. During its subsequent deployment, the camera and lights worked without tripping. The electro-magnet performed very well to the extent that all the grabs were taken from the target site and not triggered prematurely. During the final deployment period (3-7-09 at approx. 0230 z), the video-grab camera and light bracket was entangled in a rope lying across the seabed in the northern area of Mingulay Area 1. Fortunately the rope came free from the seabed and the video-grab and lights were recovered without damage.

Fig. 21.1 Photograph of video-grab (#1490) showing live coral (bright white) and underlying dead coral framework.

After modifications at sea to the baffles used to produce laminar flow, the experimental flume performed very well providing consistent flow conditions in the ranges 0-25 cm s^{-1} measured using a Nortek Acoustic Doppler Velocimeter (ADV). Unfortunately the video camera and integrated lights were not suitable to record as the diode array within the video camera proved too bright inside the flume. Also the DVR recording unit did not interface correctly with a hard disc recorder. Trials using freshly collected *L. pertusa* within the flume scored by eye every half hour over two hour flow exposures showed some initial evidenced for a relationship between polyp expansion and flow (Fig. 21.2). This work will be further developed in the laboratory.

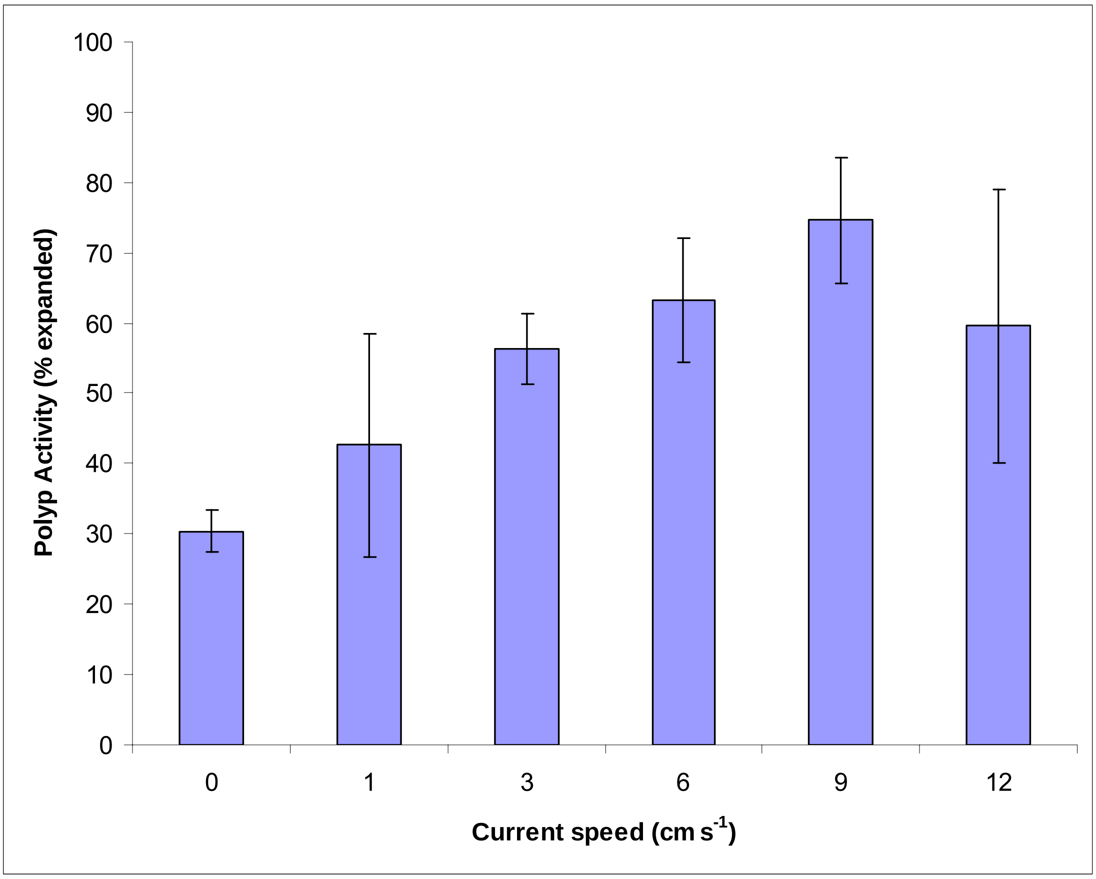


Fig 21.2. The effect of water flow velocity on polyp expansion in *Lophelia pertusa*.

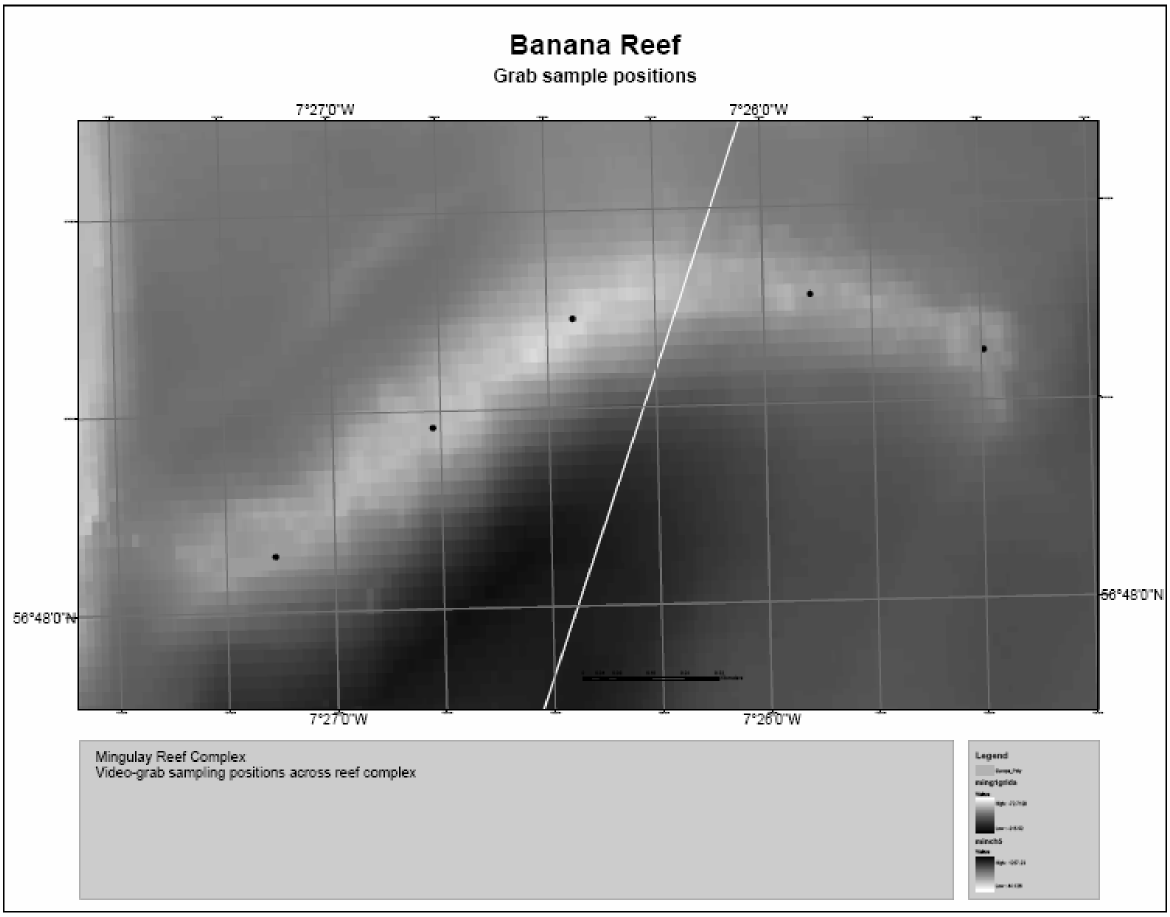


Figure 21.3: Coral sample sites at Banana Reef

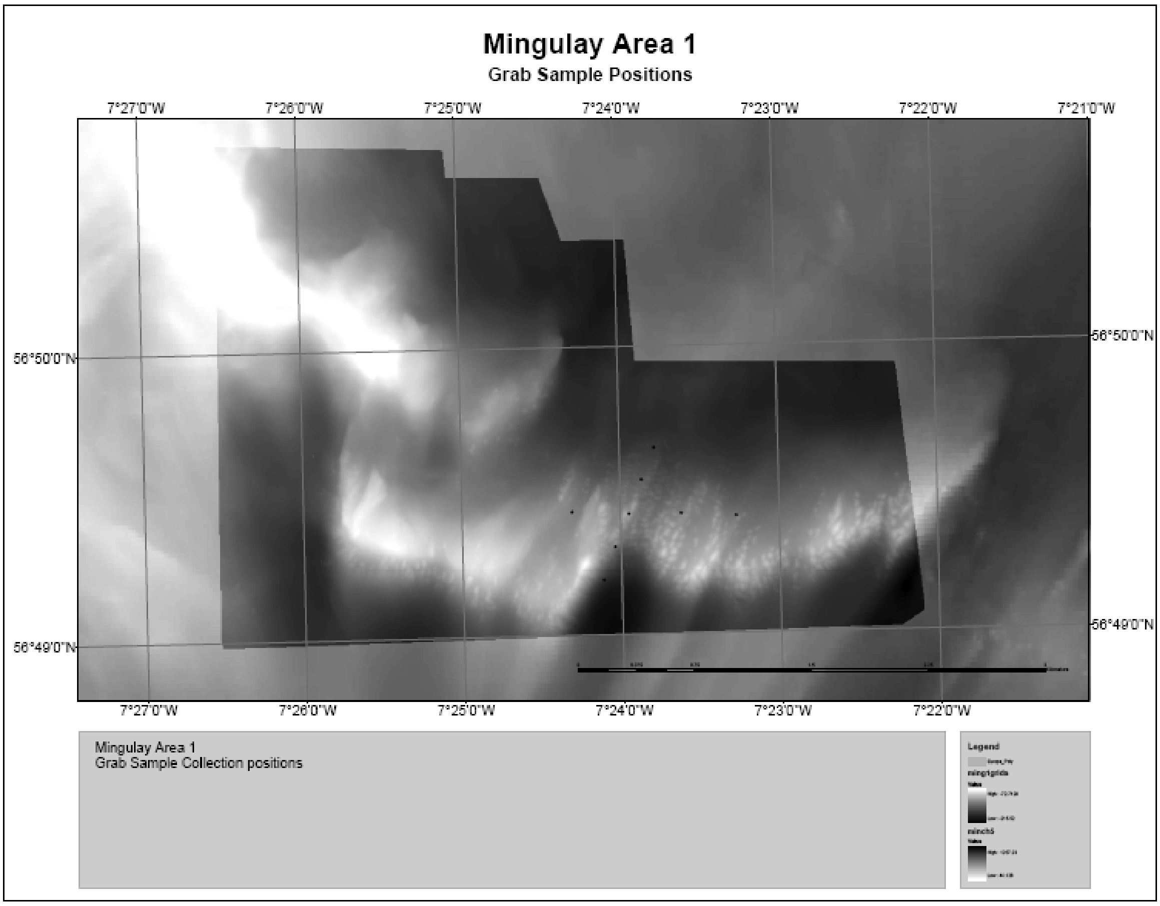


Figure 21.4: Coral sample sites at Mingulay Area 1

21.4 Samples obtained

21.4.1 Video-grab samples

Table 21.1: Summary of video-grab samples

SAMS Deep-sea Benthos Group station number	Date GMT	Position	Depth (m)	Sampling area and grab contents
1484	28-6-09 1532	56 49.134 07 24.796	133	Mingulay Area 1. Two small epifauna-encrusted stones
1485	28-6-09 1715	56 49.38171 07 23.69985	127	Mingulay Area 1. Large sample dead coral framework with rich epifauna
1486	28-6-09 1750	56 49.3832 07 23.6326	133	Mingulay Area 1. Small sample dead coral
1487	1-7-09 1515	5 48.23357 07 26.73868	138	Banana Reef. Live and dead coral with epifauna
1488	1-7-09 1627	56 48.33187 07 26.52099	118	Banana Reef. Small sample dead coral rubble, some epifauna

1489	1-7-09 1808	56 48.38337 07 26.43147	127	Banana Reef. Dead coral
1490	1-7-09 1855	56 48.08807 07 27.19588	165	Banana Reef. Large sample live coral with some dead coral and epifauna
1491	1-7-09 2042	56 49.20902 07 23.5661	108	Mingulay Area 1. Small sample dead coral and epifauna
1492	1-7-09 2134	56 49.3682 07 23.67047	127	Mingulay Area 1. Small sample live coral
1493	1-7-09 2210	56 49.31686 07 23.83956	137	Mingulay Area 1. Live coral
1494	1-7-09 2345	56 49.37223 07 23.702	127	Mingulay Area 1. Live corals, sponges and large ophiuroid
1495	2-7-09 0013	56 49.39496 07 23.73248	134	Mingulay Area 1. Small fragment live coral with dead framework
1496	2-7-09 0104	56 49.3504 07 23.74511	125	Mingulay Area 1. Very small sample coral rubble and fauna
1497	3-7-09 0110	56 49.38464 07 23.75833	134	Mingulay Area 1. Very small sample live coral
1498	3-7-09 0148	56 49.43751 07 23.82588	146	Mingulay Area 1. Small sample live coral with dead framework
1499	3-7-09 0227	56 49.5406 07 23.70533	167	Mingulay Area 1. Grab caught on rope, deployment abandoned. *Alcyonium* & hydroids sampled from rope
1500	3-7-09 0340	56 49.38755 07 23.68426	131	Small sample live coral and single adult *Munida*

21.4.2Water samples

Water samples were obtained from the following CTD casts:

CTD 092: Over Mingulay reef at sack high water at Barra Head (BH) +2

Date: 28-06-09

Time (GMT): 13:20-14:01

Position: 56°49.287 N 07°23. 573 W

Depth: 126.5m

CTD 093: Over Mingulay reef at sack low water at BH+2

Date: 28-06-09

Time (GMT): 18:50-19:32

Position: 56°49.395 N 07°23. 673 W

Depth: 135m

CTD 094: Over reef of max NW flow BH+2
Date: 28-06-09
Time (GMT): 21:13-21:42
Position: 56°49.336 N 07°23. 503 W
Depth: 134 m

CTD 100: Over Mingulay reef at max SW flow BH+2
Date: 01-07-09
Time (GMT): 12:20-12:59
Position: 56°49.337 N 07°23. 414 W
Depth: 119 m

Table 21.2: CTD casts, depths and water samples obtained for trace element and oxygen isotope analysis

		Samples Obtained	
CTD	**Depth**	**Trace Elements**	**Oxygen Isotopes**
CTD 092	2	√	√
	30	√	√
	50	√	√
	70	√	√
	124	√	√
CTD 093	2	√	√
	30	√	√
	50	√	√
	70	√	√
	130	√	√
CTD 093	2	√	√
	30	√	√
	50	√	√
	90	√	√
	125	√	√
CTD 100	2	√	√
	30	√	√
	50	√	√
	70	√	√

	116	√	√

References

Mortensen PB, Roberts JM, Sundt RC (2000). Video-assisted grabbing: a minimally destructive method of sampling azooxanthellate coral banks. Journal of the Marine Biological Association of the UK 80: 365-366

Roberts JM, Brown CJ, Long D, Bates CR (2005) Acoustic mapping using a multibeam echosounder reveals cold-water coral reefs and surrounding habitats. Coral Reefs 24: 654-669

Roberts JM, Davies AJ, Henry L-A, Duineveld GCA, Lavaleye MSS, Dodds LA, Maier C, van Soest RWM, Bergman MIN, Hühnerbach V, Huvenne V, Sinclair D, Watmough T, Long D, Green S, van Haren H (in press) The Mingulay reef complex, northeast Atlantic: an interdisciplinary study of cold-water coral habitat, hydrography and biodiversity. Marine Ecology Progress Series

22 DMS analysis

Andrew Mogg, SAMS

(PIs: Angela Hatton, David Green & Mark Hart)

22.1 Introduction

DMS incubation experiments

Whole seawater incubations were initiated using productive waters from the area off Barra Head to characterise the sulphur metabolism of natural algae and associated bacteria in the presence of antibiotics and added DMSP. See table 11.1 for details of incubation and sample list.

22.2 Method

Incubation experiment

Incubations

6 triplicate 2l incubations were initiated using 40l of 150µm filtered bulk water from the deep chlorophyll maximum (25m) of station M1. Incubations were treated as follows:

-3x whole seawater, untreated (-1,-2,-3)

-3x whole seawater, antibiotic treated to a final concentration 50µg/ml each of chloramphenicol and streptomycin (AB1, AB2, AB3)

-3x whole seawater, treated to a final concentration of 1.5µM DMSP (P1, P2, P3).

-3x whole seawater, treated to a final concentration of 50µg/ml each of chloramphenicol and streptomycin, and 1.5µM DMSP (AB+P1, AB+P2, AB+3).

-3x whole seawater, treated to a final concentration of 1.5 µM DMSO (O1, O2, O3)

-3x whole seawater, treated to to a final concentration of 50µg/ml each of chloramphenicol and streptomycin, and 1.5µM DMSO.

Incubations were set up in a random sequence incubated in fibreglass tanks with a constant supply of fresh seawater and 50% light screens. The incubations were sampled for DMS, DMSP and DMSO immediately after treatment, then once every 24 hours at the same time point to give a T0, T1, T2 time series. Replicate samples for phytoplankton, dissolved organic carbon (DOC), fluorescence in-situ hybridisation (FISH, duplicate) and RNA/DNA denaturing gradient gel electrophoresis (DGGE) were taken from the bulk water at T0, whilst triplicate samples for DGGE were taken from individual incubations after DMS analysis on T1 and T2.

Analysis system

Samples were analysed on a pair of GCs: a Varian 3400 series with an flame photodetector (FPD) for high sulphur concentration detection and a Varian 3400CX series with a pulse flame photodetector for low sulphur concentration detection. The GCs were calibrated daily with a range of standards.

As DMS sulphur is present as a dissolved gas in nanomolar concentrations in seawater, samples were first injected into a sealed purge tube, where they were sparged with oxygen-free nitrogen to purge the DMS off and into a liquid nitrogen cooled cryotrap loop (-150C). The cryotrap concentrated the DMS for 17-30 minutes (depending on sample size) and is then rapidly warmed up in boiling water to release the DMS in the GC.

DMS analysis

A known volume of sample (30-50mls) was drawn up into a syringe and injected through an AP depth filter into the injection port of a sealed purge tube. The filter was removed and stored for later DMSPp analysis. The process was repeated with another known volume of sample for DMSOp. 2mls of deionised water were then injected to rinse the injection port. The sample in the purge tube (60-100mls) was then bubbled with oxygen-free nitrogen at a rate of 60mls/min for 30 minutes. After this time, the cryotrap was immersed in a freshly boiled kettle of water to release the DMS into the GC. DMS sulphur was returned as a peak area, and concentrations were determined using a calibration curve.

After the DMS had been purged off, the sample was split evenly for DMSOd and DMSPd analysis.

DMSOd analysis

The DMSOd sample earlier purged of DMS was analysed using the DMSO reductase enzymatic method. Briefly, the sample was injected into a purge tube containing 2mls of DMSOr solution (25 µg cm^{-3} DMSO reductase, 30 mM EDTA, and 540 pM) FMN) and mixed through the action of 60mls/minute oxygen-free nitrogen, which also promoted microaerophilic conditions. The mixture was illuminated with three 60W equivalent daylight bulbs. Under these conditions, EDTA forms radicals which reduce FMN to FMN H_2. FMN H_2 may then act as an electron donor to DMSOreductase, catalyzing the reduction of DMSO to DMS. The DMS is then analysed as previously described.

Sample storage

DMSOd samples were frozen at -20C until they could be thawed and analysed as previously described. Samples of DMSPd and DMSPp were added to 60ml vial containing 1ml of 10M NaOH, topped up to the brim with deionised water and capped with gastight crimp tops. The purpose of NaOH was to prevent further biological action, lyse cells and convert DMSP into DMS for later anaylsis. Samples for DMSOp were stored in 15ml falcon tubes containing 9mls of 50mM Tris HCL buffer and 1ml of 10M NaOH. All samples were stored in the dark.

For phytoplankton: 100 ml samples were taken and stored using a 1:100 dilution of both lugols iodine and formaldehyde (triplicates for lugols, triplicates for formaldehyde, from bulk water).

For DOC, 10 ml samples were taken and filtered through ashed GF/F filters into an ashed glass DOC vial (triplicate from bulk water). 11µl of orthophosphoric acid was added to fix the sample, and the vial was sealed by melting the neck and twisting shut. The samples were then stored in the dark.

For FISH, 9mls of sample were taken and fixed with 1 ml of formaldehyde for at least 1 hour, The fixed samples were then filtered onto a 47mm 0.2 µm polycarbonate filter and the formaldehyde rinsed off by filtering 10 mls of deionised water. The samples were then stored at -20C. For DGGE, 30 mls of sample were taken and filtered onto a 25mm 0.2 µm polycarbonate filter. The filter was then stored at -20C.

23 Vessel Mounted ADCP (VM-ADCP) and navigation data

John Allen, NOCS (D340 Leg A)

Vladimir Ivanov, SAMS (D340 A & B)

23.1 Introduction

During the refit for RRS Discovery in March 2008, the original narrow band RDI 150 kHz Vessel-Mounted Acoustic Doppler Current Profiler (VM-ADCP) was replaced with an RDI broad band 150 kHz (Ocean Surveyor) phased array style VM-ADCP. This was in addition to the similar 75 kHz Ocean Surveyor instrument that had been in use in the forward ADCP housing since 2001.

The 150 kHz ADCP is mounted in the hull 1.75 m to port of the keel, 33 m aft of the bow at the waterline and at an approximate depth of 5 m. The 75 kHz ADCP is also mounted in the hull, but in a second water chest 4.15 m forward and 2.5 m to starboard of the 150 kHz well.

This section describes the operation and data processing paths for both ADCPs. The navigation data processing is described first since it is key to the accuracy of the ADCP current data. All integrated underway data were logged using the Ifremer TechSAS data logging system that has been gradually implemented on RRS *Discovery* for approximately 3 years. The extensive NMFSS scripts to read the netcdf format TechSAS file streams and create RVS data streams have been developed alongside the implementation of the system and most errors and wrinkles have been worked out. However, a residual problem with the reading precision of position data (nclistit) was noticed and it is recommended that this is addressed as soon as practical, an extra 2 characters should be sufficient. The number of characters for position is constant, and currently if degrees of latitude or longitude are less than ten then the precision is 10^{-6} (i.e. ~ 10 cm resolution – and indeed this appears to be the limit of the netcdf data), however where degrees of latitude or longitude exceed 10 then the precision read reduces to 10^{-5} (i.e. only ~ 1 m resolution), and should the longitude exceed 100 degrees then the precision read would decrease to 10^{-4} (i.e ~ 10 m resolution !!).

23.2 Method

23.2.1 Navigation

The ship's primary position instrument was the GPS Trimble 4000 system. The positional accuracy for the GPS 4000 system was determined from the data recovered whilst tied up alongside in Reykjavik (**Figure 23.1**). Standard deviation for positional accuracy was ~ 2.13 m in latitude and 1.53 m in longitude, but some of this maybe due to heave in the mooring lines.

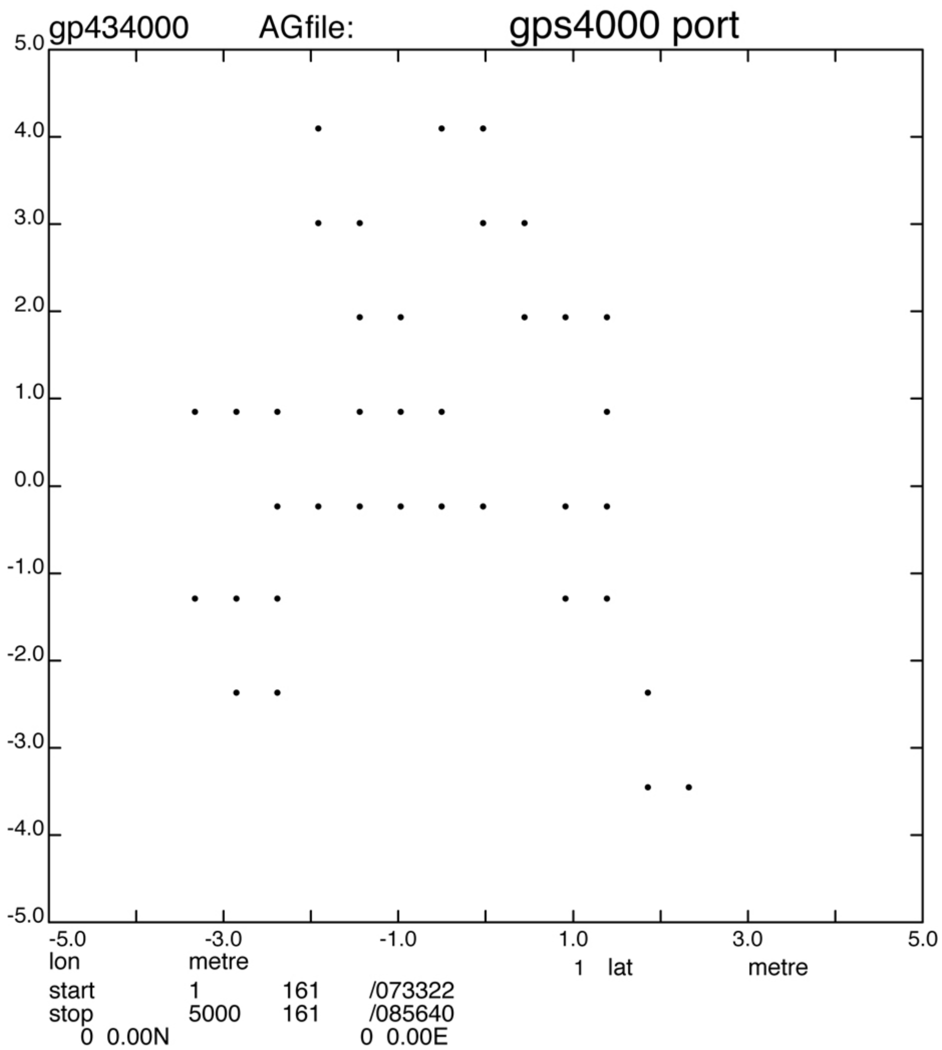


Figure 23.1. Positional accuracy in port at the beginning of the cruise for the gps4000 system

The GPS 4000 system therefore had sufficient precision to enable the calculation of ship's velocities to better than 1 cms^{-1}, and therefore below the instrumental limits (~ 1 cms^{-1}) of the RDI ADCP systems. Using the GPS 4000 system as its primary navigation source, the

NMFSS Bestnav combined (10 second) clean navigation process was operational and working well on D340.

Navigation and gyro data were transferred daily from the RVS format file streams to pstar navigation files, e.g. abnv3401, gp434001 and gyr34001.

Scripts:

navexec0: transferred data from the RVS *bestnav* file to PSTAR, calculated the ships velocity, appended onto the absolute (master) navigation file and calculated the distance run from the start of the master file. Output: abnv3401

gyroexec0: transferred data from the RVS gyronmea file to Pstar, a nominal edit was made for directions between 0-360° before the file was appended to a master file.

gp4exec0: transferred data from the RVS gps_4000 file to Pstar, edited out pdop (position dilution of precision) greater than 7 and appended the new 24 hour file to a master file. The master file was averaged to create an additional 30 second file and distance run was calculated and added to both.

23.2.2Heading

The ships attitude was determined every second with the ultra short baseline 3D GPS Ashtech ADU2 navigation system. During the preceding refit, all four antennae had been removed and replaced with the single mast Christmas tree antennae system originally fitted to RRS *Charles Darwin*.

The Ashtech data were used to calibrate the gyro heading information as follows:

ashexec0: transferred data from the RVS format file gps_ash to pstar.

ashexec1: merged the ashtech data from ashexec0 with the gyro data from gyroexec0 and calculated the difference in headings (hdg and gyroHdg); ashtech-gyro (a-ghdg).

ashexec2: edited the data from ashexec1 using the following criteria:

heading	0 < hdg < 360 (degrees)
pitch	-5 < pitch < 5 (degrees)
roll	-7 < roll < 7 (degrees)
attitude flag	-0.5 < attf < 0.5
measurement RMS error	0.00001 < mrms < 0.01
baseline RMS error	0.00001 < brms < 0.1
ashtech-gyro heading	-7 < a-ghdg < 7 (degrees)

The heading difference (a-ghdg) was then filtered with a running mean based on 5 data cycles and a maximum difference between median and data of 1 degree. The data were then averaged to 2 minutes and further edited for

-2 < pitch <2

0 < mrms < 0.004

The 2 minute averages were merged with the gyro data files to obtain spot gyro values. The ships velocity was calculated from position and time, and converted to speed and direction. The resulting a-ghdg should be a smoothly varying trace that can be merged with ADCP data to correct the gyro heading. Diagnostic plots were produced to check this. During ship manoeuvres, bad weather or around data gaps, there were spikes which were edited out manually (plxyed, Fig.23.2).

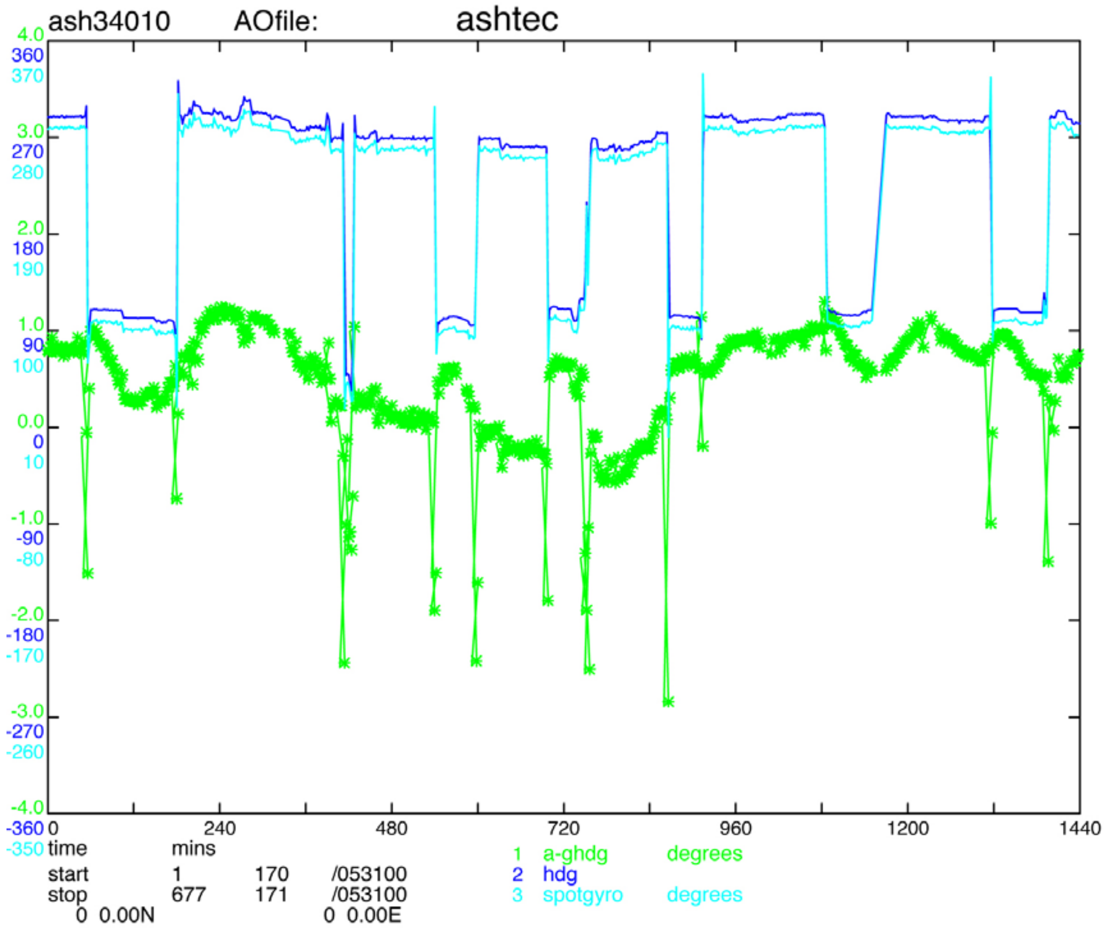


Fig. 23.2. Example of the onscreen output of daily navigation hdg data generated by gyro (blue line) and ashtech (green line)

Ashtech 3D GPS coverage was generally good. Gaps over 1 minute in the data stream are listed below.

time gap : 09 163 01:16:14 to 09 163 01:17:15 (61 s)

time gap : 09 163 07:50:29 to 09 163 09:08:48 (78.3 mins) time gap : 09 163 17:25:39 to 09 163 19:47:07 (2.4 hrs)

time gap : 09 164 01:47:50 to 09 164 01:49:21 (91 s)

time gap : 09 164 19:43:26 to 09 164 19:44:28 (62 s)

time gap : 09 165 17:09:27 to 09 165 17:14:48 (5.3 mins)

time gap : 09 167 17:05:00 to 09 167 17:06:06 (66 s)

time gap : 09 168 17:33:27 to 09 168 17:40:53 (7.4 mins)

time gap : 09 169 22:16:16 to 09 169 22:17:19 (63 s)

time gap : 09 171 00:42:29 to 09 171 00:43:36 (67 s)

time gap : 09 171 01:52:46 to 09 171 01:53:48 (62 s)

time gap : 09 171 02:01:24 to 09 171 02:02:26 (62 s)

time gap : 09 171 02:09:28 to 09 171 02:10:51 (83 s)

time gap : 09 172 15:21:12 to 09 172 15:22:16 (64 s)

time gap : 09 173 17:17:00 to 09 173 17:18:05 (65 s)

23.2.3 VM-ADCP data

This section describes the operation and data processing paths for both ADCPs, and closely follows that used on RRS *Discovery 332*.

23.2.4 75 kHz and 150 kHz VM-ADCP data processing

The RDI Ocean Surveyor 150 kHz Phased Array VM-ADCP was configured to sample over 120 second intervals with 100 bins of 4m depth and a blank beyond transmit of distance of 4m. The instrument is a broad-band phased array ADCP with 153.6 kHz frequency and a 30° beam angle.

The RDI Ocean Surveyor 75 kHz Phased Array VM-ADCP was configured to sample over 120 second intervals with 100 bins of 8m depth and a blank beyond transmit of distance of 8m. The instrument is a broad band phased array ADCP with 76.8 kHz frequency and a 30° beam angle.

Both deck units had firmware upgrades to VMDAS 23.17 after the March 2008 refit. Both PCs ran RDI software VmDAS v1.46 to begin with. On JDay 165 (14th June) we reverted to VmDAS v1.42 on both PCs (files adp34005 and sur34005 onwards) in order to try to repeat the Matlab processing of VM-ADCP data carried out by Dr. M. Inall on RRS *Discovery* D312.

Gyro heading, and GPS Ashtech heading, location and time were fed as NMEA messages into the serial ports of the both PCs and VmDAS was configured to use the Gyro heading for co-ordinate transformation. VmDAS logs the PC clock time, stamps the data (start of each ensemble) with that time, and records the offset of the PC clock from GPS time. This offset was applied to the data in the processing path before merging with navigation.

The 2 minute averaged data were written to the PC hard disk in files with a .STA extension, eg D340001_000000.STA, D340002_000000.STA etc. for the 150kHz data and D340_75001_000000.STA, D340_75002_000000.STA etc. for the 75 kHz data. Sequentially numbered files were created whenever data logging was stopped and re-started. The software was set to close the file once it reached 100MB in size, though on D340 files were closed and data collection restarted daily such that the files never became that large. All files were transferred to the unix directories /data32/d340ro/os150/raw and /data32/d340ro/os75/raw as appropriate. This transfer included the plethora of much larger ping by ping data files, these can be useful in the event of major failure of the ship's data handling systems as they record all the basic navigation and ships heading/attitude data supplied by NMEA message.

Both instruments were configured to run in 'Narrowband' range over resolution mode. Bottom tracking was used throughout D340b.

The VM-ADCP processing path followed an identical route to that developed in 2001 for the 75 kHz ADCP (RRS *Discovery* cruise 253). In the following script descriptions, "##" indicates the daily file number.

S75exec0 and S150exec0: data read into Pstar format from RDI binary file (psurvey2). Water track velocities written into "sur" (75kHz) or "adp" (150kHz) files, bottom track into "sbt" (75kHz) or "sur" (150kHz) files if in bottom track mode. Velocities were scaled to cm/s and amplitude by 0.45 to db. The time variable was corrected to GPS time by combining the PC clock time and the PC-GPS offset. An offset depth for the depth bins was provided in the user supplied information (13 m for the 75kHz and 9 m for the 150 kHz instruments), this equated to the sum of the water depth of the transducer in the ship's hull (~5 m in RRS *Discovery*) and the blank beyond transmit distance used in the instrument setup (see earlier). Output Files: 75kHz (sur340##.raw, sbt340##.raw), 150 kHz (adp340##.raw, bot340##.raw).

S75exec1 and s150exec1: data edited according to status flags (flag of 1 indicated bad data). Velocity data replaced with absent data if variable "2+bmbad" was greater than 25% (% of pings where >1 beam bad therefore no velocity computed). Time of ensemble moved to the end of the ensemble period (120 secs added with pcalib). Output files: 75kHz (sur340##, sbt340##), 150 kHz (adp340##, bot340##).

S75exec2 and s150exec2: this merged the adcp data (both files) with the ashtech a-ghdg created by ashexec2. The adcp velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables. Output files: 75kHz (sur340##.true, sbt340##.true), 150 kHz (adp340##.true, bot340##.true).

S75exec3 and s150exec3: applied the misalignment angle, ø, and scaling factor, A, to both files. Variables were renamed and re-ordered to preserve the original raw data. Output Files: 75kHz (sur340##.cal, sbt340##.cal), 150 kHz (adp340##.cal, bot340##.cal).

S75exec4 and s150exec4: merged the adcp data (both files) with the bestnav (10 sec) NMFSS combined navigation imported to pstar through navexec0 (abnv3401). Ship's velocity was calculated from spot positions taken from the abnv3401 file and applied to the adcp velocities. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 2 minute ensemble by subtracting 60 seconds and new positions were taken from abnv3321. Output Files: 75kHz (sur340##.abs, sbt340##.abs), 150 kHz (adp340##.abs, bot340##.abs).

23.2.5 75 kHz and 150 kHz VM-ADCP calibration

A calibration of both VM-ADCPs was achieved during D340A using bottom tracking data available from our departure from Reykjavik across the Icelandic continental shelf. No further calibration was deemed necessary from inspection of the processed data during the cruise. Using long, straight, steady speed sections of standard two minute ensemble profiles over reasonably constant bottom depth the following calibrations for mis-alignment angle, ϕ, and necessary amplification (tilt), A, were derived by comparing GPS derived component vectors of the vessel speed and direction with processed VM-ADCP bottom track determined component vectors of the vessel speed and direction:

150 kHz:

ϕA

mean1.5315312891.001492999

s.d0.1265279060.002441841

75 kHz:

ϕA

mean0.034627721.001979978

s.d.0.143425350.002759036

Both of these calibrations were somewhat different to those obtained on D332, but RRS *Discovery* had been in dry-dock refit over the intervening winter, and, although it was not thought that the ADCPs had been removed on this occasion, it is not unreasonable that some rotation of order 1-1.5 degrees might have occurred as a result of the general upheaval of such a procedure.

23.3 Results and Discussion

Initial data inspection included two stages. At the first stage absolute velocity vectors at selected depths, **41 m** (75 kHz), and **23 m** (150 kHz) were averaged in 4 km regular grid and plotted along the ship track. Visual comparison of these plots allowed rough assessment of the data consistency. An example of such plot is shown in Fig.23.3.

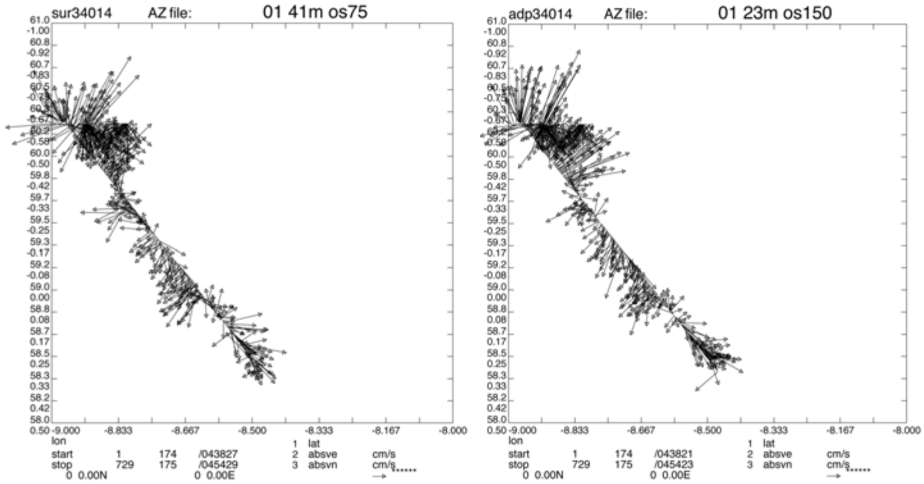


Fig. 23.3. Absolute velocity vectors for 2 minutes ensemble average

Vertical sections of 4km averaged data where then plotted for each of the scanfish lines run during D340b. Figure 23.4 shows the N/S velocity component from the 150kHz instrument along the Scanfish line SB-E (see Figure 5.1).

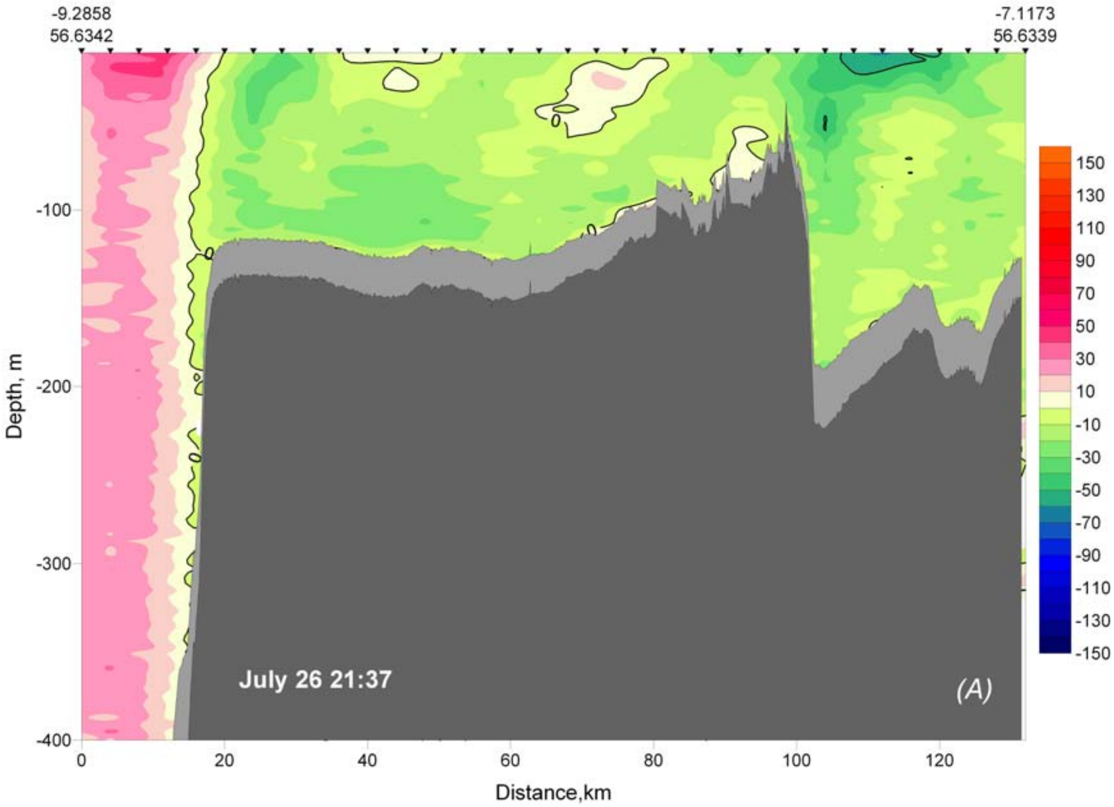


Figure 23.4: Meridional component of velocity from the 150 kHz VM-ADCP during Scanfish line SB-E (see Figure 5.1 for location).

24 Computing and Instrumentation

Chris Barnard, NMF-SS

24.1 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_4kl)
2) Chernikeef EM speed log (converted to RVS format as log_chfl)
3) Ships Gyrocompass (converted to RVS format as gyrol)
4) Simrad EA500 Precision Echo Sounder (ea500l)
5) NMFD Surface-water and Meteorology (SURFMETl) instrument suite
6) ASHTECH ADU-2 Altitude Detection Unit (gps_ash)
7) NMFD Winch Cable Logging And Monitoring CLAM (winch)
8) Ashtech GPS G12 integral to the FUGRO Seastar DGPS receiver (gps_g12l)
9) Seabird SBE45 MicroTSG (seabirdl)

24.2 Techsas NetCDF to RVS Data Conversion

The Techsas system is capable of network broadcasts and is now recorded directly to RVS Data streams using an application called fromTechsas which calls a portgrabber application to listen to all the UDP Ports that TECHSAS uses.

An in house application was used to handle the conversion of NetCDF files to the RVS format. This was then parsed back to the data file and was processed as normal. These 2 applications being ncvars and nclistit.

These new binaries require to environment variables in order to function:

$NCBASE – the base for the NetCDF binaries system, set to /rvs/def9

$NCRAWBASE – the base for the raw data files, set to /rvs/pro_data/TECHSAS/T1backup/D40/NetCDF

The existing $PATH variable must also include the path to the nc binaries, the path /rvs/def9/bin was appended to the $PATH variable.

All Techsas data file names are in the format of YYYYMMDD-HHMMSS-name-type.category with the data/timestamp being the time the file was created by Techsas.

The files were each processed in the following way for this cruise:

nclistit 20060813-000001-gyro-GYRO.gyr - | sed s/head/heading > $DARAWBASE/gyro.225

At this stage the data is converted to the correct format and its header replaced by the header required by the RVS software suite.

The file is then passed to the titsil application which simply reads the data from the text file that was created and enters it as records in the RVS data file.

cat $DARAWBASE/gyro.225 | titsil gyronmea –

This command reads the gyro.225 file in the /rvs/raw_data directory and passes it to titsil for input in the gyronmea file. The – dictates that all variables will be included.

The TECHSAS system was set to create a new file for each day, however on days when errors occurred multiple files were created as that is normal practice for Techsas when it is restarted.

24.3 Fugro Seastar DGPS Receiver

The Fugro Seastar is the source of custom differential corrections based on its position fixed by its internal Ashtec G12 GPS module. It outputs corrections via RS-232 using the standards RTCM message. The message is distributed among all GPS receivers where they are used to compute their own DGPS positions.

The Fugro Seastar functioned correctly throughout the cruise. There have been issues with this system previously not detecting the correct satellites due to location. However in this instance it performed correctly and differential positions were calculated throughout the cruise.

NetCDF files for this system ADUPOS-G12PAT.gps.

24.4 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

24.5 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 G12 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

24.6 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

24.7 RDI Ocean Surveyor 75KHz 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.

100 Bins; 8 Meter Bin Size; 8 meter Blank; 5.3 Meter Transducer Depth; Hi Resolution (short Range); Ping as fast as possible.

24.8 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.

100 Bins; 4 Meter Bin Size; 4 meter Blank; 5.3 Meter Transducer Depth; Hi Resolution (short Range); Ping as fast as possible.

24.9 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 Chernikeef was accurate at the lower speeds but then an offset was obvious when the speed was increased at 10.6 Knots over ground the speed of the Chernikeef was at 8 Knots.

The system was logged by the TECHSAS logging system.

DYLog-LOGCHF-DYLog

24.10 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 PES was deployed on the fish as soon as we stopped to deploy the first CTD. 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 ea500d1 on the TECHSAS System.

EA500 on Hull Transducer 09 176 000000

EA500 off 09 184150000

24.11 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. TSG flow is approx 25 litres per minute whilst fluorometer and transmissometer flow is approx 3 l/min. Flow to instruments is degassed using a debubbler with 40 l/min inflow and 10/l min waste flow.

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.

Surfmet Non Toxic On around 091760000

Surfmet Non Toxic Off (End of Cruise) 09184123500

For Salinity Samples please see the scientists log sheets and report. I intend to perform a regression and trend analysis on the data once I have access to it during the 2nd leg as the SBE45 is quite a new system on board Discovery.

The SBE45 unit was changed prior to sailing as another unit had just been returned from Calibration at Seabird and was available for the cruise while the existing unit was out of calibration.

The Transmissometer was also changed prior to sailing for this reason.

The Light Sensors on the foremast appeared not to be working during the Mobilisation due to a fault in the Starboard TIR Sensor. This was changed for a spare unit and appears that the fault was due to the connector on the new cable system that Kipp and Zonen have now adopted.

Techsas NetCDF Files for Surfmet

Surf-SURFMET.SURFMETv2

MET-SURFMET.SURFMETv2

Light-SURFMET.SURFMETv2

SBE45-SBE45.TSG

Surfmetl is the TECHSAS Logged file

Surftmp is the cleaned file

24.12 Network Services

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

24.13 Data Storage

Two USB external hard drives are being use as a RAID 0 mirror hosted by Discovery3 at the /data32 export. The mirror uses the modern meta device commands available in Solaris 10. This increases storage robustness by providing another layer of redundancy at the online storage level. The maintenance and administration of the disk set is minimal and the performance more than adequate.

All cruise data except for the /rvs path were stored on this storage area. Access was given to scientists to some of the folders via Samba shares.

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

PSTAR was used directly on data32 directory.

Level C data was logged to the discovery1 internal disk, Techsas backs its data to here under /rvs/pro_data/TECHSAS and also stores it on its own internal raided drive array.

24.14 Data Backups

Backups of the Level C data were done twice daily as a tar file to DLT tape and 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

In addition to the redundancy provided by the RAID 0 pair, daily backups of the /data32 directory were done by a tar of the file system to the LTO 2 tape. The whole disk was backed up not just current cruise data.

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

24.15 Data Archiving

The proposed data archive will consist of the following components.

1) All CTD data
2) All ADCP data
3) All LADCP Data
4) All TECHSAS NetCDF data files
5) All RVS Data Streams including Listit Text file outputs
6) Moored ADCP Data from STC.

All PSTAR Data will be taken back by hard drive at the end of the cruise as well as Tapes being made as a backup and returned to NOCS.

24.16 Surfmet Sensor Information

Ship	RRS Discovery
Cruise	D340a andb
Technician	Chris Barnard
Date	21/06/09

Manufacturer	Sensor	Serial no	Comments
SeaBird	SBE 38 Digital Thermometer	0476	Remote Seawater Temperature
SeaBird	SBE 45 microTSG	0229	Housing Temperature and Conductivity Swapped Prior to Cruise
Wetlabs	Fluorometer	WS3S-247	
Wetlabs	Transmissometer	CST-113R	Swapped Prior to Cruise
Vaisala	Barometer PTB100A	S361008	Port Foremast
Vaisala	Temp/humidity HMP45	B4950010	Port Foremast
Skye	PAR	28557	Port
Skye	PAR	28556	Starboard
Kipp and Zonen	TIR CMB6	994133	Port
Kipp and Zonen	TIR CMB6	962301	Starboard Swapped Prior to Cruise
Sensors without cal			
Gill	Windsonic	071123	Port Foremast

SPARES

Manufacturer	Sensor	Serial no	Comments
Seabird	SBE 38 Digital Thermometer	416, 475	
Seabird	SBE 45 MicroTSG	0233	
Wetlabs	Fluorometer	N/A	
Wetlabs	Transmissometer	CST-112R, CST-113R	
Vaisala	Barometer PTB100A	S3440012	
Vaisala	Temp/humidity HMP45	C132001	
Skye	PAR	28559	
Skye	PAR	N/A	
Kipp and Zonen	TIR CMB6B	N/A	
Kipp and Zonen	TIR CMB6B	N/A	
Sensors without cal			
Gill	Windsonic	071121	

Appendix 1

Appendix 1
D340b Event Log

D340b Event Log

Evt No.	Date	Station	Latitude	Longitude	Sounding (m)	Time IN	Time bottom	Time OUT	Activity	Comments
001	26/06/09	BH	56° 36.06’ N	07° 43.03’ W	113	05:35	05:47	06:07	CTD087	Stainless Steel frame (SS)
002	26/06/09	BH	56° 38.03’ N	07° 42.55’ W	101	06:42			Mooring deployment	SAMS minilogger single pt rig 06:42 in water, 07:32 weights released End lat: 56° 37.33’ N. End lon: 07° 44.92’ W
003	26/06/09	W	56° 38.06’ N	08° 09.91’ W	139	09:05	09:12		Mooring deployment	SAMS ADCP and RBR T-chain
004	26/06/09	W	56° 37.99’ N	08° 09.93’ W	139	09:31	09:38	09:55	CTD088	SS
005	26/06/09	W	56° 38.01’ N	08° 09.82’ W	139	09:36	09:40	09:44	Plankton net #1	15m cast. Net Lost
006	26/06/09	SB	56° 38.06’ N	09°14.07’ W	1004	13:40	14:11	15:05	CTD089	SS
007	26/06/09	SB to BH	56° 37.99’ N	09° 15.59’ W	1045	17:11		27/06/09 02:18	Scanfish #1	End lat: 56° 38.01’ N. End lon: 07° 06.17’ W End depth: 130 m
008	27/06/09	BH	56° 37.36’ N	07° 44.92’ W	80	04:36			Mooring deployment	Lander ADCP model: WHS300-I-UG714. Serial No: 10628
009	27/06/09	BH	56° 37.34’ N	07° 44.86’ W	76	04:58		05:45	T/Fl chain #1	Recovered earlier than planned to allow for unplanned mooring recovery (Event 010)
010	27/06/09	BH	56° 37.51’ N	07° 44.96’ W	97	06:03		06:22	Mooring recovery	06:03 release signal sent. 06:12 grappled. 06:22 on board. (SAMS minilogger single pt rig). This mooring (Event 002) had to be recovered, shortened, and redeployed
011	27/06/09	BH	56° 37.35’ N	07° 44.75’ W	85	06:55	07:01	07:15	CTD090	SS
012	27/06/09	BH	56° 37.35’ N	07° 44.93’ W	87	07:43			Mooring deployment	SAMS minilogger single pt rig – redeployment of shortened mooring
013	27/06/09	BH	56° 37.10’ N	07° 44.10’ W		09:57		28/06/09 11:20	T/Fl chain #2	Redeployed End lat: 56° 35.4’N End long: 7° 43.3’ W
014	27/06/09	BH	56° 37.15’ N	07° 44.04’ W	91	09:56		15:00	MSS90 #1	Microstructure profiler. Deployment interrupted at 15:00 to allow for CTD cast
015	27/06/09	BH	56° 37.20’ N	07° 43.80’ W	83	15:13	15:21	15:48	CTD091	SS
016	27/06/09	BH	56° 37.34’ N	07° 43.88’ W	95	15:51		28/06/09 11:05	MSS90 #1	Continuation of profiling
017	28/06/09	M1	56° 49.29’ N	07° 23.57’ W	127	13:19	13:30	14:02	CTD092	SS
018	28/06/09	M1	56° 49.40’ N	07° 23.98’ W	129	14:30	~15:32	15:53	GRAB #1	Grab position Lat: 56° 49.13’ N, Lon:07° 24.80’ W
019	28/06/09	M1	56° 49.65’ N	07° 23.07’ W	183	16:26	17:15	17:19	GRAB #2	Grab position Lat: 56° 48.38’ N, Lon: 07° 23.71' W
020	28/06/09	M1	56° 49.40’ N	07° 23.68’ W	137	17:25			GRAB #3	Grab fired too soon, small samples of dead coral retrieved.
021	28/06/09	M1	56° 49.38’ N	07° 23.63’ W	133	17:50		18:14	GRAB #4	Video link kept cutting out so removed from water to fix problem
022	28/06/09	M1	56° 49.40’ N	07° 23.66’ W	136	18:50	19:00	19:22	CTD093	SS
023	28/06/09	M1	56° 49.33’ N	07° 23.50’ W	134	21:07	21:13	21:42	CTD094	SS

Evt No.	Date	Station	Latitude	Longitude	Sounding (m)	Time IN	Time bottom	Time OUT	Activity	Comments
024	28/06/09	M1	56° 49.03' N	07° 24.25' W	154	22:37		29/06/09 11:30	Scanfish #2	First profile 23:12 End position: Lat: 56° 44.65' N, Lon: 07° 2.52' W
025	29/06/08	W	56° 38.05' N	08° 11.07' W	137	14:10	14:19	14:47	CTD095	SS
026	29/06/08	W	56° 37.30' N	08° 11.29' W	140	15:20		30/06/09 16:58	T/Fl chain #3	End position: Lat: 56° 38.59' N, Lon: 08° 10.54' W
027	29/06/09	W	56° 37.35' N	08° 11.32' W	140	15:30		30/06/09 07:13	MSS90 #2	Break for CTD
028	30/06/09	W	56° 37.50' N	08° 10.71' W	136	07:15	07:26	07:57	CTD096	SS
029	30/06/09	W	56° 37.90' N	08° 10.49' W	135	08:07		12:59	MSS90 #2	Resumed after break for CTD
030	30/06/09	W	56° 38.56' N	08° 10.87' W	137	13:08	13:17	13:39	CTD097	SS
031	30/06/09	W	56° 38.'57' N	08° 10.79' W	135	13:45		16:41	MSS90 #2	Resumed after break for CTD End position Lat: 56° 38.33' N, Lon: 08° 10.74' W
032	30/06/09	W	56° 38.59' N	08° 10.54' W	134	17:06	17:14	17:20	CTD098	No sampling, just collecting water for coral flume tank
033	30/06/09	W	56° 38.16' N	08° 10.37' W	134	17:36			CTD099	No sampling, just collecting water for coral flume tank
034	30/06/09	W	56° 38.02' N	08° 00.59' W	110	18:48	19:00	19:05	Grab #5	Test grab. Grab closed at 19:00 Lat: 56° 38.09' N Lon: 08° 00.54' W
035	30/06/09	W	56° 37.99' N	08°02.84' W	116	19:45		20:14	Scanfish #3	Scanfish recovered due to technical problem
036	30/06/09	W	56° 37.98' N	08° 09.40' W	137	22:21		01/07/09 05:53	Scanfish #3	Scanfish redeployed. Started recording 22:45 End lat:56°42.58'N End lon: 08°00.54'W
037	01/07/09	Tiree Passage	56° 37.42' N	06° 24.08' W	20	07:52			Mooring recovery	Mooring grappled, but dropped. To be recovered from R.V. Calanus instead.
038	01/07/09	M1	56° 49.35' N	07° 23.37' W	133	12:20	12:27	12:59	CTD100	SS
039	01/07/09	B2	55° 48.22' N	07° 26.73' W	144	13:48	15:15	15:22	Grab #6	Grab closed at 15:15 at Lat: 56° 48.23' N, Lon: 07° 26.74' W. (End Lat: 56° 48.27' N, End Lon: 07° 26.69' W). 'Banana Reef'
040	01/07/09	B3	56° 48.39' N	07° 26.44' W	130	15:55	16:27	16:32	Grab #7	Grab closed 16:27 at Lat: 56° 42.33'N Lon: 07° 26.53' W (End Lat: 56°48.34'N, End Lon: 07° 26.54' W). 'Banana Reef'.
041	01/07/09	B4	56° 48.39' N	07° 25.89' W	157	16:55	18:08	18:14	Grab #8	Grab closed 18:08 at Lat: 56°48.38'N, Lon: 07° 26.43' W (End Lat: 56° 48.35' N, End Lon: 07° 26.51' W). 'Banana Reef'.
042	01/07/09	B1	56° 48.08' N	07° 27.17' W	161	18:36	18:55	19:01	Grab #9	Grab closed 18:55 at Lat: 56° 48.09' N, Lon: 07° 27.20' W (End Lat: 56° 48.12' N, End Lon: 07° 27.29' W). 'Banana Reef'.
043	01/07/09	M1	56° 49.33' N	07° 23.49' W	130	19:52	20:42	20:47	Grab #10	Grab closed 20:42 at Lat: 56° 49.21' N, Lon 07° 23.57' W. Dead coral.
044	01/07/09	M1	56° 49.48' N	07° 23.62' W	152	21:08	21:34	21:39	Grab #11	Grab closed 21:34 at Lat: 56° 49.37' N, Lon 07° 23.67' W. Live coral.
045	01/07/09	M1	56° 49.34' N	07° 23.75' W	125	21:59	22:10	22:14	Grab #12	Grab closed 22:10 at Lat: 56° 49.32' N, Lon: 07° 23.84' W. Live coral.
046	01/07/09	M1	56° 49.31' N	07° 23.78' W	129	22:34	22:48	22:53	Grab #13	Grab closed 22:48 at Lat: 56° 49.34' N, Lon: 07° 23.73' W. Did not close.
047	01/07/09	M1	56° 49.35' N	07° 23.72' W	124	23:10	23:45	23:49	Grab #14	Grab closed 23:45 at Lat: 56° 49.37' N, Lon: 07° 23.70' W. Live coral.

Evt No.	Date	Station	Latitude	Longitude	Sounding (m)	Time IN	Time bottom	Time OUT	Activity	Comments
048	02/07/09	M1	56° 49.37' N	07° 23.70' W	128	00:00	00:13	00:18	Grab #15	Grab closed 00:13 at Lat: 56° 49.39' N, Lon: 07° 23.73' W
049	02/07/09	M1	56° 49.40' N	07° 23.76' W	140	00:31	01:04	01:12	Grab #16	Grab closed 01:04 at Lat: 56° 49.35' N, Lon: 07° 23.74' W. All on deck 01:12 at lat: 56° 49.36' N, Lon: 07° 23.77' W. 127 m.
050	02/07/09	W	56° 38.23' N	08° 10.24' W	134	04:20	04:31	05:09	Mooring Recovery	ADCP and thermistor chain recovered. Grappled at 04:31. All on board 05:09.
051	02/07/09	BH	56° 36.73' N	07° 45.27' W	98	06:57		20:03	T/Fl Chain #4	End Lat: 56° 36.63' W, End Lon: 07° 44.89' W
052	02/07/09	BH	56° 36.59' N	07° 45.09' W	99	07:15		13:02	MSS90 #3	Break for CTD
053	02/07/09	BH	56° 36.34' N	07° 45.43' W	107	13:10	13:20	13:38	CTD101	SS
054	02/07/09	BH	56° 36.33' N	07° 45.18' W	110	13:49		19:48	MSS90 #3	Profiler resumed after CTD End Lat: 56° 36.56' N, End Lon: 07° 45.07' W
055	02/07/09	BH	56° 37.29' N	07° 45.20' W	86	20:32	20:51	20:57	Mooring Recovery	LANDER ADCP. Release signal sent 20:32. Grappled 20:51. All on board 20:57.
056	02/07/09	BH	56° 37.40' N	07° 45.37' W	93	21:10	21:30	21:37	Mooring Recovery	SAMS minilogger single pt rig. Release signal sent 21:10. Grappled 21:30. All on board 21:37.
057	03/07/09	M1	56° 49.31' N	07° 23.75' W	127	00:16	01:07	01:10	Grab #17	Grab closed 01:07 Lat: 56° 49.38' N, Lon: 07° 23.76' W
058	03/07/09	M1	56° 49.47' N	07° 23.89' W	146	01:28	01:48	01:52	Grab #18	Grab closed 01:48. Lat: 56° 49.43' N, Lon: 07° 23.83' W
059	03/07/09	M1	56° 49.47' N	07° 23.78' W	157	02:10	02:45	02:48	Grab #19	No coral
060	03/07/09	M1	56° 49.29' N	07° 23.76' W	116	03:19	03:46	03:49	Grab #20	Grab closed 03:46 Lat: 56° 49.30' N, Lon: 07° 23.68' W. End position Lat: 56° 49.42' N, Lon: 07° 23.67' W.
061	03/07/09	BH to SS	56° 37.64' N	07° 44.37' W	92	05:43		11:55	Scanfish #4	End Lat: 55° 54.97' N, End Lon: 08° 00.01' W

Appendix 2

Appendix 2
D340b CTD Log Sheets

Key to acronyms and abbreviations

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

DO = dissolved oxygen
Chl = chlorophyll
POC/PON = particulate organic carbon / particulate organic nitrogen
Primary prod. = primary productivity
Bact. prod. = bacteria production
Bact. abund. = bacterial abundance
Plankt. = phytoplankton abundance
DMS = dimethyl sulphide
HDB = hydrocarbon degrading bacteria
Deck-board incubs. = deck-board incubations
DOC/N = dissolved organic carbon / dissolved organic nitrogen

Shaded rows of CTD logs indicate problems with bottle firings

D340b CTD log sheet

Station	BH	CTD No	087	Date	26/06/09
Lat	56° 36.01' N	Event No	001	Time I/W	05:35 GMT
Lon	07° 43.04' W	Depth	113 m	Time bottom	05:47 GMT
Filename	D340_CTD_087.hex	Cast Depth	100 m	Time O/W	06:07 GMT
Weather	Calm				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	100	05:48	X				X												1
2	2	2	100	05:48																	2
3	3	3	80	05:52					X												3
4	4	4	80	05:52		X															4
5	5	5	60	05:55	X				X												5
6	6	6	60	05:55																	6
7	7	7	40	05:58					X												7
8	8	8	40	05:58																	8
9	9	9	30	06:00					X												9
10	10	10	30	06:00																	10
11	11	11	24	06:02					X												11
12	12	12	24	06:02																	12
13	13	13	15	06:04					X												13
14	14	14	15	06:04		X															14
15	15	15	5	06:06	X				X												15
16	16	16	5	06:06																	16
17																					
18																					
19																					
20																					
21																					
22																					
23																					
24																					
			Analyst		**Estelle**	**Clare**			**Sharon**												

D340b CTD log sheet

Station	W	CTD No	088	Date	26/06/09
Lat	56° 38.00' N	Event No	004	Time I/W	09:31 GMT
Lon	08° 09.84' W	Depth	140 m	Time bottom	09:38 GMT
Filename	D340_CTD_088.hex	Cast Depth	130 m	Time O/W	09:55 GMT
Weather	Calm and sunny				
Comments					

Fire Seq	Rosette Pos^n	Bot. No.	Depth (m)	Time (GMT)	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	Bot. No.
1	1	1	130	09:40	X				X							X					1
2	2	2	130	09:40																	2
3	3	3	70	09:44	X				X							X					3
4	4	4	70	09:44		X															4
5	5	5	22	09:47	X		X		X		X					X					5
6	6	6	22	09:47			X				X		X								6
7	7	7	22	09:47			X				X										7
8	8	8	22	09:47			X														8
9	9	9	10	09:50	X				X							X					9
10	10	10	10	09:50		X															10
11																					
12																					
13																					
14																					
15																					
16																					
17																					
18																					
19																					
20																					
21																					
22																					
23																					
24																					
			Analyst		Estelle	Clare	Alex		Sharon		Mark Hart		Mark Hart			Mark Hart					

D340b CTD log sheet

Station	SB	CTD No	089	Date	26/06/09
Lat	56° 38.06' N	Event No	006	Time I/W	13:40 GMT
Lon	09° 14.07' W	Depth	1039 m	Time bottom	14:11 GMT
Filename	D340_CTD_089.hex	Cast Depth	1034 m	Time O/W	15:05 GMT
Weather	Calm and sunny				
Comments					

Fire Seq	Rosette Pos^n	Bot. No.	Depth (m)	Time (GMT)	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	Bot. No.
1	1	1	925	14:16	X	X															1
2	2	2	750	14:21		X															2
3	3	3	575	14:27	X	X															3
4	4	4	150	14:37		X															4
5	5	5	100	14:41					X												5
6	6	6	100	14:41	X																6
7	7	7	80	14:44					X												7
8	8	8	80	14:44																	8
9	9	9	68	14:47					X		X	X	X	X		X					9
10	10	10	68	14:47			X	X													10
11	11	11	60	14:49					X												11
12	12	12	60	14:49																	12
13	13	13	40	14:52					X		X		X	X						X	13
14	14	14	40	14:52	X		X	X													14
15	15	15	30	14:55					X											X	15
16	16	16	30	14:55			X	X			X		X	X							16
17	17	17	20	14:58					X			X				X				X	17
18	18	18	20	14:58			X	X		X	X		X	X							18
19	19	19	20	14:58																	19
20	20	20	15	15:00			X	X	X		X		X	X		X					20
21	21	21	15	15:00																	21
22	22	22	15	15:00																	22
23	23	23	5	15:03	X		X	X	X	X		X	X	X						X	23
24	24	24	5	15:03		X					X										24
			Analyst		Estelle	Clare	Alex	Alex	Sharon	Linda	Mark Hart	Lewis	Mark Hart	David Keith		Mark Hart				Keith	

D340b CTD log sheet

Station	BH	CTD No	090	Date	27/06/09
Lat	56° 37.35' N	Event No	011	Time I/W	06:55 GMT
Lon	07° 44.75' W	Depth	85 m	Time bottom	07:01 GMT
Filename	D340_CTD_090.hex	Cast Depth	75 m	Time O/W	07:15 GMT
Weather	Calm				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	75	07:01	X				X												1
2	2	2	50	07:04					X												2
3	3	3	40	07:05					X												3
4	4	4	30	07:07					X												4
5	5	5	20	07:09					X												5
6	6	6	15	07:11															X		6
7	7	7	15	07:11															X		7
8	8	8	15	07:11															X		8
9	9	9	15	07:12															X		9
10	10	10	10	07:13					X												10
11	11	11	5	07:14	X				X												11
12																					
13																					
14																					
15																					
16																					
17																					
18																					
19																					
20																					
21																					
22																					
23																					
24																					
			Analyst		Estelle				Sharon										Keith		

D340b CTD log sheet

Station	BH	CTD No	091	Date	27/06/09
Lat	56° 37.20' N	Event No	015	Time I/W	15:13 GMT
Lon	07° 43.80' W	Depth	83 m	Time bottom	15:21 GMT
Filename	D340_CTD_091.hex	Cast Depth	75 m	Time O/W	15:48 GMT
Weather	Calm, overcast				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	75	15:21	X				X												1
2	2	2	70	15:23		X			X												2
3	3	3	60	15:25					X		X										3
4	4	4	60	15:25			X	X					X	X						X	4
5	5	5	50	15:27					X												5
6	6	6	45	15:29					X												6
7	7	7	40	15:31					X		X	X		X						X	7
8	8	8	40	15:31		X	X	X													8
9	9	9	40	15:31									X								9
10	10	10	35	15:33					X												10
11	11	11	30	15:35					X					X		X				X	11
12	12	12	30	15:35			X	X			X		X			X					12
13	13	13	25	15:37					X												13
14	14	14	20	15:39					X					X						X	14
15	15	15	15	15:41					X				X								15
16	16	16	15	15:41			X	X			X										16
17	17	17	10	15:43					X			X				X				X	17
18	18	18	10	15:43		X	X	X						X		X					18
19	19	19	10	15:43						X	X		X								19
20	20	20	5	15:45			X	X				X		X		X				X	20
21	21	21	5	15:45	X				X	X	X		X			X					21
22																					
23																					
24																					
			Analyst		Estelle	Clare	Alex	Alex	Sharon	Linda	Mark Hart	Lewis	Mark Hart	Keith		Mark Hart				Keith	

D340b CTD log sheet

Station	M1	CTD No	092	Date	28/06/09
Lat	56° 49.29’ N	Event No	017	Time I/W	13:19 GMT
Lon	07° 23.57’ W	Depth	127 m	Time bottom	13:30 GMT
Filename	D340_CTD_092.hex	Cast Depth	124 m	Time O/W	14:01 GMT
Weather	Calm				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	124	13:30	X																1
2	2	2	124	13:30													X	X			2
3	3	3	110	13:34		X															3
4	4	4	70	13:38					X								X	X			4
5	5	5	60	13:40			X	X	X	X	X	X	X	X						X	5
6	6	6	60	13:41																	6
7	7	7	50	13:43													X	X			7
8	8	8	40	13:46			X	X	X	X	X	X	X	X						X	8
9	9	9	40	13:46	X											X					9
10	10	10	30	13:48			X	X	X	X	X	X	X	X						X	10
11	11	11	30	13:48													X	X			11
12	12	12	25	13:51		X									X						12
13	13	13	25	13:51			X	X	X	X	X	X	X	X						X	13
14	14	14	25	13:51												X					14
15	15	15	25	13:51											X						15
16	16	16	25	13:51											X						16
17	17	17	25	13:52											X						17
18	18	18	25	13:52											X						18
19	19	19	25	13:52											X						19
20	20	20	15	13:55			X	X	X	X	X	X	X	X						X	20
21	21	21	15	13:55																	21
22	22	22	5	13:58			X	X	X	X	X	X	X	X						X	22
23	23	23	5	13:58	X											X					23
24	24	24	2	14:00													X	X			24
			Analyst		Estelle	Clare	Alex	Alex	Sharon	Linda	Mark Hart	Lewis	Mark Hart	Keith	Andy	Mark Hart	Melanie	Melanie		Keith	

D340b CTD log sheet

Station	M1	CTD No	093	Date	28/06/09
Lat	56° 49.40’ N	Event No	22	Time I/W	18:50 GMT
Lon	07° 23.66’ W	Depth	136 m	Time bottom	19:00 GMT
Filename	D340_CTD_093.hex	Cast Depth	130 m	Time O/W	19:22 GMT
Weather	Calm				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	130	19:00	X				X								X	X			1
2	2	2	70	19:03					X								X	X			2
3	3	3	60	19:06					X												3
4	4	4	60	19:06					X								X	X			4
5	5	5	50	19:08	X				X												5
6	6	6	40	19:10					X								X	X			6
7	7	7	30	19:13					X												7
8	8	8	25	19:15					X												8
9	9	9	15	19:17	X				X												9
10	10	10	5	19:19					X								X	X			10
11	11	11	2	19:21																	11
12																					
13																					
14																					
15																					
16																					
17																					
18																					
19																					
20																					
21																					
22																					
23																					
24																					
			Analyst		Estelle				Sharon								Melanie	Melanie			

D340b CTD log sheet

Station	M1	CTD No	094	Date	28/06/09
Lat	56° 49.34' N	Event No	023	Time I/W	21:08 GMT
Lon	07° 23.50' W	Depth	134 m	Time bottom	21:13 GMT
Filename	D340_CTD_094.hex	Cast Depth	125 m	Time O/W	21:43 GMT
Weather	Calm				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	125	21:19					X												1
2	2	2	110	21:21	X	X			X												2
3	3	3	90	21:24					X												3
4	4	4	70	21:27					X												4
5	5	5	70	21:27		X															5
6	6	6	60	21:29	X				X												6
7	7	7	50	21:31					X												7
8	8	8	40	21:33					X												8
9	9	9	30	21:34					X												9
10	10	10	20	21:36		X			X												10
11	11	11	15	21:38					X												11
12	12	12	5	21:40	X	X															12
13	13	13	2	21:41																	13
14																					
15																					
16																					
17																					
18																					
19																					
20																					
21																					
22																					
23																					
24																					
			Analyst		Estelle	Clare			Sharon												

D340b CTD log sheet

Station	W	CTD No	095	Date	29/06/09
Lat	56° 38.05' N	Event No	025	Time I/W	14:10 GMT
Lon	08° 11.07' W	Depth	136 m	Time bottom	14:19 GMT
Filename	D340_CTD_095.hex	Cast Depth	125 m	Time O/W	14:47 GMT
Weather	Slight swell, overcast				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	125	14:19	X																1
2	2	2	120	14:21		X			X												2
3	3	3	70	14:25					X												3
4	4	4	60	14:28			X	X			X		X	X						X	4
5	5	5	60	14:28					X												5
6	6	6	60	14:28												X					6
7	7	7	50	14:31	X	X			X												7
8	8	8	40	14:33			X	X			X		X	X						X	8
9	9	9	40	14:33					X												9
10	10	10	30	14:36			X	X			X	X	X	X						X	10
11	11	11	30	14:36					X												11
12	12	12	27	14:38																	12
13	13	13	27	14:38																	13
14	14	14	27	14:38																	14
15	15	15	20	14:40			X	X	X	X	X	X		X						X	15
16	16	16	20	14:40		X															16
17	17	17	20	14:41									X			X					17
18	18	18	15	14:42			X	X			X		X	X						X	18
19	19	19	15	14:43					X												19
20	20	20	5	14:45			X	X		X	X	X	X	X						X	20
21	21	21	5	14:45	X				X												21
22	22	22	5	14:45												X					22
23																					
24																					
			Analyst		Estelle	Clare	Alex	Alex	Sharon	Linda	Mark Hart	Lewis	Mark Hart	Keith		Mark Hart				Keith	

D340b CTD log sheet

Station	W	CTD No	096	Date	30/06/09
Lat	56° 37.50' N	Event No	028	Time I/W	07:15 GMT
Lon	08° 10.71' W	Depth	136 m	Time bottom	07:26 GMT
Filename	D340_CTD_096.hex	Cast Depth	127 m	Time O/W	07:57 GMT
Weather	Slight swell				
Comments	Bottle 9 did not close properly				

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	127	07:27	X				X												1
2	2	2	110	07:30		X			X												2
3	3	3	80	07:33					X												3
4	4	4	60	07:36	X				X												4
5	5	5	50	07:38					X												5
6	6	6	50	07:38		X															6
7	7	7	40	07:41					X												7
8	8	8	35	07:43					X												8
9	9	9	30	07:45																	9
10	10	10	21	07:48					X										X		10
11	11	11	21	07:48															X		11
12	12	12	21	07:48															X		12
13	13	13	21	07:48															X		13
14	14	14	21	07:48															X		14
15	15	15	21	07:48															X		15
16	16	16	21	07:48															X		16
17	17	17	20	07:50					X												17
18	18	18	15	07:52					X												18
19	19	19	10	07:53					X												19
20	20	20	10	07:53		X															20
21	21	21	5	07:56	X				X												21
22																					
23																					
24																					
			Analyst		**Estelle**	**Clare**			**Sharon**										**Keith**		

D340b CTD log sheet

Station	W	CTD No	097	Date	30/06/09
Lat	56° 38.56' N	Event No	030	Time I/W	13:08 GMT
Lon	08° 10.87' W	Depth	137 m	Time bottom	13:17 GMT
Filename	D340_CTD_097.hex	Cast Depth	100 m	Time O/W	13:39 GMT
Weather	Sunny, breezy, slight swell.				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	100	13:21	X	X			X												1
2	2	2	60	13:24			X	X			X		X	X						X	2
3	3	3	60	13:24					X												3
4	16	16	60	13:24																	16
5	17	17	60	13:24																	17
6	18	18	60	13:24																	18
7	19	19	60	13:24																	19
8	20	20	60	13:24																	20
9	4	4	40	13:29			X	X			X	X	X	X						X	4
10	5	5	40	13:29	X				X												5
11	6	6	35	13:30		X															6
12	7	7	30	13:32			X	X			X		X	X						X	7
13	8	8	30	13:32					X												8
14	9	9	20	13:34			X	X		X	X	X	X	X						X	9
15	10	10	20	13:34					X		X										10
16	11	11	15	13:36			X	X			X		X	X						X	11
17	12	12	15	13:36					X												12
18	13	13	5	13:38			X	X		X	X	X	X	X						X	13
19	14	14	5	13:38					X												14
20	15	15	5	13:38	X	X															15
21																					
22																					
23																					
24																					
			Analyst		**Estelle**	**Clare**	**Alex**	**Alex**	**Sharon**	**Linda**	**Mark Hart**	**Lewis**	**Mark Hart**	**Keith**						**Keith**	

D340b CTD log sheet

Station	W	CTD No	098	Date	30/06/09
Lat	56° 38.59’ N	Event No	032	Time I/W	17:06 GMT
Lon	08° 10.54’ W	Depth	134 m	Time bottom	17:14 GMT
Filename	D340_CTD_098.hex	Cast Depth	100 m	Time O/W	17:20 GMT
Weather	Very slight swell				
Comments	All bottles were fired to acquire seawater for coral flume tank				

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	100	17:14																	1
2	2	2	100																		2
3	3	3	100																		3
4	4	4	100																		4
5	5	5	100																		5
6	6	6	100																		6
7	7	7	100																		7
8	8	8	100																		8
9	9	9	100																		9
10	10	10	100																		10
11	11	11	100																		11
12	12	12	100																		12
13	13	13	100																		13
14	14	14	100																		14
15	15	15	100																		15
16	16	16	100																		16
17	17	17	100																		17
18	18	18	100																		18
19	19	19	100																		19
20	20	20	100																		20
21	21	21	100																		21
22	22	22	100																		22
23	23	23	100																		23
24	24	24	100	17:16																	24
			Analyst																		

D340b CTD log sheet

Station	W	CTD No	099	Date	30/06/09
Lat	56° 38.16’ N	Event No	033	Time I/W	17:36 GMT
Lon	08° 10.37’ W	Depth	134 m	Time bottom	-
Filename	D340_CTD_099.hex	Cast Depth	50 m	Time O/W	17:44 GMT
Weather	Slight swell				
Comments	All bottles were fired to acquire seawater for coral flume tank				

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	50																		1
2	2	2	50																		2
3	3	3	50																		3
4	4	4	50																		4
5	5	5	50																		5
6	6	6	50																		6
7	7	7	50																		7
8	8	8	50																		8
9	9	9	50																		9
10	10	10	50																		10
11	11	11	50																		11
12	12	12	50																		12
13	13	13	50																		13
14	14	14	50																		14
15	15	15	50																		15
16	16	16	50																		16
17	17	17	50																		17
18	18	18	50																		18
19	19	19	50																		19
20	20	20	50																		20
21	21	21	50																		21
22	22	22	50																		22
23	23	23	50																		23
24	24	24	50																		24
			Analyst																		

D340b CTD log sheet

Station	M1	CTD No	100	Date	01/07/09
Lat	56° 49.35' N	Event No	037	Time I/W	12:20 GMT
Lon	07° 23.37' W	Depth	133 m	Time bottom	12:27 GMT
Filename	D340_CTD_100.hex	Cast Depth	116 m	Time O/W	12:59 GMT
Weather	Overcast. Drizzle. Slight swell.				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	116	12:28	X				X								X	X			1
2	2	2	90	12:32		X			X												2
3	3	3	70	12:35					X								X	X			3
4	4	4	60	12:37			X	X			X	X	X	X						X	4
5	5	5	60	12:37												X					5
6	6	6	60	12:37		X			X												6
7	7	7	50	12:40					X								X	X			7
8	8	8	42	12:42			X	X			X		X	X						X	8
9	9	9	42	12:42	X				X												9
10	10	10	34	12:45			X	X		X	X	X	X	X						X	10
11	11	11	34	12:45					X				X								11
12	12	12	30	12:47																	12
13	13	13	30	12:47					X							X					13
14	14	14	30	12:47													X	X			14
15	15	15	25	12:49			X	X			X		X	X						X	15
16	16	16	25	12:49					X												16
17	17	17	25	12:50		X															17
18	18	18	15	12:52			X	X		X	X	X	X	X						X	18
19	19	19	15	12:53	X				X												19
20	20	20	5	12:55			X	X			X		X	X						X	20
21	21	21	5	12:55					X							X					21
22	22	22	2	12:57													X	X			22
23																					23
24																					24
			Analyst		Keith	Clare	Alex	Alex	Sharon	Linda	Mark Hart	Lewis	Mark Hart	Keith		Mark Hart	Melanie	Melanie		Keith	

D340b CTD log sheet

Station	BH	CTD No	101	Date	02/07/09
Lat	56° 36.34' N	Event No	053	Time I/W	13:10 GMT
Lon	07° 45.43' W	Depth	107 m	Time bottom	13:20 GMT
Filename	D340_CTD_101.hex	Cast Depth	90 m	Time O/W	13:38 GMT
Weather	Overcast. Slight swell.				
Comments					

Fire Seq	*Rosette Pos^n*	*Bot. No.*	*Depth (m)*	*Time (GMT)*	Salinity	DO	Chl	POC/ PON	Nutrients	Primary prod.	Bact. prod.	15N uptake	Bact. abund.	Plankt.	DMS	HDB	Metals/ Trace metals	Oxygen isotopes	Deck-board incubs.	DOC/ DON	*Bot. No.*
1	1	1	90	13:20		X			X												1
2	2	2	60	13:25			X	X			X		X	X						X	2
3	3	3	60	13:25					X												3
4	4	4	60	13:25												X					4
5	5	5	40	13:27			X	X			X	X	X	X						X	5
6	6	6	40	13:27		X															6
7	7	7	40	13:27					X												7
8	8	8	30	13:30			X	X			X		X	X						X	8
9	9	9	30	13:30					X												9
10	10	10	30	13:30												X					10
11	11	11	20	13:32			X	X			X		X	X						X	11
12	12	12	20	13:32					X												12
13	13	13	14	13:34			X	X		X	X	X	X	X						X	13
14	14	14	14	13:34					X												14
15	15	15	14	13:34												X					15
16	16	16	5	13:36			X	X		X	X	X	X	X						X	16
17	17	17	5	13:36		X															17
18	18	18	5	13:36					X												18
19																					
20																					
21																					
22																					
23																					
24																					
			Analyst			Clare	Alex	Alex	Sharon	Linda	Mark Hart	Lewis	Mark Hart	Keith		Mark Hart				Mark Hart	

Appendix 3

Surfmet : The Sensor List

Met Platform Sensors

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

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

Temperature and Humidity

Manufacturer : Vaisala

Model Number : HMP45A

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

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

Operating environment

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

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

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

Barometric Pressure

Barometric pressure measurement

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

Operating environment

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

Inputs and outputs

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

Sea Surface Instruments

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

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

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)

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)