National
Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre

Cruise Report No. 39

RRS *Discovery* Cruise DY034

06 AUG – 02 SEP 2015

Shelf sea biogeochemistry
Southampton to Southampton, UK

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2016

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DOCUMENT DATA SHEET

AUTHOR RUHL, H A et al	*PUBLICATION DATE* 2016
TITLE RRS *Discovery* Cruise DY034, 06 Aug - 02 Sep 2015, Southampton to Southampton. Shelf sea biogeochemistry.	
REFERENCE Southampton, UK: National Oceanography Centre, Southampton, 121pp. (National Oceanography Centre Cruise Report, No. 39)	

ABSTRACT

We addressed four interdisciplinary themes to provide a holistic view of the biogeochemistry of benthic shelf ecosystems, including the nepheloid layer. The relative size of the carbon (C) and nitrogen (N) pools, microbial transformation rates and fluxes between pools were quantified in shelf sediments on this, the last of several integrated cruises (Winter, post-bloom Spring, late Summer) scheduled to coincide with contrasting biogeochemical conditions. During each cruise, observations and experiments are to be made across a gradient of soft cohesive mud to coarse advective gravel. The effort has four modules: Module 1: Biogeochemical cycling of nitrogen, phosphorus, silicon and carbon within sediment; Module 2: Role of sediments in carbon storage; Module 3: Role of macrofauna and the impacts of natural and anthropogenic disturbance on sediment biogeochemical processes; Module 4: Role of sediment resuspension and near-bed current flow: Impacts on carbon and nutrient sediment-water exchange in diffusive and pumped sediments. Four primary sites were selected based on representation of the dominant habitat types (% area covered/ biogeochemically activity) within the Celtic Sea. This approach is to ensure that all data generated are applicable to the largest area of shelf sediments and thus suitable for scaling-up activities. Sites were chosen from a limited depth and temperature range to ensure high comparability between sites. Notably this was the last scientific research cruise of the Shelf Sea Biogeochemistry programme.

KEYWORDS

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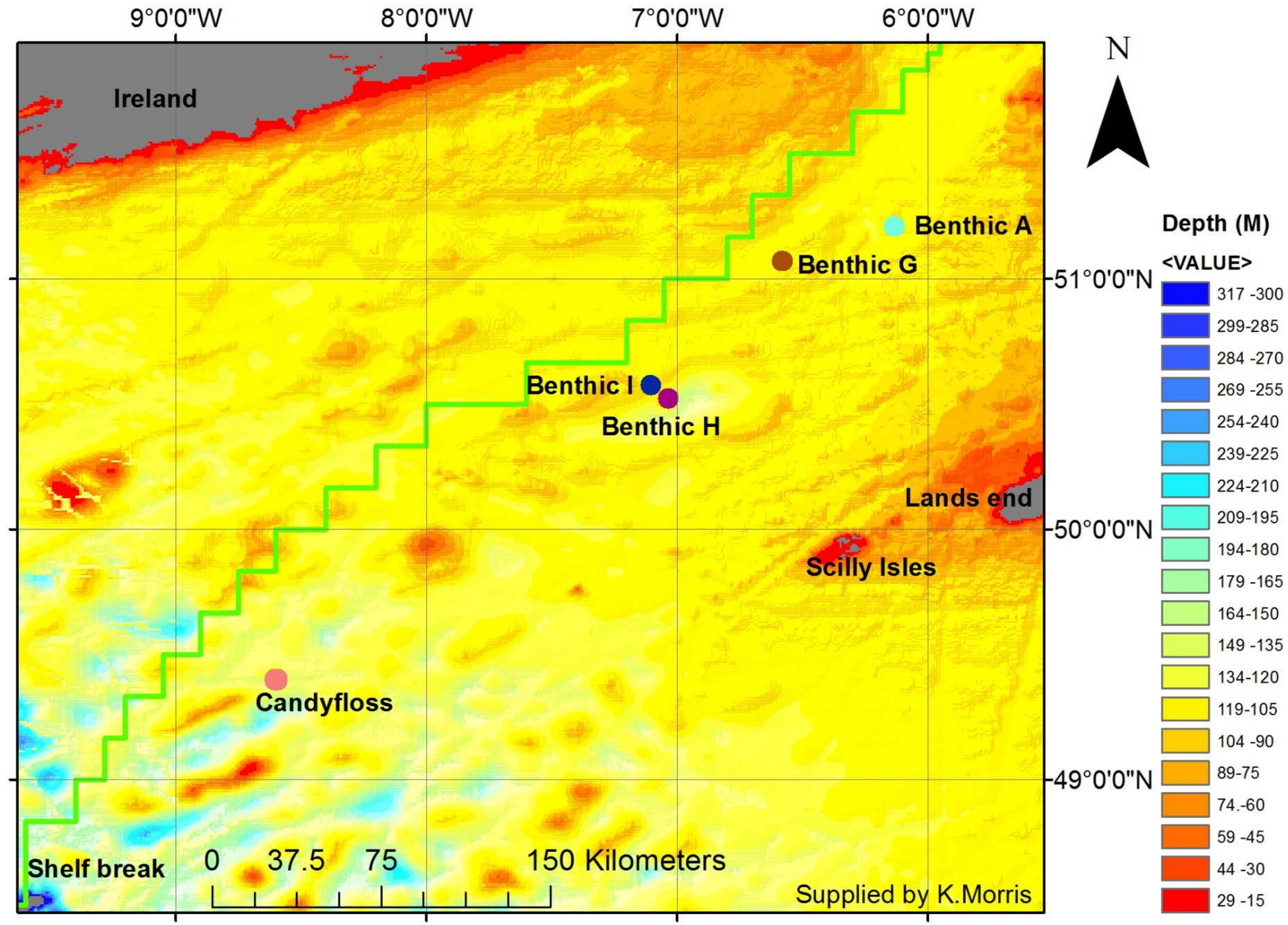

2. Chart illustrating key sampling areas during DY03

Itinerary

Departure: Southampton, UK, 06 August 2015

Arrival: Southampton, UK, 02 September 2015

3. Underway navigation, sea surface hydrography and meteorology

Louis Byrne, Joanne Hopkins

Navigation

The following navigational sensors were used for processing positions, ship heading and sea floor depth (Table 3.2). The POS MV GPS unit was one of the primary GPS sources for science. It was capable of differential GPS (DGPS), accurate to 0.5 m and not prone to drop outs. The POS MV system also comprised an Inertial Measurement Unit (IMU) which was accurate to 0.010° with a 4 m baseline. The gyro heading was filtered and was preferred to the ship gyro which may be prone to oscillations. The Kongsberg Simrad EM122 swath bathymetry sensor was located on the port drop keel approximately 6.5 m below seawater (when retracted). The central beam was the preferred source of sea floor depth because it was corrected for local sound velocity during the cruise using sound velocity probes (SVP) mounted on the stainless steel CTD frame and was not prone to heavy noise.

Meteorology

The suite of ship-fitted meteorological sensors formed part of the ship's scientific *surfmet* system. The sensors were mounted on the meteorology platform which was located on the ship's foremast at the bow of the ship. According to the ship's plans, the foremast was approximately 17.4 m above typical sea level (16.2 m above the maximum loading mark - 7 m draft mark) and approximately 38 m in front of the nearest ship superstructure. Table 3.3 describes the current suite of sensors. Figure 3.1 shows the orientation of sensors on the platform. The met platform had two sonic anemometers. The starboard-side was used for science while the port-side anemometer was used by the MET office. The scientific anemometer orientation was 0^0 on the bow.

Sea surface hydrography

The suite of ship-fitted sea surface hydrography sensors formed part of the ship's scientific *surfmet* system (Table 3.3). The sea surface hydrography suite of sensors were plumbed, in-line, to the clean seawater pumped system. The Sea-Bird SBE 38 temperature sensor (SST) was located close to the seawater intake towards the hull of the ship where it was less likely to suffer from any interior heating effects. The remaining sensors were located in the clean seawater laboratory on the main deck, directly above the intake pipe (estimated to be ~ 5 m). The depth of the seawater intake was estimated to be approximately 5.5 m below sea level. In the clean laboratory, the flow of seawater through the system was initially down-regulated to 16-18 l/min using a flow meter and de-bubbled using an Instrument Laboratory, Vortex VDB-1H de-bubbler. The flow was then further regulated to approximately 1500 ml/min using a floating ball flow meter prior to the first sensor, the fluorometer. This was followed in-line by the transmissometer and finally the thermosalinograph (TSG) before the water was wasted to the drain.

Data processing

Output from the *surfmet* sensors were initially logged by a designated PC. Some of the sensor's firmware, connection modules and PC software manipulated the output (Figure 3.2). All the sensors used (including the *surfmet* sensors) were then registered by the TECHSAS logging system and broadcast to NetCDF, pseudo-TECHSAS ascii and UKORS format in the *raw_data* area of the level-C logging system. With the exception of the wind, data used here was extracted from the daily TECHSAS ascii files.

Navigation

Daily pseudo-TECHSAS ascii files were copied to the local PC where they were reformatted and appended using the following matlab scripts:

> ***uw_nav*** – reformatted daily 1 Hz POS MV positional files (*#Applanix_GPS_DY1.aplnx*) to ascii (*DY034_NAV_#_raw.txt*).
>
> ***uw_swath*** - reformatted daily 1 Hz swath files (*#EM120_DY1.EM1_1*) to ascii (*DY034_SWATH_#_raw.txt*).
>
> ***uw_gyro*** - reformatted daily 1 Hz POS MV gyro files (*#-GYRO1_DY1.GYRO1*) to ascii (*DY034_GYRO1_#_raw.txt*).
>
> ***uw_append*** – appended daily 1 Hz ascii files to master ascii files (*DY034_NAV_master_raw.txt*, *DY034_SWATH_master_raw.txt* and *DY034_GYRO1_master_raw.txt*)

The swath bathymetry was filtered of noise and averaged as follows:

> ***uw_swclean*** – filtered the swath bathymetry (*DY034_SWATH_master_raw.txt*). Output: *DY034_SWATH_master_filt.txt.*
>
> ***uw_swavg*** – averaged the filtered 1 Hz data (*DY034_SWATH_master_filt.txt*) over 30 second (*DY034_SWATH_master_30secav.txt*) and 150 second (*DY034_SWATH_master_150secav.txt*) intervals.

The swath bathymetry was filtered of noise twice by applying a moving average window of 60 seconds and removing all data outside 2 standard deviations of that average.

Sea surface temperature and TSG

Sea surface temperature (*tempr*, from the SBE38 at the water inlet) and the water temperature (*temph*) and salinity (*salin*) from the SBE45 housing were duplicated in both the *sbe45* and *surfmet* streams, however, the *sbe45* stream was considered the best source for this data as it is unlikely to be delayed in time. Therefore, daily pseudo-TECHSAS ascii files were copied to the local PC where they were reformatted, appended and cleaned using the following matlab scripts:

> ***uw_tsg*** - reformatted daily 1 Hz TSG files (*#SBE45_DY1.SBE45*) to ascii (*DY034_TSG_#_raw.txt*).
>
> ***uw_append*** – appended daily 1 Hz ascii files to a master ascii file (*DY034_TSG_master_raw.txt*)
>
> ***uw_tsgclean*** – applied moving average filters to the TSG data (*temph, tempr, con* and *salin*). Output: *DY034_TSG_master_filt.txt*

All channels (*tempr, temph, salin, con*) were filtered of noise once by applying a moving average window of 60 seconds and removing all data outside 2 standard deviations of that average. The following periods of bad data were also converted to NaN values in *tempr*, *salin* and *cond*:

Between 06 August 2015 13:36:30 UTC and 06 August 2015 14:45:29 UTC when the underway flow rate was adjusted.

Between 28 August 2015 13:23:47 UTC and 28 August 2015 13:25:41 UTC.

Between 28 August 2015 13:48:58 UTC and 28 August 2015 13:56:41 UTC.

Meterology

Aside from the relative and absolute winds all the meteorological data was taken from the daily pseudo-TECHSAS ascii files. To limit file sizes and ease memory issues on the laptop being used for processing variables were split into two groups and processed separately.

Air temperature, humidity, pressure

The TECHSAS ascii files were copied to the local PC where they were reformatted, appended and cleaned as follows:

> ***uw_met***–reformatted daily 1 Hz SURFM files (*#SM_DY1.SURFM*) to ascii (*DY034_MET_#_raw.txt*)
>
> ***uw_append*** – appended daily 1 Hz ascii files to a master ascii file (*DY034_MET_master_raw.txt*)
>
> ***uw_metclean*** – Flagged suspect data. Applied moving average filters to air temperature, humidity and pressure (*DY034_MET_master_filt.txt*)

Air temperature was filtered of noise once by applying a moving average window of 120 seconds and removing all data outside 2 standard deviation of that average. A 60 second window and a standard deviation threshold of 2 was applied to the humidity and pressure.

PIR and TIR

The TECHSAS ascii files were copied to the local PC where they were reformatted, appended and cleaned as follows:

uw_pirtir –reformatted daily 1 Hz SURFM files *(#SM_DY1.SURFM*) to ascii (*DY034_PIRTIR_#_raw.txt*)

uw_pirtircal – applied manufacturers calibrations (*DY034_PIRTIR_#_raw_mcal.txt*)

uw_append – appended daily 1 Hz ascii files to a master ascii file (*DY034_PIRTIR_master_raw.txt*)

The raw light channels (*ppar, spar, ptir, stir*) were initially converted to volts and calibrated as follows:

$$[\text{voltage}] = raw \times 10^{-5}$$

$$[\text{W/m}^2] = (voltage \times 10^6)/x$$

where *raw* is the raw light channel, *voltage* is the output in volts and *x* is the calibration scale factor. Scale factors were as follows for each sensor:

spar = 10.93 µV/W m^{-2} (s/n 28563, starboard, 04/07/2013)

ppar = 10.05 µV/W m^{-2} (s/n 28561, port, 01/05/2015)

stir = 10.14 µV/W m^{-2} (s/n 962276, starboard, 13/11/2014)

ptir = 10.97 µV/W m^{-2} (s/n 973134, port, 19/03/2015)

Winds

The relative wind speed and direction were taken from the daily pseudo-TECHSAS ascii files.

uw_wind –reformatted daily 1 Hz SURFM files *(#SM_DY1.SURFM*) to ascii (*DY034_PRO_#_raw.txt*)

uw_append – appended daily 1 Hz ascii files to a master ascii file (*DY034_PRO_master_raw.txt*)

uw_proclean – Flagged suspect data. Applied moving average filters to relative wind speed and direction. Removal of directions > 360 degrees (*DY034_WIND_master_filt.txt*).

Speed and direction were filtered of noise once by applying a moving average window of 120 seconds and removing all data outside 2 standard deviation of that average.

Fluorescence and transmittance

The TECHSAS ascii files were copied to the local PC where they were reformatted, calibrated , appended and cleaned as follows:

uw_opt_fl– reformatted daily 1 Hz SURFM files *(#SM_DY1.SURFM*) to ascii (*DY034_OPTF_#_raw.txt*)

uw_opt_tr–reformatted daily 1 Hz SURFM files *(#SM_DY1.SURFM*) to ascii (*DY034_OPTT_#_raw.txt*)

uw_optcal_fl – applied manufacturers calibrations to obtain chlorophyll-a (*DY034_OPTF_#_raw_mcal.txt*)

uw_optcal_tr – applied manufacturers calibrations to obtain beam transmission and attenuation (*DY034_OPTT_#_raw_mcal.txt*)

uw_append – appended daily 1 Hz ascii files to a master ascii file (*DY034_OPTF_master_raw.txt* and *DY034_OPTT_master_raw.txt*)

uw_optclean_fl / uw_optclean_tr – Removed suspect data. Applied moving average filters to chlorophyll-a, beam transmission and attenuation (*DY034_OPTF_master_filt.txt* and *DY034_OPTT_master_filt.txt*)

Chlorophyll-a, beam transmission and attenuation were filtered of noise once by applying a moving average window of 120 seconds and removing all data outside 1.5 standard deviations of that average.

Manufacturer calibrations applied

The fluorescence voltage channel (*fluo*) was converted to *chla* using the following calibration:

$$Chl\ a\ [\mu g/L] = SF\ (fluo - CWO)$$

where SF = 5.5 µg/L/V and CWO = 0.068 V.

The transmissometer voltage channel (*trans*) was converted to beam transmission (*beamtrans*) and beam attenuation (*atten*) as follows:

$$trans\ [V] = trans \geq Vdark$$

$$beamtrans\ [\%] = \left(\frac{[trans - Vdark]}{[Vref - Vdark]}\right)100$$

$$atten\ [per\ m] = \left(-\frac{1}{pathlength}\right)\ln\left(\frac{beamtrans}{100}\right)$$

where Vdark = 0.058 V, Vref = 4.623 V and pathlength = 0.25 m.

Calibration

Salinity and SST were calibrated against underway discrete salinity samples and CTD temperature after the cruise.

Table 3.1. Dates and times of salinity samples taken from the underway non-toxic supply.

Date	**Time**	**Depth (m)**	**Crate #**	**Bottle #**
07/08/2015	17:21	81	TSG01	1
08/08/2015	17:18	108	TGS01	2
09/08/2015	04:24	105	TSG01	3
09/08/2015	12:47	107	TSG01	4
10/08/2015	13:26	101	TGS01	5
11/08/2015	02:26	107	TSG01	6
11/08/2015	10:42	100	TSG01	7
11/08/2015	15:47	101	TGS01	16
12/08/2015	07:37	99	TSG01	15
12/08/2015	14:09	99	TSG01	14
12/08/2015	23:19		TGS01	13
13/08/2015	21:05	100	TSG01	12
14/08/2015	13:44		TSG01	11
14/08/2015	23:21		TGS01	10
15/08/2015	07:48	98	TSG01	9
15/08/2015	14:23		TGS01	17
15/08/2015	22:36	99	TSG01	18
16/08/2015	13:57	106	TSG01	19
17/08/2015	12:34	127	TSG01	20
17/08/2015	22:19	106	TSG01	21
18/08/2015	08:43	108	TSG01	22
19/08/2015	01:00	105	TSG01	23
20/08/2015	08:09	110	TSG01	24
21/08/2015	10:24	109	TSG03	49
21/08/2015	18:52	121	TSG03	50
21/08/2015	23:32	144	TSG03	51
22/08/2015	06:51	305	TSG03	52
22/08/2015	14:21	150	TSG03	53
23/08/2015	06:34	150	TSG03	54

23/08/2015	17:25	146	TSG03	55
24/08/2015	10:19	113	TSG03	56
24/08/2015	18:29	109	TSG03	64
25/08/2015	15:00	101	TSG03	63
26/08/2015	15:15	103	TSG03	62
27/08/2015	10:54		TSG03	61
28/08/2015	10:49		TSG03	60
28/08/2015	15:17	77	TSG03	59
29/08/2015	08:33	100	TSG03	58
30/08/2015	06:14	110	TSG03	57
30/08/2015	12:49	106	TSG03	72
30/08/2015	23:32	134	TSG03	71

Data quality notes

At the beginning of the cruise the underway flow rate was too low and this compromised the salinity values recorded until 07 August 2015 14:45 UTC, and may have compromised data recorded by other sensors. The chlorophyll sensor begins to drift from the 21st August 2015 until the instruments were cleaned on the 29th of August 2015.

Log of significant events:

03 August 2015 09:53 UTC – Underway switched on

07 August 2015 14:45 UTC – Underway flow rate adjusted.

01 September 2015 18:10 UTC – Last cycle recorded before final underway data processed.

02 September 2015 06:40 UTC – underway switched off.

Table 3.2. Navigation sensors used for processing.

Manufacturer	**Model**	**Function/Data types**	**Comments**
Applanix	POSMV 320 V5	DGPS and IMU 7	General use gyro. Secondary *bestnav* positional source.
Kongsberg	EM122	Deep Water Multi-Beam echo sounder	Port drop keel

Table 3.3. Surfmet sensors used for processing.

Manufacturer	Sensor	Serial No.	Comments (e.g. port)	Calibration applied?	Last calibration (DD/MM/YYYY)
Skye	PAR SKE510	28563	Starboard	No	04/07/2013 (2yr)
Skye	PAR SKE510	28561	Port	No	01/05/2015 (2yr)
Kipp & Zonen	TIR CM6B	962276	Starboard	No	13/11/2014 (2yr)
Kipp & Zonen	TIR CM6B	973134	Port	No	19/03/2015 (2yr)
Gill	Windsonic Option 3	071121	Starboard Inv:250004845	No	N/A (tested 25/02/2015)
Vaisala	HMP155 Temp./Hum.	K0950058		No	16/01/2015
Vaisala	PTB110 Air Pres.	L0650612		No	06/02/2015
Wet Labs	WS3S Fluorimeter	WS3S-248	Inv:240002939	No	14/10/14
Wet Labs	CST Transmissometer	CST-112R	Inv:240002369	No	26/06/2014 (2yr)
Sea-Bird	SBE38 Temperature	3854115-0491		No	25/06/2015
Sea-Bird	SBE45 TSG	4548881-0230		No	23/09/2014 (1yr)

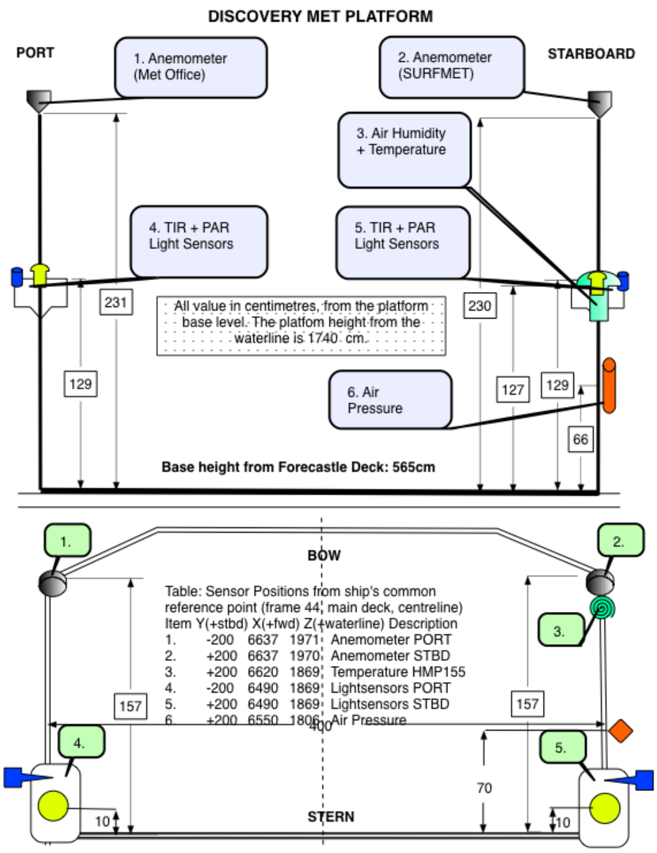

Figure 3.1. Schematic of the RRS *Discovery* met platform layout.

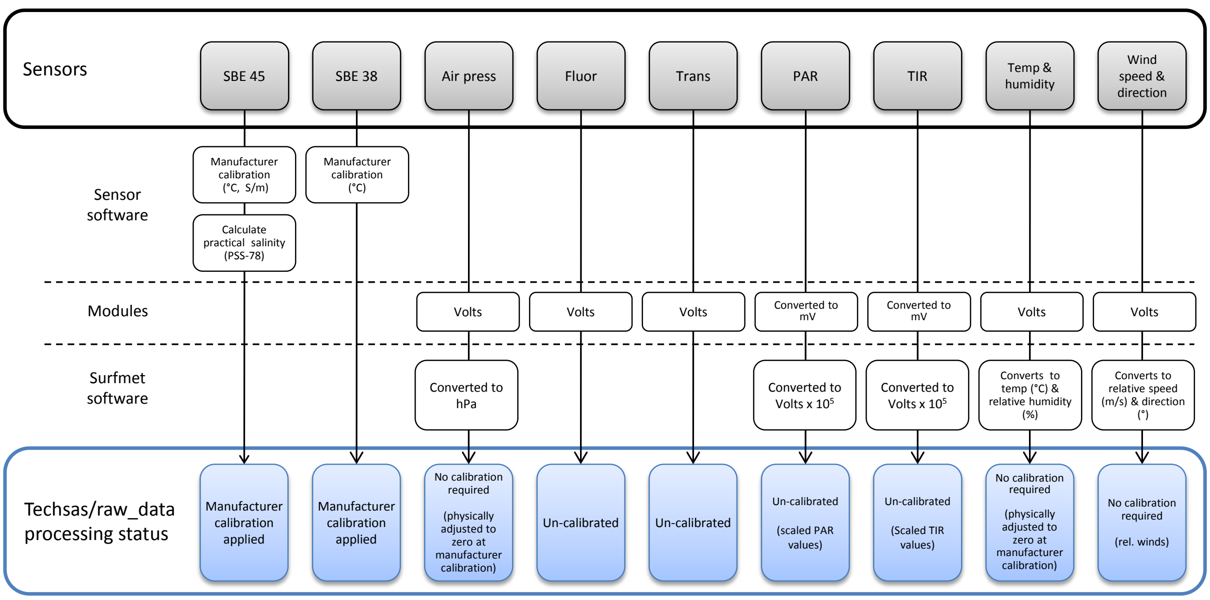

Figure 3.2. Surfmet data processing. Diagrams shows the processing route from sensor to raw_data in the level-C logging system.

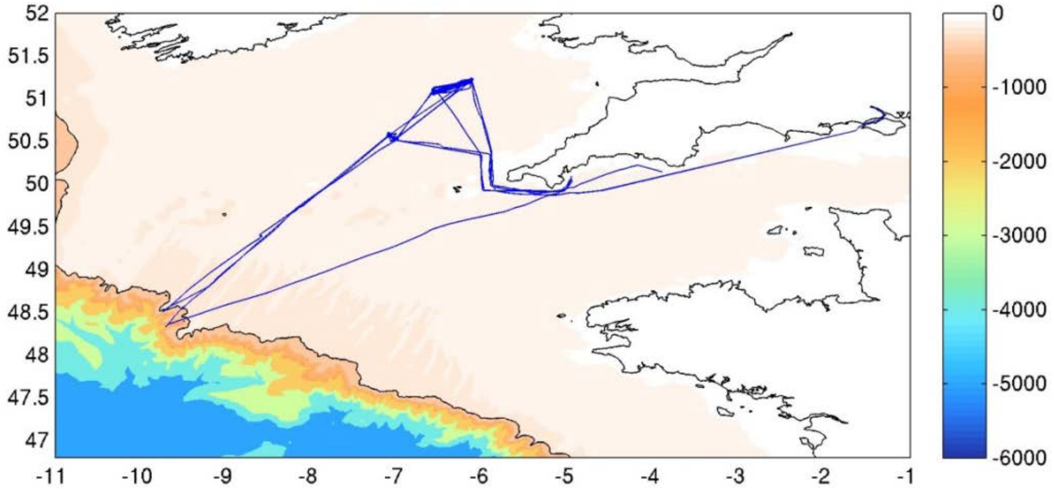

Figure 3.3. DY034 cruise track with x-axis giving longitude and y axis giving latitude and the colour gradient key showing depth in meters on the right side.

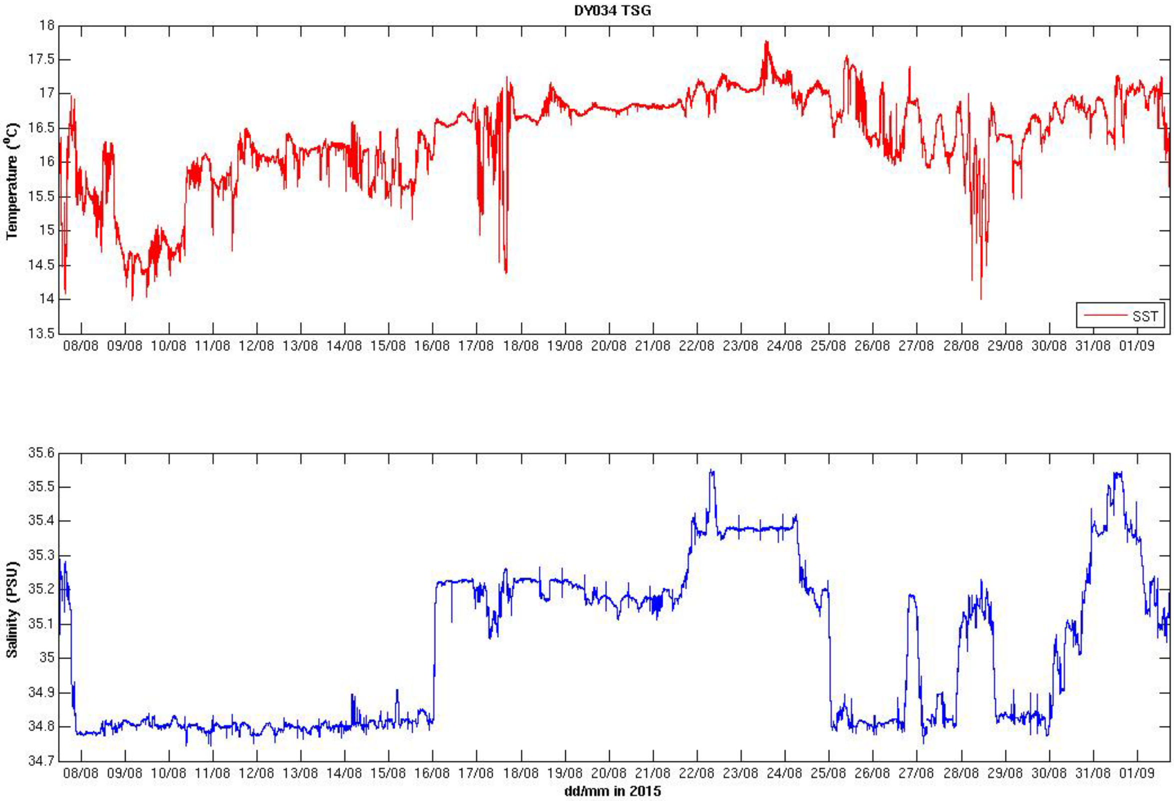

Figure 3.4. DY034 SST (top) and salinity (bottom).

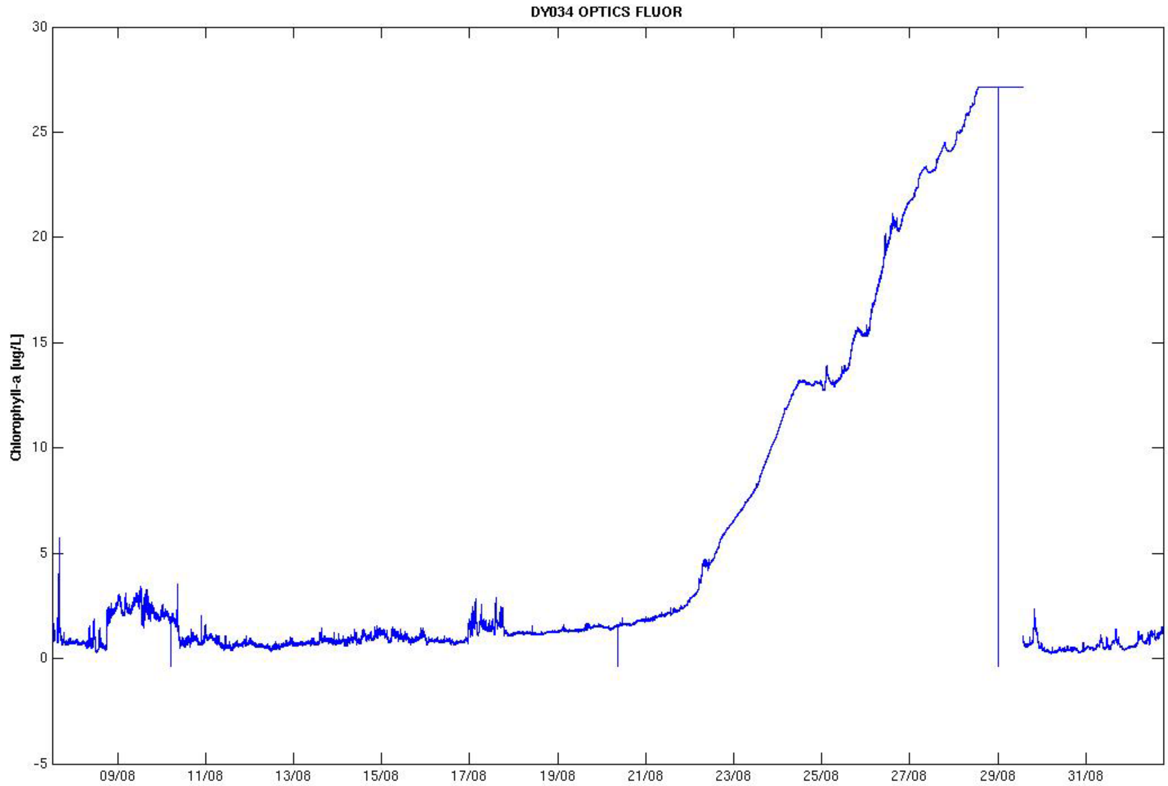

Figure 3.5. DY034 chlorophyll.

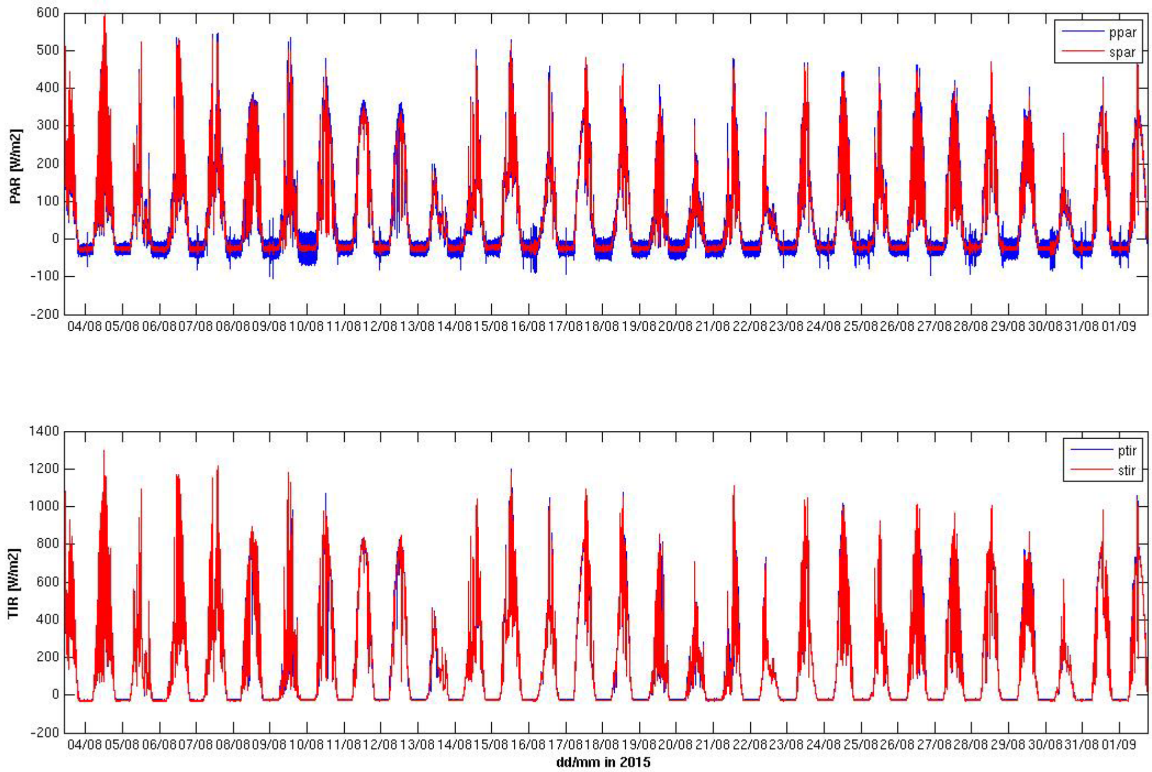

Figure 3.6. DY034 PAR (top) and TIR (bottom).

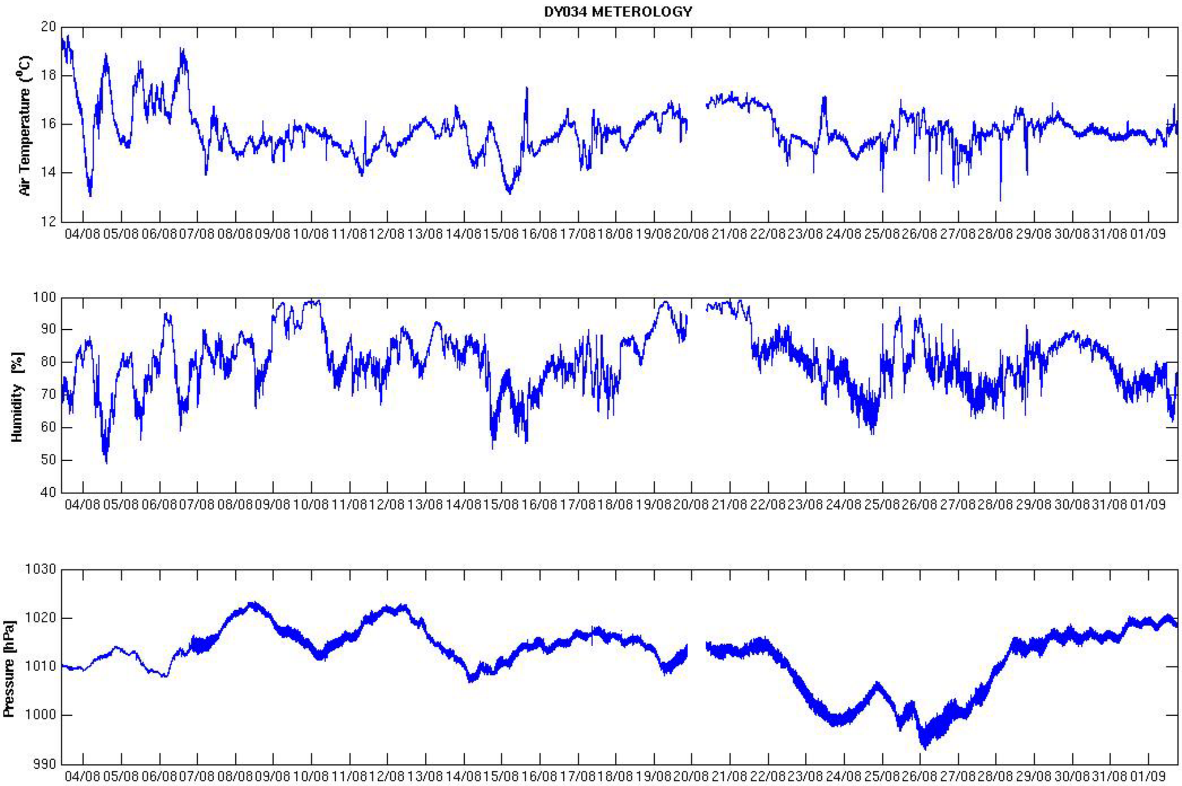

Figure 3.7. DY034 air temperature (top), humidity (middle) and pressure (bottom).

4. Underway pCO$_2$ analyser

Vas Kitidis

A Plymouth Marine Laboratory (PML)-Dartcom Live pCO_2 instrument was set up in the meteorological laboratory on the boat deck (hereafter met-lab). Gas standards (BOC Ltd.; nominal mixing ratios 250, 380, 450 ppmv in synthetic air; calibrated against NOAA primaries) were located in the gas bottle rack in the forward moorings area on the boat deck (port-side) and an air sampling line was taken from the met-lab to the foremast. The system comprises a showerhead equilibrator vented through a second equilibrator, in-line oxygen optode and platinum resistance thermometer, nafion dryer, non-dispersive infrared detector (LiCOR, LI-840) and associated hardware and electronics. The system was linked to the ship's LAN of with the help of Gareth Knight and transmitted data in near-real-time to a server at PML. Underway pCO was measured every 15 minutes, marine air every 45 minutes and standards every hour. Water leaks related to the ships plumbing continued to be an issue and the underway water supply was intermittently shut off, particularly in bad weather and during transits where the ship might roll in a predominant direction for long periods.

5. Long-term buoys, moorings and landers

Daniel Comben, David Sivyer, Chris Balfour *et al.*

Cefas CandyFloss SmartBuoy

The SmartBuoy was recovered 23/08/2015 13:26 UTC with all sensors and instruments intact, the Cefas ESM2 logger had recorded data and the water sampler had collected 20 calibration water samples. The NOCL and PML thermistors were recovered successfully. The buoy was very badly bio-fouled.

Mooring Site 1 - (49.40, -8.60) Candyfloss - CEFAS smartbuoy Deployed on 23/05/2015 at 07:56, recovered on 21/08/15 at 10:00 water depth 147m After the deployment the loggers were put in a bucket of fresh water for measurement comparison at 10:00 on 26/08/15 and removed at 16:00 on 26/8/15.	
NOCL component	**Details**
Starmon Mini SN3898 at -2.5m	84% of battery life left, clock reset and logging set for 300s interval starting at 15:30 on 05/05/15. Data recorded OK until downloading on 26/08/15.
RBR Solo SN76788 at -5m	Clock reset and logging set for 300s interval starting at 15:45 on 05/05/15. Data recorded OK until downloading on 26/08/15.

Below is a brief overview of actions taken with PML logger on the smartbuoy/smartbuoy mooring. Mooring Site 1 - (49 Deg 24.14916', 8 Deg. 36.26310'N) Candyfloss - CEFAS smartbuoy, deployed at 07:56 on 23/05/15, RRS *Discovery* – DY030 Nominal 49° 29.134'N, 8° 36.251'W, depth 147 m, Recovered on 21/08/15 at 10:00, RRS *Discovery* – Cruise DY034. At 10:00 on 26/08/15 the loggers were placed into a bucket of fresh water for measurement comparison, the loggers were removed at 16:00 on 26/08/15. This was then end of the deployment of these loggers.

All loggers were set for a 15s measurement interval
1.-SBE 56SN4389 at -0.3m – data downloaded OK
2.-SBE 56SN4391 at -0.6m – data downloaded OK
3.-SBE 56SN4429 at -1.6m – data downloaded OK
4.-SBE 56SN4432 at -3.5m – data downloaded OK
5.-SBE 56SN4431 at -7m – data downloaded OK
6.-DST SN7552 at -10m – This star oddi DST TP logger recorded data was downloaded and reported 79% battery life remaining.

Note that at the selected 15s sampling regime the Star Oddi DST Centi logger at -10m only has memory capacity for ~15 days of data recording.

Cefas East of Haig Fras Minilander

This lander was recovered 30/08/2015 11:54 UTC. All instrumentation was intact; the Cefas ESM2 logger and NOC, Liverpool's RDI ADCP had both recorded data. This site has been the most successful throughout the SSB programme collecting data from March 2014 throughout. The guard buoy at this site was also successfully recovered.

Mooring Site 2 - (50 35.48616'N, 7 01.021'W) – East of Haig Fras - CEFAS Minilander Deployed on 16/05/15 at 09:30 in 100m of water, recovered at 10:00 on 30-08-15	
NOCL component	**Details**
*600 kHz RDI ADCP, SN5806 no pressure sensor	One internal and two external batteries, internal batteries used at deployment start. Beam 1 points to the recovery spooler and the ADCP is ~110 cm above the deck. Clock reset and logging set to start at 11:00 on 15/05/15, 2.5GB of memory installed. Data recovered OK.

* Script file/parameters available upon request

Celtic Deep SmartBuoy, MiniLander and NOCL bedframe

The instrumented SmartBuoy was recovered at 15/08/2015 13:15UTC. The main surface instrumentation was intact, still operational, the Cefas ESM2 logger had recorded data and the water sampler had collected 21 calibration water samples. The temperature sensors on the mooring wire were all present (see NOCL for data). The surface floats of the Cefas MiniLander were observed to be very close and possibly caught around the Trinity House guard buoy. As the guard buoy was due to be lifted on the 24th August it was decided to leave the recovery until afterwards. Trinity House vessel *Patricia* duly recovered the guard buoy and a length of the minilander recovery line. The acoustic release on the minilander was unresponsive so a Cefas grapple was deployed to pick up the ground wire. This was successful on the first attempt and the minilander was recovered on 27/08/15 17:13 UTC. All instrumentation was intact with only one wiper arm bent; the Cefas ESM2 logger and NOC, Liverpool's RDI ADCP had both recorded data.

The NOCL bedframe was recovered using a bespoke grapnel, camera and line system after the acoustically operated release assembly was fouled during an extended deployment.

Mooring Site 3 – (51 8.1075' N, 6 34.3340'W) – Celtic Deep 2 - CEFAS Minilander Deployed on 08/05/2015 at 12:29, 51° 08.15310'N, 6° 34.07664'W. Note that the position of this lander has been changed to close to the Celtic Deep work area, i.e. 'Celtic Deep 2', water depth = 96m. **After suspected trawling damage the lander was recovered with a ground line trawl at 18:00 on 27/08/15.**	
NOCL component	**Details**
*600 kHz RDI ADCP, SN220252 no pressure sensor	One internal and two external batteries, all unused at deployment start. Beam 1 points to the backup recovery spooler and the ADCP is 110 cm above ship's deck. Clock reset and logging set to start at 09:00 on 09/05/15, 4GB of memory installed. The first ~50 days of the deployment show the pitch and roll probably out of range due to a toppled lander. After this an event occurs such as a mooring entanglement or dragging that nulls the pitch error and reduced the roll error to ~10 degrees for the remaining ~60 days of the deployment.

* Script file/parameters available upon request

Mooring Site 4 – Celtic Deep 2 (51 8.15286'N, 6 33.98072'W) - CEFAS smartbuoy	
Deployed on 09/05/2015 at 13:51, water depth 96m recovered on 15/08/2015 at 13:00 At 13:42 on 15/08/15 the SBE 39 and 56 loggers were added to a bucket of water for measurement cross checks after the recovery. The loggers were then removed from the bucket at 16:22 on 15/08/15.	
NOCL component	**Details**
SBE 39 T+P SN6761	Mounted at -10m with 300s sample interval. Clock reset and logging set to start at 06:00 on 06/05/15. Data recovered OK.
SBE 56 T SN3593	Mounted at -20m with 300s sample interval. Clock reset and logging started at 06:00 on 09/05/15. Data recovered OK.
SBE 56 T SN3590	Mounted at -30m with 300s sample interval. Clock reset and logging started at 06:00 on 09/05/15. Data recovered OK.
SBE 56 T SN3592	Mounted at -40m with 300s sample interval. Clock reset and logging started at 06:00 on 09/05/15. Data recovered OK.
SBE 56 T SN3596	Mounted at -60m with 300s sample interval. Clock reset and logging started at 06:00 on 09/05/15. Data recovered OK.

* Script file/parameters available upon request

Mooring Site 1 - (49.40, -8.60) Candyfloss - NOCL Bedframe	
Recovered on 23/08/2014 at 16:30, GPS 49° 23.942'N, 8° 35.863'W, depth 148m The frame had been lodged on the seabed primarily due to an extended deployment from November 2014 until the first recovery attempt during April 2015. Examination in August 2015 with a NMF/CEFAS camera and grapple system showed that the frame ballast was buried in sediment and the burn wire ballast release assembly was ceased due to suspected sediment and biofouling. The frame was recovered using a grapple system on 23rd August 2015 during the RRS *Discovery* based DY034 research cruise.	
Instrument	**Details**
RS485 + DQ pressure, pumped CTD, SN4736	On recovery the CTD was still running and 79772 samples had been recorded. The clock drift was GMT + 43 seconds at 08:46 on 25/08/15. Clock GMT + 43 seconds at 08:47 on 25/08/15 after the prolonged deployment. Data set seems OK from 21/11/14 to 23/08/15.
*Flowquest 150 kHz underwater current profiler (ADCP), SN015963	The FlowQuest real time clock was reset and a delayed start was set for 12:00 on 18/11/14. The top of the FlowQuest sensor array was 97cm above the deck. An extra external battery case with two internal packs was connected to double the endurance of the FlowQuest to ensure that data is recorded until the next scheduled recovery of the NOCL bedframe during April 2015. After an extended deployment until a grapple recovery during DY034 on 23/08/15 data was recorded from 18/11/14 to 09/08/15 and successfully downloaded.
*600 kHz RDI (turbulence mode) ADCP, SN12239 fitted to a gimbal. 2GB of memory was installed and the pressure sensor port was blanked.	The top of the ADCP sensor array was 96cm above the deck. Beam 2 pointed towards the FlowQuest. The instrument clock was reset on 08/11/14 and logging was set to commence at 00:00 on 01/01/15. The next recovery is scheduled for April and battery conservation is essential. This was a significantly delayed start until early 2015 to allow for the battery endurance of the ADCP and record measurements over the more scientifically interesting January to April 2015 winter to spring transition. Data recorded OK from 01/01/15 to 02/06/15 and the clock drift was GMT -96s at 09:33 on 24/08/15.
NOCL ballast jettison acoustic release 1	SN72863, RX 13.5, TX 12.0, Release A
NOCL ballast jettison acoustic release 2	SN70358, RX 11.0, TX 12.0, Release A

* Script file/parameters available upon request

6. UUCTD (Fe) casts

Peter J Statham, Jessy Klar, Carolyn Graves

Background

DY034 is the last of the 7 *Discovery* cruises done for the Shelf Sea Biogeochemistry Programme. As with the other 6 cruises, Work-Package 3 [WP3; Shelf sources of Fe to the ocean] is represented on DY034 and these scientists collected samples and data for both the pelagic and benthic components of WP3.

Water Column Work

All samples were collected with the NMF Ultraclean CTD [UCCTD], or Ti CTD as it is sometimes called. This system has a frame constructed from solid Ti and plastic, instruments are housed in titanium casings, uses OTE Niskin style externally closing bottles modified for trace metal work, and the system is deployed from a conducting Kevlar cable. In total there were 8 casts for particulate and different forms of dissolved Fe (<0.2 µm [dFe], <0.02µm [sFe], total dissolvable [TDFe]). Additional samples were collected at selected sites for particulate Cr isotopes, Fe isotopes, Nd isotopes and for calibration of the transmissometer, oxygen sensors, salinity and fluorometer. Nutrients were collected at all stations. Bulk water samples were collected from several main site casts for shipboard experiments (see below). Nutrient analyses (nitrite, nitrate, ammonium, silicon, phosphate) were done on board by Carolyn Harris from PML (see Section 9).

Table 6.1. Water column sampling with clean CTD system (UCCTD).

CTD number	Event Number	Site name	Date	Samples collected
1	2	A	7/08/15	Clean bulk water samples
2	3	A	7/08/15	Profile for Fe, standard parameters
7	132	G	11/08/15	Clean profile samples and water for shipboard experiments
15	217	H	16/08/15	Clean profile samples
17	292b	H	18/08/15	Bottom water samples
20	330	I	19/08/15	Clean profile samples
26	406	CCS (Candyfloss)	22/08/15	Clean profile samples
30	474	G	29/08/15	Bulk clean water for shore experiments
34	483	CS2 (shelf break)	31/08/15	Profile at 200m station

7. Sediment Fe sampling

Peter J Statham, Jessy Klar

Standard sampling

The main targets were the sites A (muddy), I (sandy mud) and H (muddy sand), that had been sampled on earlier cruises. Site G was too sandy for the megacorer used for sampling, and sediments were studied using through flow reactors (see below).

Table 6.2. Core samples collected by mega corer for standard sampling, and material from NIOZ cores for specific purposes. Note that if an event is missing from a sequence, no samples were taken or samples were used for alternative experiments.

Event Number	Date	Location	Cores used	Comments
068-070	09/08/15	A	none	All disturbed or did not collect material, or bottom seal did not operate
071	09/08/15	A	A, F, G	Standard analytical sequence
118	10/08/15	A	NIOZ	Sub core used for SPI work (see below)
237	16/08/15	H	A	Difficult to get good cores at this more sandy site
243	16/08/15	H	C	Standard analytical sequence
244	16/08/15	H	A	Standard analytical sequence
400	21/08/15	I	A, I, C	Difficult to get good cores at this more sandy site, with tough shell layers.
467	25/08/15	A	NIOZ	Used for SPI inter-comparison
485 & 486	31/08/15	Slope, ~1030 m	NIOZ	Surface sediment for Nd studies 48° 21.468N, 9° 41.173W. Surface sediment from both for Nd but biology only from second (circa 30 cm) core

The standard sampling and analytical sequence for collected material in a controlled temperature laboratory involved:

1) For each of 3 cores most surface water was drawn off to leave circa 2 cm of water above the sediment surface, and then oxygen penetration depths were measured using a Unisense 100 micron tip oxygen sensor, and associated micro-profiler system and software. Triplicate profiles were measured on each core. Samples were collected from the surface water for tdFe, dFe, Fe isotopes and nutrients.
2) Residual surface water was removed and then porewaters were collected at set nominal depths (1,2,3,4,6,8,10,12 cm) starting at 0.5 cm by inserting rhizons through pre-drilled holes in the core tube, and pulling the samples into clean all plastic syringes without contact with air. The core was initially moved within the tube to give correspondence with appropriate pre drilled holes.
3) Porewaters were sampled for FeII (sample immediately fixed with Ferrozine, FZ), FeII+III (FZ plus ascorbic acid reductant), Fe isotopes, U-236 (for Maria Villa Algafame at U. Sevilla on

some cores) nutrients (after dilution with low nutrient seawater), dissolved sulphide, and DOP/N/C.

4) After porewater removal the core was sliced and the material labelled and stored frozen for later analysis in Southampton, and U. Sevilla.

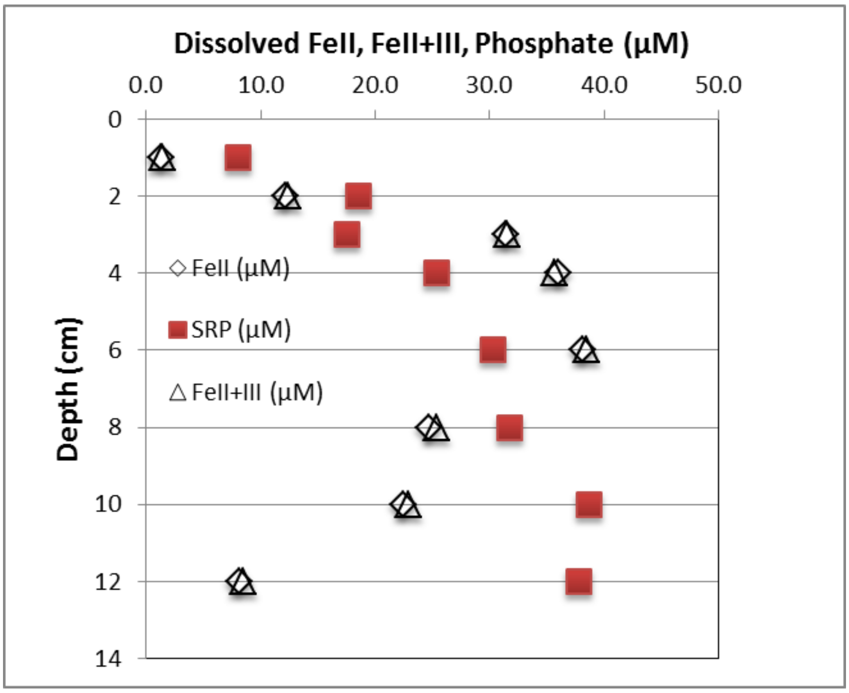

Figure 6.1. Site I Core 400A. Porewater d Fe, dFeII+III, and P (soluble reactive phosphate, SRP) with depth. Data is preliminary.

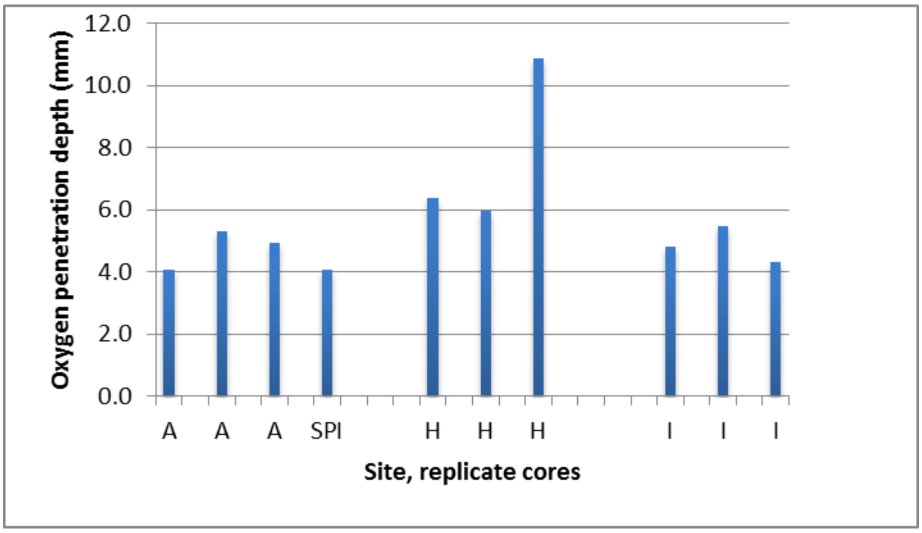

Figure 6.2. Oxygen penetration depths (OPDs) at each site. Each bar is the average of between 2 and 5 oxygen profile OPDs. The third core at site H showed significant bioturbation.

Site H appeared to be the best oxygenated with deepest OPD, presumably because of the significant bioturbation evident (Figure 6.2).

Through Flow Reactor (TFR) systems

In coarse sediments, such as site G, it is very difficult to collect pore waters using the megacorer and rhizon technology because the fluids rapidly drain through the sandy material. An alternative approach to investigating the biogeochemistry in these sediments is to pass seawater through them and monitor the changes in key parameters (oxygen, pH, Fe, nutrients etc.) before and after passage through the sediment. The group at the University of Portsmouth (in particular Drs Reynolds and Fones) are leading this work and our collaboration involved the measurement of dFeII and dFeII+III in the effluent from the cores. See Section 16 for more detail.

Sediment-water incubations (SWINC)

Mixing surface oxygenated sediment with seawater can mimic resuspension events with associated release and/or removal of iron. Large scale experiments using 25 L carboys and additions of surface mixed sediment from Sites A and H were carried out. Mixing experiments were done in triplicate together with a control (seawater only). These data will be compared with information from previous SWINC experiments run during other SSB cruises.

Some scaled down mixing experiments (mini-SWINCS) in which changes in dissolved Fe chemistry were monitored using the high sensitivity LWCC system (see below) were also done. The main purpose here was to enable measurement of any released reduced Fe II, which is not possible to determine in stored samples.

FeII release under sub-oxic conditions

During DY030 in May 2015 an experiment was run in which water over a collected core was capped and allowed to go sub-oxic. Substantial release of dissolved Fe was found at this time of year. The experiment was repeated on DY034 using sealing caps and non-contaminating magnetic stirrers that were purpose built in Southampton, with Firesting sensors in the solutions to follow changes in oxygen. Duplicate samples from Site A and a control were sealed and natural biological respiration allowed to occur. Samples were incubated in the dark in the cold room (T= about 10°C).

After a week the oxygen was reduced to about 50% of saturation in one tube. This was then aerated and any changes in the iron concentrations followed. The FeII and total dissolved Fe in the samples were determined using Ferrozine and Ferrozine plus ascorbic acid respectively, and a light waveguide capillary cell (LWCC) detector with a detection limit of about 3 nM was used to determine these species. Unlike the experiment in May when several hundred nM Fe II was released, there was close to no detectable Fe in the samples on DY034. This presumably reflects much lower concentrations of labile carbon in the sediments than earlier in the year after the bloom event.

Geochemistry of Sediment Profile Images

The sediment profile imager (SPI) is an instrument that provides a cross sectional view of the sediment water interface. Whilst often used as a monitoring tool for sediment quality status, interpretation of the images has not extended to the geochemistry of the sediments imaged. In order to improve the linkage between the images and the geochemistry, a modified core tube with a flat window on one side was constructed to collect core samples from a NIOZ box corer. Images were then taken and geochemical measurements made on porewaters collected by rhizon sampling. Solid phases were collected for later laboratory analyses. Once analyses are complete comparison between image and geochemistry will be done.

Neodymium Studies.

Shelf and slope systems appear important in the ocean geochemistry of neodymium. A sample of shelf sediment will be taken for Dr. Torben Stichel (UoS) to be used in his studies on this element.

Key points from work at this stage

Sediments appear to be much less of a potential source of dissolved Fe to the water column in August than in June. This most probably reflects the rapid turnover of labile carbon deposited to the sediment immediately after the spring bloom so that by August the labile C is largely gone. As Fe release from sediments is largely a function of reducing conditions reflecting carbon content, a strong seasonal pattern of sediment release of Fe is predicted.

8. Water column biogeochemical sampling

Louis Byrne and Sebastian Sims

Aim: The aims of the organic biogeochemistry team were to collect water column samples at the four main benthic sampling site, CANDYFLOSS and the shelf edge sites to; (a) collect samples for silicate, phytoplankton community and DIC/Alk for NOC Southampton (b) collect samples for calibration of fluorometer and SPM sensors attached to the CTD, sensors deployed on CEFAS smart buoy and lander and the NOC-L bedframe; and (c) collect samples for calibration of sensors deployed on gliders. A series of sampling regimes were followed: (a) depth profiles using CTDs at six sites (Site A, G, I, H, CANDYFLOSS and shelf edge), and (b) sampling surface water from the uncontaminated seawater supply.

Sample collection techniques and analytical methods

Chlorophyll a: Seawater samples were collected in 250 ml dark brown plastic bottles from 6-7 depths. 200 ml of the water sample was then vacuum filtered through 25 mm diameter Whatman GF/F (effective pore size 0.7 µm) filters and frozen immediately at -20°C.

Size-fractionated Chlorophyll-a: Seawater samples were collected in 500 ml dark brown plastic bottles from 6 depths. 200 ml was filtered under gravity through a 25 mm diameter 20 µm polycarbonate filter, with a further 200 ml being filtered under gravity through a 25 mm diameter 2 µm polycarbonate filter. Once filtered, the samples were frozen immediately at -20°C.

Particulate silica ($bSiO_2$): Seawater samples were collected in 1L dark brown plastic bottles from 6 depths. 500 ml was then vacuum filtered through 25 cm diameter 0.8 µm Nucleopore™ polycarbonate filters, dried for 12 hours at 50°C and refrigerated.

DIC/Alk: Seawater samples were collected in 250 ml glass bottles from 6-7 depths using a rubber tube connected to the Niskin outflow pipe. While sampling care was taken to ensure no bubbles were present in the bottle or the tube, and three bottle volumes were filled before the glass bottle was stoppered. Immediately after collection the water samples were taken to the laboratory where 2.5 ml of the sample was removed and 50 µl of mercuric chloride was immediately added to the sample before the lid of the bottle was replaced. In addition to CTD sampling, one underway sample was collected per day to calibrate the pCO_2 sensor on board the ship.

SPM: A known volume of water (~1000 ml) was sub-sampled from the clean CTD bottles from 4 different depths. This was filtered through pre-weighed GFF filters to extract SPM. It is important to be aware that all SPM samples were not being stored correctly up until the 23rd of August, at which point the samples were moved to a refrigerator, where they remained until the end of the cruise.

Table 8.1. Locations of sites sampled, approximate water depth, date sampled and corresponding CTD and event number.

Site	**Latitude (N)**	**Longitude (W)**	**Water Depth (approx . m)**	**Date Sampled**	**CTD Number**	**Event Number**
Benthic A	051º12.660’	006º07.850’	106	08/08/2015	003	004
Benthic G	051º04.030’	006º34.920’	106	08/08/2015	004	030
Benthic A	051º12.560’	006º07.800’	104	09/08/2015	005	078
Benthic G	051º04.250’	006º03.464’	100	10/08/2015	006	120
Benthic G	051º04.350’	006º34.870’	101	11/08/2015	007	132
Benthic G	051º04.340’	006º34.860’	100	11/08/2015	008	133
Celtic Deep	051º07.390’	006º34.580’	097	12/08/2015	010	180
Benthic A	051º12.760’	006º07.970’	105	13/08/2015	011	201
Benthic G	051º04.360’	006º34.390’	101	13/08/2015	012	202
Benthic A	051º12.820’	006º08.220’	107	15/08/2015	013	208
Benthic H	050º31.260’	007º02.300’	109	16/08/2015	015	217
Benthic H	050º31.280’	007º02.280’	109	16/08/2015	016	218
Benthic H	050º31.240’	007º01.970’	108	18/08/2015	018	293
Benthic H	050º31.050’	007º02.330’	107	19/08/2015	019	329
Benthic I	050º34.560’	007º06.290’	107	19/08/2015	020	330
Benthic I	050º34.560’	007º06.290’	107	19/08/2015	021	331
Benthic I	050º34.570’	007º06.300’	110	20/08/2015	022	388
Benthic H	050º31.020’	007º01.770’	107	21/08/2015	023	397
Shelf Break	048º31.820’	009º40.900’	253	22/08/2015	024	402
Candyfloss	049º23.690’	008º35.270’	146	22/08/2015	025	404
Candyfloss	049º24.400’	008º36.000’	147	22/08/2015	026	406
Candyfloss	049º24.420’	008º35.880’	147	23/08/2015	027	449
Benthic I	050º34.110	007º06.170’		24/08/2015	029	463
Benthic A	051º13.820	006º08.033’	107	29/08/2015	031	475
Benthic I	050º34.348	007º06.244’	112	30/08/2015	032	476
East of Haig Fras	050º35.728	007º01.119’	104	30/08/2015	033	478
CS2	048º34.246	009º30.577’	202	31/08/2015	034	483
CS2	048º34.246	009º30.577’	200	31/08/2015	035	484

9. Nutrients

Carolyn Graves

Objectives

To investigate the spatial and temporal variations of the micromolar nutrient species; Nitrate, Nitrite, Silicate, Ammonium and Phosphate during the DY034 research voyage on RRS *Discovery*, in the Celtic Sea, Shelf and Shelf Edge off the West coast of the UK. To work alongside the Benthic biogeochemists investigating nutrient pore water distributions of the major nutrients and to sample for overlying waters and benthic re-suspension of the nutrients over various time-series experiments. Carry out nutrient analysis from benthic experiments for the WP3 trace metals group as part of the SSB programme. Also analyse nutrient samples from the Benthic Flume, Benthic Mini-Flume (Thompson) and the NOC-L Benthic Lander (Balfour). The Benthic Lander samples were preserved with Mercuric Chloride. Please see the relevant Section reports for these as to specific sampling protocols.

Sample preparation and procedure

There was absolutely minimal storage of the CTD water column samples except for the time waiting to be analysed in the laboratory. These samples were always run at lab temperature and were not filtered. 60m ml HDPE Nalgene bottles were used for all the nutrient sampling, these were aged, acid washed and cleaned initially, and stored with a 10% acid solution between sampling. Samples were taken from the Sea-Bird CTD systems on-board the RRS *Discovery*, both Stainless Steel and Titanium units. The sample bottle was washed 3 times before taking final sample, and capping tightly. This was then taken immediately to the analyzer in the lab, and analysis conducted as soon as possible after sampling. Nutrient free gloves (Duratouch and Semperguard) were used and other clean handling protocols were adopted as close to those according to the GO-SHIP protocols, (2010) as possible.

Sample Analysis

The micro-molar segmented flow auto-analyser used was the PML 5 channel (nitrate, nitrite, phosphate, silicate and ammonium) Bran and Luebbe AAIII system, using classical proven analytical techniques. The instrument was calibrated with home produced nutrient standards and then compared regularly against Nutrient Reference Materials, from KANSO Technos, Japan (Batch BU). The results from this also being part of a global nutrient programme (the INSS, International Nutrient Scale System) to improve nutrient analysis data quality world-wide. The analytical chemical methodologies used were according to Brewer and Riley (1965) for nitrate, Grasshoff (1976) for nitrite, Kirkwood (1989) for phosphate and silicate, and Mantoura and Woodward (1983) for ammonium.

Summary

The 5-channel autoanalyser worked very well throughout the cruise. KANSO nutrient reference materials (Batch BU) were run regularly to check analyser integrity and analytical continuity from one day to the next. Very good continuity in sensitivity for all 5 channels was found, demonstrating excellent analytical performance.

References

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Mantoura, R.F.C and Woodward E.M.S, 1983. Estuarine, Coastal and Shelf Science, 17, 219-224.

Table 9.1. CTD event, position and bottle metadata.

Date	CTD	Event	Position	CTD bottle analysed
07/08/15	CTD_002	003	51° 12.638'N 6° 7.827'W	Bottles 22,19,16,12,8,1 (depths: 25,40,60,80,95,102m)
08/08/15	CTD_004	030	51° 4.153'N 6° 34.666'W	Bottles 21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1 (depths: 10,10,10,20,20,20,30,30,30, 40,40,40,50,50,50,80,80,80,94,94,94m)
09/08/15	CTD_005	078	51° 12.561'N 6° 7.801'W	Bottles 22,19,16,13,10,7,3 (depths: 10,20,30,40,50,80,95m)
10/08/15	CTD_006	120	51°04.508N 6°35.0749'W	Bottles 21,18,15,12,9.6,3 (depths:10,20,30,40,50,80,95m)
11/08/15	CTD_007	0132	51° 04.344'N 6° 34.865'W	Bottles 22,20,18,16,14 (depths:27,47,62,82,97m)
11/08/15	CTD_008	0133	51° 04.344'N 6° 34.865'W	Bottles 21,18,15,12,9,6,3 (depths:10,20,30,40,50,80,94m)
12/08/15	CTD_010	180	51° 07.39'N 6° 34.58'W	Bottles 21,18,15,12,9,6,3 (depths:12,21,28,41,51,81,90m)
13/08/15	CTD_011	201	51° 12.76'N 6° 07.97'W	Bottles 18,15,12,9,6,3 (depths:11,21,30,49,81,99m)
13/08/15	CTD_012	202	51° 04.36'N 6° 34.89'W	Bottles 21,18,15,12,9,6,3 (depths:10,20,30,40,50,80,95m)
15/08/15	CTD_013	208	51° 12.82'N 6° 08.22'W	Bottles 21,18,15,12,9,6,3 (depths:10,20,30,42,51,81,101m)
16/08/15	CTD_015	217	50° 31.26'N 7° 218'W	Bottles 22,21,20,10,9,8 (depths:25,45,66,76,90,104m)
16/08/15	CTD_016	218	50° 31.28'N 7° 02.28'W	Bottles 24,22,20,18,16,14,12,10 (depths: 10,29,34,38,42,55,79,103m)
18/08/15	CTD_018	293	50° 31.24'N 7° 01.97'W	Bottles 22,19,16,13,10,7,4(depths: 10,20,30,40,60,80,100m)
19/08/15	CTD_019	329	50° 31.53'N 7° 02.339'W	Bottles 21,18,16,13,10,7,4,3 (depths:10,12,20,30,40,5080,100m)
19/08/15	CTD_020	330	50° 34.56'N 7°06.29'W	Bottles 23,21,19,9,7 (depths:28,44,68,88,102m)
19/08/15	CTD_021	331	50° 34.56'N 7°06.29'W	Bottles 21,17,13,9,5,1 (depths:5,20,30,45,60,98m)
20/08/15	CTD_022	388	50° 35.392'N 7° 5.962'W	Bottles 23,20,17,14,11,8,5 (depths:12,21,32,42,52,81,103m)
22/08/15	CTD_025	404	49° 23.698'N 8° 35.267'W	Bottles:22,20,18,16,14,11,10 (depths:10,30,40,42,46,81,142m)
22/08/15	CTD_026	406	49° 23.892N 8° 36.925'W	Bottles:22,18,16,10,7,4 (depths:27,50,62,91,121,141m)
23/08/15	CTD_027	449	49°24.736 8° 35.882	Bottles:21,18,15,12,9,6,3 (depths:10,20,35,44,79,132,142m)
24/08/15	CTD_029	463	50°34.174'N 7° 7.347'W	Bottles:21,18,15,12,9,6,3(depths:10,20,30,40,60,90,100m)
29/08/15	CTD_031	475	51° 13.820'N 6° 8.0331'W	Bottles:18,15,12,9,6,3 (depths:12,22,32,46,81,101m)
30/08/15	CTD_032	476	50° 34.350'N 7° 6.246'W	Bottle:24,22,20,18,16,14,12 (depths:10,20,30,37,50,85,105m)
30/08/15	CTD_033	478	50° 35.728'N 7° 1.118'W	Bottles:19,17,15,13,11,4,2 (depths:10,20,30,39,50,80,99m)
31/08/15	CTD_034	483	48° 34.246'N 9° 30.577'W	Bottles: 19,17,16,13,11,9,7,6,2 (depths:47,61,81,27,111,140,170,184,198m)
31/08/15	CTS_035	484	48°34.243'N 9° 30.577'W	Bottles:21,18,15,12,9,6,3 (depths:10,20,40,60,100,178,198m)

Table 9.2. Nutrient Underway Non-toxic water system Samples Analysed by AAIII Micromolar analysis.

8/08/15 17:00	Non Toxic 1+2	51θ 4.153'N 6θ 34.666W
9/08/15 10:20	Non Toxic 3+4	51θ 4.153'N 6θ 34.666'W
10/08/15 09:30	Non Toxic 5+6	51^{0}08.15N 6^{0}34.27W
11/08/15 09:30	Non Toxic 7+8	51θ 4.153'N 6θ34.666W
12/08/15 12:00	Non Toxic 9+10	51^{0}07.39'N 6^{0}34.58W
13/08/15 13:00	Non Toxic 11+12	51^{0}12.76 'N 6^{0}08. 22W
14/08/15 10:00	Non Toxic 13+14	51θ12.76'N 6θ7.827'W
15/08/15 15:40	Non Toxic 15+16	51θ 12.82'N 006θ 08.22'W
16/08/15 10:00	Non Toxic 17+18	50θ 31.28'N 007θ 02.28'W
17/08/15 10:00	Non Toxic 19+20	50^{0}31.28N 7^{0}02.33'W
18/08/15 16:15	Non Toxic 21+22	50^{0}31.24N 7^{0}01.97'W
19/08/15 12:00	Non Toxic 23+24	50^{0}31.05'N 7^{0}02.33'W
20/08/15 12:00	Non Toxic 25+ 26	50θ 35.'N 07 5.962''W
21/08/15 12:20	Non Toxic 27+28	50θ.31.053'N 07θ02.339'W
23/08/15 10:00	Non Toxic 29+30	49θ.23.698;N 8θ 35.267
24/08/15 13:20	Non Toxic 31+32	50θ 34.174'N 7θ7.347W.
25/08/15 12:20	Non Toxic 33+34	51^{0}04.364'N 6^{0}34.781W
26/08/15 12:20	Non Toxic 35+36	51θ 05.790'N 6θ34.433W
28/08/15 08:30	Non Toxic 37+38	51^{0}07.39'N 6^{0}34.58W
29/08/15 16:40	Non Toxic 39+40	51^{0}13.82 'N 6^{0}08. 03W
30/08/15 08:00	Non Toxic 41+42	50θ 34.350'N 7θ 6.246'W
30/08/15 10:00	Non Toxic 43+44	50θ 35.728'N 7θ 1.118'W
31/08/15 10:00	Non Toxic 45+46	48θ 34.246'N 9θ 30.577'W

Nutrient analysis of experimental samples

8th August Helen Smith T0 12 Cores Samples

9th August Helen Smith T18 12 Cores Samples

9th August Rachel Hale T0 Exp. 1. 15 Samples

9th August Dave Sivyer Flux Exp. 43 Samples

9th August WP3 Iron team 3 Samples

10th August Helen Smith T24 11 Ssamples

10th August Rachel Hale T0 5 Samples

10th August WP3 Iron team site A core G 8 samples

10th August Dave Sivyer Flux 8 samples+ Pore water 33 Samples

11th August Helen Smith T0 12 Core Samples

11th August Helen Smith T18 12 Core Samples

11th August Anouska Panton Core mini flume 001-018

11th August WP3 Iron team Site A Core 1-8

11th August WP3 Iron team Site A Core F 1-8

11th August WP3 Iron team SP1 1-8

11th August Helen Smith T 24 +Fe Cores 1-12

12th August Core mini flume 019-027 9 Samples

12th August Dave Sivyer Pore water samples Box G 30 Samples

#1 0cm-17cm -10 Samples

#2 0cm-17cm- 10 Samples#3 0cn-17cm- 10 Samples

13th August Helen Smith 12/08/15 Core 1-12 T-0 12 Samples

13th August Helen Smith 13/08/15 Core 1-12 Box G T-18 12 Samples

13th August Sarah Reynolds FTR Samples 8 Samples

13th August Dave Sivyer box G Flux 51 Samples

14th August Helen Smith 13/08/15 Core 1-12 T-24 12 Samples

14th August Sarah Reynolds FTR Samples 7

14th August Dave Sivyer Box G Flux 14 Samples

14th August WP3 Iron Team SITE A 8 SWINC Samples

15th August Rachel Hale T0- T-5 10 Samples

15th August Sarah Reynolds FTR T-5 T-6 7 Samples

15th August Dave Sivyer 1-T8 5 T9 14 Samples

15th August WP3 Iron Team T-3 T-4 SWINC 8 Samples

16th August Sarah Reynolds FTR T7 T8 7 Samples

16th August Dave Sivyer 1T-10 5 T-10 7Samples

16th August WP3 Iron Team Control T-5 Carboy T-5 4SWINC Samples

17th August Helen Smith Core 1-12 T-0 12Samples

17th August Helen Smith Core 1-12 T-18 12 Samples

17th August Sarah Reynolds FTR 3Samples

17th August Dave Svyer Box H Flux 54 Samples

17th August Dave Svyer Box H Pore Water 33 Samples

17th August CTW 3 Samples

17th August WP3 Iron Team Site A 8 Samples

17th August WP3 Iron Team Site E 7 Samples

18th August Helen Smith Core 1-12 T-24 12 Samples
18th August Sarah Reynolds FTR T-10 4 Samples +FTR T-11 4 Samples
18th August Dave Sivyer Box H Flux T-6 8 Samples+T-7 8 Samples
18th August WP3 Iron Team Core A SITE H 8 Samples

19th August Rachel Hale H1-H5 T-0 5 Samples
19th August Anouska Panton Core mini flume 028-054 27 Samples
19th August Lesley Chapman-Greig FTR T-12 4Samples

20th August Rachel Hale G1-G5 T-5 5 Samples
20th August Dave Sivyer Box I Pore water33 Samples
#1 11 Samples
#2 11 Samples
#3 11 Samples
20th August Dave Sivyer Box I Flux 25 Samples
20th August Lesley Chapman-Greig FTR 4Samples
20th August WP3 Iron Team SITE H SWINC 20 Samples
20th August Helen Smith Core 1-12 T-0 12 Samples

21st August Lesley Chapman- Greig FTR T-14 4 Samples
21st August WP3 Iron team SWINC T-6 4 Samples
21st August WP3 Iron team SITE I 3 Samples
21st August Dave Sivyer Box I Flux T-3 +T-4 24 Samples
21st August Helen Smith Box I T-24 12 Samples
21st August Helen Smith T-18 12Samples

22nd August Dave Sivyer Box I Flux 14 Samples T-6 +T-7
22nd August Rachel Hale Experiment 1 T-0 20Samples
22nd August Anouska Panton Core mini flume 27 Samples
22nd August Lesley Chapman-Greig FTR T-15 4Samples
22nd August Steve Widdecombe Bucket Samples 6
22nd August WP3 Iron team Cores 1+A+C SITE I 23 Samples

23rd August Dave Sivyer Pore Water T-1 +T-2 +T-3 33 Samples
23rd August Dave Sivyer Flux T-0 + T-2 27 Samples
23rd August Helen Smith T-0 12 Samples

23rd August Lesley Chapman-Greig FTR T-16 4 Samples

24th August Rachel Hale T-0 5Samples +T-1 5Samples

24th August Dave Sivyer Flux Samples T-3+T-4+T-5+T-6 34Samples

24th August Helen Smith T-18 +T-24 24Samples

24th August Lesley Chapman-Greig FTR T-17 4 Samples

25th August Rachel Hale T-0 -T-5 20 Samples

25th August Dave Sivyer T-7 –T-8 16 Samples

25th August Lesley Chapman-Greig FTR T-18 4 Samples

25th August WP3 Iron team SPI 8 Samples

25th August Steve Widdecombe 6 Bucket Samples

26th August Lesley Chapman-Greig FTR T-19 4 Samples

26th August Steve Widdecombe Bucket Samples 9 Samples

28th August Rachel Hale T-5 5Samples

28th August Lesley Chapman-Greig FTR T-20 4 Samples

28th August Lesley Chapman-Greig FTR T-21 4Samples

28th August Steve Widdecombe 9 Bucket Samples

29th August Lesley Chapman- Greig FTR T-22 4Samples

30th August Rachel Hale CF1 T-5 5 Samples

30th August Steve Widdecombe Bucket Samples 12

31st August Chris Balfour 71 Samples

31st August Dave Sivyer 48 Samples

10. Biogeochemical sediment studies

Dave Sivyer et al.

SPI and Chem SPI

Sediment Profile Imagery (SPI) was collected at the four corners of the box and in the centre at all four main sites, as well as at 3 corners of the Candyfloss North site. The images produced are a slice through the sediment, showing the sediment water interface and undisturbed layering below the sediment surface. These images will be analysed at both Cefas and NOC for penetration depth, apparent redox penetration depth (aRPD), surface roughness and changing grain size with depth. The Chem SPI was used at the four main sites. In addition to the usual image analysis, the Chem SPI has a pH gel probe attached to the face plate and was left in position on the sea bed for 20 minutes per hop. Image analysis of the probe will determine an in-situ pH profile through the sediment from colour changes in the gel.

Sediment Characterisation

Samples for sediment characterisation were collected from the NIOZ corer at the four main sites and Candyfloss. Particle size analysis (PSA)/Organic carbon and Nitrogen (OCN) sub-cores were sliced to depths of 0-5 cm and 5-10 cm, while Porosity/sediment Chlorophyll sub-cores were sliced at 1 cm intervals down to a total depth of 10 cm. These will be processed at the Cefas laboratory. Rapid fines assessment (RFA) was collected at a depth of 0-5 cm using a syringe and processed on board giving an initial indication of the percentage of fines to sand at each site. A sub-core was profiled using a Unisense 500µm Oxygen Microelectrode to find the oxygen penetration depth and 500 µm pH Microelectrode to provide a pH profile. At each site duplicate pH gel probes were also inserted by hand into the sub-core and then photographed. These will be processed through image analysis to provide a pH profile. These methods will be used in conjunction with the SPI to assess the physical and biogeochemical parameters of the sediment.

Pore Water Studies

Pore water profiles were collected in triplicate directly from 20cm NIOZ core tubes using sipper probes at the four main process sites and Candyfloss. The probes were inserted into the sediment core to pre-determined depths and, after a small flush, approximately 10 ml of water was extracted using a vacuum pump. Sample depths range from 1-20 cm, providing a profile through the sediment and overlying water was also collected. Once extracted, the water was syringe filtered (0.2 µm) and analysed for nutrients by PML on-board ship.

Nutrient Flux Incubations

A 24-48 hour nutrient flux incubation was run at the four main process sites and an additional incubation was run at Candyfloss. This involved taking a sub core from 5 different NIOZ cores, as well as 3 litres of the overlying water. These 5 sub-cores were then sealed, aerated and submerged in a water filled incubation tank set to 9.0°C, along with three 1 litre core tubes with just bottom water. 20 ml of the cores overlying water was extracted using a syringe at known steps along a time series. These were then syringe filtered (0.2 µm) and analysed for nutrients on-board by PML. At the end of the incubation period, all cores were photographed and the depth of the sediment, remaining overlying water and air space were noted. Nutrient fluxes will be determined once data is available.

An additional set of triplicate cores was run without aeration and sealed against air ingress. These had oxygen sensors (Firesting oxy dots) fitted to check a good seal was achieved. The overlying water of each core was sampled at the start (before sealing) and then again after approx. 12 hours depending on the oxygen consumption. The rates of nutrient flux will be compared to the unsealed aerated sediment incubations.

11. Sediment N cycling

Steve Widdicombe and Joana Nunes

Nitrification rates from NIOZ cores – At stations A, G, H, I and Candyfloss, 12 replicate samples of surface sediment were collected in pre-weighed, 14 mL glass vials (surface scrapings of top 0.5 cm). Approximately 2-3 mL of sediment was collected in each vial and filled with bottom water to create a slurry. Subsets of the slurries were amended with 0.1 mL of 1M zinc chloride ($ZnCl_2$; n=3), 0.1 mL of 1M allylthiourea (ATU; n=3) and 0.1 mL of 1M sodium chlorate ($NaClO_3$; n=6) and incubated in the CT-room at bottom temperature for ca. 24 hours. A parallel incubation without sediment (bottom water + treatments) was conducted at the same time. At the end of the incubation period, 0.1 mL of 1M $ZnCl_2$ was added to all the bottles for preservation. Ammonium oxidation rates will be measured as rates of nitrite accumulation in the $NaClO_3$-treated samples compared to the ATU-treated samples. The initial $ZnCl_2$-treatment acts as the starting point. Sediment rates will be corrected for ammonium oxidation in bottom water.

Denitrification/Anammox rates from NIOZ cores – At stations A, G, H, I and Candyfloss, 12 replicate cores were collected (i.d. 7 cm) from 5-6 separate NIOZ cores. Each core-tube had approximately 15-20 cm of sediment and 10-15 cm of overlying water. Overlying water was discarded from each core and replaced with bottom water amended with $^{15}NO_3^-$ (Three treatments: +0 µM, +50 µM, +200 µM $^{15}NO_3^-$). The +0 treatment was homogenized with a power tool and the slurry decanted into 125 mL glass bottles. 1 mL of 1M $ZnCl_2$ was added for preservation and the bottles were sealed with Teflon-lined rubber septa and Al-crimps. The remaining two treatments were incubated in the CT-room, at bottom water temperature for ca. 24 hours. Magnetic flees were suspended in the core tubes and agitated by an external electromagnetic circuit. After the incubation period, the cores were homogenized and preserved as above. Denitrification and Anammox rates will be determined post-cruise by membrane inlet mass spectrometry.

Station	STN A	STN H	STN I	STN G	Candyfloss
Nitrification	6 reps	6 reps	6 reps	6 reps	6 reps
Denitrification	4 reps	4 reps	4 reps	4 reps	4 reps

12. Faunal and microbial community structure and biomass

Steve Widdicombe Joana Nunes

Macrofaunal sampling from 0.1m^2 NIOZ box corer - At stations A, G, H, I and Candyfloss, 5 x 0.1 m^2 sediment cores were collected using the NIOZ corer. The sediment within the NIOZ core was sieved over a nest of 2 sieves (1 mm and 0.5 mm) and the residues placed into separate pots and preserved with 10% buffered formaldehyde solution. This residue will be returned to PML where the **macrofauna** (organisms >1 mm, or >0.5 mm) will be extracted, identified and biomassed. At stations G and Candyfloss, only the 1mm mesh was used due to the course nature of the sediment.

Meiofaunal sampling from 0.1m^2 NIOZ box corer - At stations A, G, H, I and Candyfloss, 5 x 0.1 m^2 sediment cores were collected using the NIOZ corer. The overlying water was drained off to reveal the sediment surface. In each core, three 50 ml syringe corers were then pushed into the sediment to a depth of approximately 10 cm. The sediment from these 3 x 50 ml cores was pooled into a pot and preserved with 10% buffered (borax) formaldehyde solution. These samples will be returned to Plymouth Marine Laboratory (PML) where the **meiofauna** (organisms >63 µm) will be extracted, identified and biomassed.

Megafaunal sampling from 0.5m^2 SMBA boxer corer - At stations A, G, H, I and Candyfloss, 5 x 0.5 m^2 sediment cores were collected using the SMBA boxer corer. Each sample was sieved through a 1cm mesh and the residue placed into a pot and preserved with 10% buffered formaldehyde solution. This residue will be returned to PML where the **megainfauna** (organisms >1 cm) will be extracted, identified and biomassed.

Epifaunal sampling from 2m Jennings trawl – At stations A, G, H, I and Candyfloss, epifauna were collected from 3 replicate 2 m Jennings beam-trawl tows (only 2 trawls were conducted at Candyfloss due to the loss of a trawl). Each tow was conducted for 5 minutes at a ship speed of 1 knot. The trawl was paid out at a winch speed that kept the tension off the wire until 300 m (450 m at Candyfloss) of cable had been deployed. The pay-out was then halted and the timing for the trawl was started at this time. After 5 minutes the trawl recovery started (approx. 0.5 m per second) and this point constituted the end of the trawl time. At the start and end of the trawl period location and time were recorded). On recovery the fauna from the trawl cod end were placed in a 5 litre bucket and preserved with 10% buffered formaldehyde solution. This residue will be returned to PML where the **epifauna** will be identified and biomassed. These data will be used to quantify the community structure and biomass of large epifaunal organisms at each of the 4 main benthic sites.

Microbial community structure sampling from 0.1m^2 NIOZ box corer – At stations A, G, H, I and Candyfloss, 8 samples were taken for **microbial community structure** analysis. Once the overlying water had been gently drained off the NIOZ core, a 50 ml syringe (which had been previously sprayed with ethanol) was pushed into the sediment to a depth of approximately 10 cm. The microbial cores were then extracted from the sediment, sealed and immediately frozen at -80°C.

Microbial biomass sampling from 0.1m^2 NIOZ box corer – 5 replicate samples were taken at stations A, G, H, I and Candyfloss. Each sample was split into 4 depths to yield a total of 20 **microbial biomass** samples per site. Once the overlying water had been gently drained off the NIOZ core, 30 ml syringes (which had been previously sprayed with ethanol) were pushed into the sediment to a depth of approximately 10 cm. Each syringe core was sectioned into 4 depths: surface sediment (0 – 1 cm), 1 – 2.5 cm, 2.5 – 5 cm and 5 – 10 cm. From each of the 20 sediment samples, approximately 0.5 ml of sediment was added to a 2 ml tube and mixed with a spatula. Then, 1 ml of 5 mM CTC was added to sediment in each tube, this was vortex mixed and incubated at sediment temperature for 1 hour. The tubes were then centrifuged at 5000 g for 1 minute. The CTC solution was then removed from each tube and replaced with 1ml 4 % paraformaldehyde. The tubes were then sealed with parafilm and stored at – 20°C.

"Microbial bioturbation experiment" sampling for intact sediment cores and key bioturbators – At each of two stations, A and H, 30 NIOZ cores were collected and transferred into 30 large (30 L) plastic buckets. For each bucket the NIOZ core was sub-sampled using a 26 cm diameter stainless steel core. The stainless steel core was pushed into the NIOZ core to a depth of 40 cm. A plastic plate was pushed under the sub-core, which was lifted and placed over the bucket. The plate was removed and the intact sub-core of sediment was allowed to slide gently into the bucket. The buckets of sediment were transferred to a chilled (10°C) container where seawater was added to each bucket. An airstone was added to each bucket and the buckets were maintained until being transported back to PML. The overlying water in the buckets was monitored for changes in nutrients and regular water changes were conducted.

Forty individuals of Nephrops and 24 individuals of Goneplax were collected from 2 Jennings trawl deployments at station A. Animals were kept in seawater at 10°C, in individual pots, placed in large seawater tanks. The water in the tanks was changed regularly to prevent the build-up of ammonia. The animals were twice fed with squid. At each time a small piece of squid was added to the pot and then whatever food remained after a few hours was removed.

Microbial sampling from bioturbation experiments – 4-6 replicate samples were taken from each bioturbation experiment tank at stations A, G, H, I. At the end of bioturbation experiments, surface sediment was sampled using a 5 mL syringe (which had been previously sprayed with ethanol). Bioturbated and non-bioturbated sediment was specifically targeted in each tank. The sediment was immediately transferred into a 4 mL Eppendorf vial with 2 mL soil preservation solution and frozen at -20°C.

Station	**STN A**	**STN H**	**STN I**	**STN G**	**Candyfloss**
Sediment type	Mud	Muddy sand	Sandy Mud	Sand	Sand
Microbial community structure	6 reps	6 reps	6 reps	6 reps	6 reps
Microbial biomass	5 reps (4 depths)	5 reps (4 depths)	5 reps (4 depths)	5 reps (4 depths)	5 reps (4 depths)
Meiofauna (>63 µm)	5 reps	5 reps	5 reps	5 reps	5 reps
Macrofauna (>1 mm	5 reps	5 reps	5 reps	5 reps	5 reps
Megainfauna (>1 cm)	5 reps	5 reps	5 reps	5 reps	5 reps
Epifauna	3 reps	3 reps	3 reps	3 reps	2 reps

13. Pigments

Joana Nunes and Steve Widdicombe

Pigment sampling profiles from CTD – At each of the main process stations (A, H, I and G) and Candyfloss, water samples were taken from the CTD and filtered to determine water column pigment concentrations. From each CTD water was taken from 4 depths (surface, chlorophyll maximum, bottom water and a fourth depth, usually between the chlorophyll max and the surface). For surface depths, triplicate 2 L samples were collected, whilst for the other 3 depths a single 2 L sample was collected. Approximately 1 L of each sample was filtered on a 25 mm GF/F filter. The filter was inserted into a cryovial and flash frozen in liquid nitrogen. Filters were then stored at -80°C.

Pigment sampling from 0.1m^2 NIOZ box corer – At stations A, G, H, I and Candyfloss, 6 replicate samples were taken. Once the overlying water had been gently drained off the NIOZ core, a 50 ml taped (blacked out) syringe was pushed into the sediment to a depth of approximately 10 cm. The sediment ***pigment cores*** were then extracted from the sediment, sealed and immediately frozen at -80°C.

Station	**STN A**	**STN H**	**STN I**	**STN G**	**Candyfloss**
Sediment pigments	8 reps	8 reps	8 reps	8 reps	8 reps
Water column pigments	2 CTDs (4 depths)	1 CTD (4 depths)	2 CTDs (4 depths)	1 CTD (4 depths)	1 CTD (4 depths)

Figure 13.1. On behalf of the scientists on DY034, a massive thank you to all the coring support team.

14. Pulse chase sediment core incubations experiment

Helen Smith

At stations A, G, H, I and Candyfloss, a 'pulse chase' sediment core incubation experiment was performed. Sediment cores were collected in 10 cm internal diameter tubes (sub-coring from the NIOZ) and were topped up with bottom seawater. The overlying water was air bubbled for a minimum of 1 hour through a core lid port and the cores were acclimated to experimental conditions in the dark. Freeze-dried diatoms (*Chaetoceros decipiens*) that had been previously been cultured in isotopically enriched (^{13}C and ^{15}N) artificial seawater were re-suspended using 10ml of bottom seawater and then gently pipetted onto the sediment surface of the cores. The experiment was run for 24 hours in total during which time the water in the microcosms was stirred with a rotating disc powered by electric motors at 40 rpm. The overlying water cores were maintained close to 100% air saturation for the initial 18 hours through bubbling for 15 minutes every 3 hours. After 18 hours the cores were sealed after taking nutrient and DIC samples and were incubated for a further 6 hours to establish the oxygen uptake rate (measured using non-invasive sensor spots). Water samples were taken at the start, after 18 hours and at the end of the experiment and were preserved for later analysis of $DI^{13}C$, $DI^{15}N$ and nutrients. Oxygen measurements were taken at the start, end and at frequent intervals throughout the incubation. A second pulse chase experiment was performed at station A using ^{57}Fe, ^{13}C and ^{15}N enriched diatoms. Samples for Fe analysis (60 ml overlying water) were taken at T0, T18 and T24 (Klar, Statham). Care was taken during this experiment to be as clean as possible and the metal needles used for water extraction were replaced with plastic tubing. Sediment horizons (0-1 cm; 1-2 cm; 2-5 cm) were also preserved at the experiment end. Prokaryote and macrofauna biomass, and the uptake of isotopically labelled carbon and nitrogen will be determined from the sediment samples. Analysis of all samples of nutrients was carried out on board immediately following the experiments (Harris).

Table 14.1. Experiments overview.

Site	Cores incubated	Treatments (number of replicates)	Start	Intermediate	End
A, G, H, I Candyfloss	12	Control (6) Algae (6)	DIC (12) DIN (12) Nutrients (12) Oxygen	DIC (12) Nutrients (12) Oxygen	DIC (12) DIN (12) Nutrients (12) Oxygen Prokaryote (6) Fauna (6)
A	12	Control (4) Algae (4) Algae x2 (4)	DIC (12) DIN (12) Nutrients (12) Fe (12) Oxygen	DIC (12) Nutrients (12) Fe (12) Oxygen	DIC (12) DIN (12) Nutrients (12) Fe (12) Oxygen Prokaryote (6) Fauna (6)

Table (group) 14.2. Details of sampling from each site are below:

Site A - 08.08.15

Event	**Time (GMT)**	**Latitude**			**Longitude**			**Depth (m)**	**Core**
018	09:00	51	12	662	6	7	867	105	1
019	09:15	51	12	663	6	7	864	105	2
020	09:33	51	12	665	6	7	864	105	3
021	09:47	51	12	666	6	7	862	106	4
022	10:01	51	12	666	6	7	862	106	5
023	10:16	51	12	670	6	7	865	106	6
024	10:30	51	12	674	6	7	866	107	7
025	10:44	51	12	678	6	7	866	107	8
026	10:57	51	12	678	6	7	866	107	9
027	11:10	51	12	678	6	7	866	107	10. 11. 12

Site A +Fe - 10.08.15

Event	**Time (GMT)**	**Latitude**			**Longitude**			**Depth (m)**	**Core**
110	05:46	51	12	633	6	8	020	105	1,2,3
112	06:17	51	12	638	6	8	020	105	4,5,6
115	07:01	51	12	625	6	8	020	105	7.8.9
116	07:15	51	12	625	6	8	020	105	10,11,12

Site G - 12.08.15

Event	Time (GMT)	Latitude			Longitude			Depth (m)	Core
159	06:44	51	4	410	6	35	020	100	1
160	06:56	51	4	410	6	35	020	99	2
162	07:36	51	4	408	6	35	020	99	3
165	08:06	51	4	404	6	35	019	99	4
166	08:18	51	4	405	6	35	020	99	5
167	08:30	51	4	405	6	35	020	98	6
169	08:54	51	4	406	6	35	023	98	7
170	09:07	51	4	406	6	35	023	98	8
171	09:20	51	4	406	6	35	024	98	9
173	09:47	51	4	401	6	35	023	98	10
174	09:59	51	4	401	6	35	022	98	11
175	10:13	51	4	401	6	35	023	98	12

Site H – 16.08.15

Event	Time (GMT)	Latitude			Longitude			Depth (m)	Core
222	10:33	50	31	340	7	2	067	105	1
223	10:46	50	31	340	7	2	067	105	2
224	11:00	50	31	340	7	2	067	105	3
225	11:15	50	31	340	7	2	066	104	4
226	11:27	50	31	340	7	2	067	105	5
228	11:52	50	31	334	7	2	067	104	6
229	12:05	50	31	334	7	2	066	104	7
231	12:34	50	31	332	7	2	067	105	8
232	12:47	50	31	332	7	2	067	104	9
234	13:16	50	31	329	7	2	067	105	10
235	13:30	50	31	329	7	2	067	105	11, 12

Site I – 20.08.15

Event	Time (GMT)	Latitude			Longitude			Depth (m)	Core
365	06:30	50	34	593	7	6	236	109	1
366	06:46	50	34	590	7	6	235	110	2
367	06:59	50	34	591	7	6	235	110	3
368	07:14	50	34	590	7	6	235	110	4
371	08:00	50	34	596	7	6	235	110	5
373	08:27	50	34	601	7	6	235	110	6
376	09:08	50	34	602	7	6	235	110	7
377	09:20	50	34	601	7	6	235	110	8
379	09:48	50	34	609	7	6	242	110	9
382	10:26	50	34	615	7	6	242	110	10, 11
383	10:37	50	34	615	7	6	242	109	12

Candyfloss - 23.08.15

Event	Time (GMT)	Latitude			Longitude			Depth (m)	Core
433	07:17	49	24	418	8	35	840	147	1
434	07:33	49	24	418	8	35	891	147	2
436	08:05	49	24	410	8	35	891	147	3
437	08:20	49	24	418	8	35	892	147	4, 5
438	08:35	49	24	418	8	35	820	147	6
439	08:50	49	24	418	8	35	822	148	7
441	09:19	49	24	417	8	35	888	148	8, 9, 10
443	09:50	49	24	417	8	35	887	148	11
445	10:17	49	24	417	8	35	888	149	12

15. Assessment of sediment particle reworking and bio-irrigation

Rachel Hale and Christina Wood

Replicate sediment cores (n = 5, Table 15.1) of size 20 cm by 20 cm and depth 12 cm were collected using a Perspex subcorer from NIOZ cores taken at the 4 process sites (Mud, site A; Sandy Mud, site G; Muddy Sand, site H; and Sand, site I) and Candyfloss (CF) in the Celtic Sea. These sediment cores were transferred to clear perspex mesocosms and placed in randomised locations in the controlled temperature laboratory on board the RRS *Discovery* and covered with 20 cm of unfiltered seawater. All cores were aerated and maintained at approximately 10 °C in the dark. Fine sediment suspended during composition of the cores was allowed to settle out of the overlying seawater. After 24 hours this water was replaced with fresh unfiltered seawater to remove the mesocosm assembly nutrient flux due to sediment disturbance.

On the first day of each incubation nutrient samples of 30 ml (0.45 μm filtered) were taken. These samples were analysed on board. To assess sediment particle reworking and bioturbation by fauna autoclaved luminophores (fluorescent green, 235 g dry weight), fluorescently labelled sand-based particulate tracers, were added evenly to the cores to a depth of 2 – 3 mm to assess bioturbation. The luminophores were pre-soaked prior to distribution and vigorously shaken to prevent particle aggregation and flotation during application.

After 5 days, T5 nutrient samples were taken as described above. To assess bio-irrigation the mesocosms were inoculated with 8.231 g of sodium bromide dissolved in 20 ml of seawater. Five millilitre overlying water samples were then taken after 0, 4 and 6 hours and filtered to remove suspended particles and allow colorimetric analysis upon return to shore. The samples will be analysed for the change in Br^- concentration ($\Delta[Br^-]$, $mg.l^{-1}$) using a Tecator flow injection auto-analyser (FIA Star 5010 series).

After 6 days, sediment surface samples for microbial analysis were taken from each core in bioturbated areas, where obvious burrows or sediment reworking had occurred, and non-bioturbated areas, where there was no obvious sediment reworking. These samples will be analysed by Karen Tait at Plymouth Marine Laboratory for bacterial and archaebacterial abundance and activity.

Faunal mediated sediment particle reworking in the square cores was estimated non-invasively using a sediment profile imaging camera (Canon 400D set to ISO 400, 13 second exposure, aperture f5.6; image size 3888 × 2592 pixels, i.e. 10.1 megapixels effective resolution 56 × 56 μm per pixel). The camera was optically modified to allow preferential imaging of the luminophores under ultra-violet (UV) light (Figure 15.1). Images of all four sides of each core were taken in a UV illuminated imaging box. The redistribution of the tracers can be determined from stitched composite images (RGB colour, JPEG compression) using a custom-made semi-automated macro that runs within ImageJ (Version 1.47), a java-based public domain computer program developed at the US National Institutes of Health. The macro returns a binary value depending on whether luminophores are present at each pixel (value = 1) or absent (value = 0) using the sediment water interface as the uppermost row. From these data, the total luminophores in each row are summed to obtain the vertical mixing profile. The median ($^{f\text{-}SPI}L_{med}$, typical short-term depth of mixing), maximum ($^{f\text{-}SPI}L_{max}$, maximum extent of mixing over the long-term), and mean ($^{f\text{-}SPI}L_{mean}$, time dependent indication of mixing) mixed depth of particle redistribution can then be calculated from this profile. In addition, the maximum vertical deviation of the sediment-water interface (upper – lower limit = surface boundary roughness, SBR) can provide an indication of surficial activity.

After photographing the whole sediment core was transferred to labelled 10 litre buckets and preserved in 4 % formalin for sieving (500 µm) and community analysis upon return to Southampton.

Replicate sediment cores (n = 10, Table 15.2) of the same size were collected in the same way and maintained in the controlled temperature laboratory until transferred to the Biodiversity and Ecosystem Futures Facility at the National Oceanography Centre. These cores will be randomly allocated to one of two treatments: ambient conditions (10 °C and 380 ppm CO_2) and future projected conditions (14 °C and 1000 ppm CO_2).

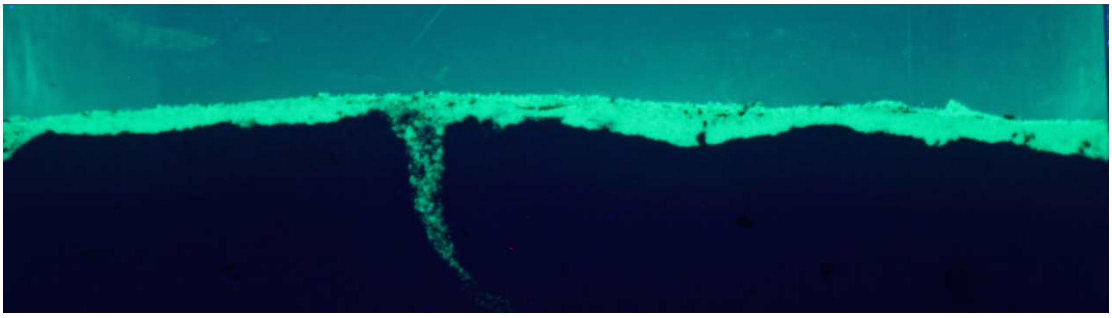

Figure 15.1. An example of faunal mediated sediment reworking from a sediment core taken from site H.

Table 15.1. The event number, date, time, location and depth of collection of the replicate sediment cores (n = 5) taken for incubation on board the RRS *Discovery* on DY034.

Core	Event	Date	Time	Latitude	Longitude	Depth
A1	9	08/08/2015	05.26	51' 12.65538	6' 7.85556	103.7
A2	11	08/08/2015	05.55	51' 12.65508	6' 7.85496	103.7
A3	13	08/08/2015	06.29	51' 12.65742	6' 7.85970	104
A4	14	08/08/2015	06.45	51' 12.65778	6' 7.85952	104.1
A5	16	08/08/2015	07.18	51' 12.65700	6' 7.85860	104.3
G1	143	12/08/2015	01:19	51' 4.42248	6' 35.02360	100.5
G2	144	12/08/2015	01:33	51' 4.423	6' 35.023	101
G3	145	12/08/2015	01:46	51' 4.42318	6' 35.02302	100.5
G4	146	12/08/2015	01:59	51' 4.42354	6' 35.02248	100.4
G5	147	12/08/2015	02:14	51' 4.420	6' 35.023	101
H1	252	16/08/2015	19:12	50' 31.30740	7' 2.04132	108.5
H2	253	16/08/2015	19:24	50' 31.30818	7' 2.04222	107.9
H3	254	16/08/2015	19:38	50' 31.31394	7' 2.05830	107.8
H4	255	16/08/2015	19:52	50' 31.31154	7' 2.05782	108.3
H5	257	16/08/2015	20:20	50' 31.30878	7' 2.05776	107.5
I1	338	19/08/2015	20:27	50' 34.56600	7' 6.23316	110.4
I2	339	19/08/2015	20:42	50' 34.56630	7' 6.23304	110.3
I3	340	19/08/2015	20:53	50' 34.56630	7' 6.23298	109.5
I4	341	19/08/2015	21:07	50' 34.56678	7' 6.23046	109.7
I5	343	19/08/2015	21:35	50' 34.56948	7' 6.23064	109.5
CF1	417	22/08/2015	23.11	49' 24.42144	8' 35.91846	147.1
CF2	419	22/08/2015	23.47	49' 24.42090	8' 35.91912	147.3
CF3	420	22/08/2015	23.57	49' 24.41916	8' 35.91714	146.3
CF4	422	23/08/2015	00.37	49' 24.41940	8' 35.91456	147.3
CF5	423	23/08/2015	00.54	49' 24.41958	8' 35.91060	147.4

Table 15.2. The event number, date, time, location and depth of collection of the replicate sediment cores (n = 10) taken for incubation in the Biodiversity and Environmental Futures Facility at the National Oceanography Centre under ambient and future conditions.

Core	Event	Date	Time	Latitude	Longitude	Depth
A6	32	08/08/2015	20.47	51' 12.68484	6' 7.01282	104
A7	33	08/08/2015	21.02	51' 12.68454	6' 7.01180	104
A8	34	08/08/2015	21.18	51' 12.68478	6' 7.01282	104
A9	35	08/08/2015	21.34	51' 12.68502	6' 8.01208	106
A10	36	08/08/2015	21.46	51' 12.68496	6' 8.01276	106
A11	37	08/08/2015	00:28	51' 12.68478	6' 8.01240	106
A12	38	08/08/2015	03:50	51' 12.68766	6' 8.01174	106
A13	39	08/08/2015	07:26	51' 12.68634	6' 8.01030	106
A14	40	08/08/2015	11:02	51' 12.68574	6' 8.01090	106.7
A15	41	08/08/2015	23.00	51' 12.68412	6' 8.00880	106.5
G6	148	12/08/2015	02.26	51' 4.41972	6' 35.02260	101.2
G7	150	12/08/2015	02.53	51' 4.41690	6' 35.02266	101.2
G8	151	12/08/2015	03.07	51' 4.41696	6' 35.02254	101
G9	152	12/08/2015	03.19	51' 4.41702	6' 35.02254	101
G10	153	12/08/2015	03.33	51' 4.41342	6' 35.02188	101
G11	154	12/08/2015	03.46	51' 4.41282	6' 35.02002	101
G12	155	12/08/2015	04.01	51' 4.41276	6' 35.02020	101
G13	156	12/08/2015	05.57	51' 4.41306	6' 35.01984	100
G14	157	12/08/2015	06.18	51' 4.41282	6' 35.01960	100
G15	158	12/08/2015	06.30	51' 4.41282	6' 35.01972	100
H6	259	17/08/2015	04:04	50' 31.29570	7' 2.03778	107.2
H7	260	17/08/2015	07:55	50' 31.29828	7' 2.03790	106.7
H8	261	17/08/2015	11:31	50' 31.29846	7' 2.03742	106.6
H9	264	17/08/2015	07:26	50' 31.29990	7' 2.03022	106.7
H10	265	17/08/2015	10:33	50' 31.30002	7' 2.03016	106.1
H11	266	17/08/2015	13:40	50' 31.29912	7' 2.02956	105.7
H12	267	17/08/2015	03:36	50' 31.29948	7' 2.02410	105.2
H13	269	17/08/2015	23.40	50' 31.29264	7' 2.01888	105.0
H14	270	17/08/2015	12:43	50' 31.29282	7' 2.01876	105.2
H15	271	18/08/2015	00.06	50' 31.29282	7' 2.01882	104.8
I6	346	19/08/2015	03:36	50' 34.57182	7' 6.23082	109.1
I7	347	19/08/2015	07:26	50' 34.57434	7' 6.23286	109.1
I8	348	19/08/2015	10:19	50' 34.57542	7' 6.23346	108.5
I9	349	19/08/2015	13:40	50' 34.57578	7' 6.23322	108.2
I10	355	20/08/2015	01.38	50' 34.57962	7' 6.23490	107.1
I11	356	20/08/2016	01.52	50' 34.57956	7' 6.23526	106.7
I12	358	20/08/2017	02.20	50' 34.58226	7' 6.23472	107.3
I13	359	20/08/2018	02.33	50' 34.58214	7' 6.23532	107.2
I14	360	20/08/2019	02.49	50' 34.58490	7' 6.23544	106.8
I15	361	20/08/2020	03.01	50' 34.58460	7' 6.23502	106.9

16. DET/DGT gel probes and flow through reactor work

Sarah Reynolds & Lesley Chapman-Greig

This work covered three main objectives:

(i) Study sediment resuspension over the main SSB process sites encompassing pumped and diffusive sediment types;

(ii) Utilise DET gel probes to examine the phosphorus, iron and alkalinity biogeochemistry of all diffusive sediment types;

(iii) Examine the capacity of permeable/advective sediments in their ability to remineralise organic matter and gain further understanding of their biogeochemistry through the use of flow through reactors.

1. Sediment Resuspension

In order to examine the impact of sediment resuspension events on nutrient fluxes at the diffusive process sites (A, I and H) core mini-flume incubations were conducted. Samples were collected for nutrients (analysed on board by Carolyn Harris) dissolved organic carbon (DOC) and particulate organic carbon and nitrogen (to be analysed by the University of Portsmouth). Please see Dr. Charlie Thompson's cruise report for full details of the experiments conducted and samples taken.

2. DET gel probes.

The technology of Diffusive Equilibration in Thin films (DET) and Diffusive Gradients in Thin Films (DGT) have been successfully used to quantify in situ sediment solute species at high resolutions of µm to mm in various aquatic environments (Stockdale et al., 2009; Docekalova et al., 2002). Recently the DET method has undergone further development to produce 2D contour images of vertical and lateral diffusion through the use of colorimetric staining partnered with Computer Imaging Densitometry (CID) (Bennett et al,. 2015; Pagés et al,. 2011; Robertson et al., 2008).

As a consequence of work carried out in Cruise DY021, concerns regarding the detection limits of the phosphate colorimetric stain for soluble reactive phosphate (SRP) were raised. The shelf sediments at A, H and I were observed to have lower phosphate concentrations then the detection limits of the molybdate-ascorbic acid staining solution. To rectify this situation a recently developed titanium dioxide based DGT probe (Panther et al., 2010) was trialled with success on Cruise DY030, so will be used on this cruise to quantify the phosphate biogeochemistry within cohesive shelf sediments.

Method

During DY034, 2D DET gels probes were deployed in NIOZ cores collected at the diffusive sediment sites (A, I and H). Initially, gels were deoxygenated overnight by placing in artificial seawater and bubbled with N_2 gas. Upon deployment gels were pushed into the sediment ensuring the sediment water interface was around three quarters from the bottom of the gel face. The gel probes were left in the sediment for around 24 hours with the overlying water being continuously bubbled with air throughout the deployment. An additional 1D probe was deployed into a core at site A as part of team Iron's investigation. When recovered, the gels were analysed using colorimetric techniques and image scanning for iron II and alkalinity following methods described by Bennett et al (2012) and Bennett et al (2015). Further image and data processing is required for quantification and this will be conducted at the University of Portsmouth to produce 1D sediment concentration profiles and 2D contour images.

DGT probes were deoxygenated and deployed in the same cores alongside the DET's for 24 hours. Upon retrieval these were briefly washed and stored to be analysed by ICP-OES. The final concentrations will be calculated from Flick's First Law of Diffusion Equation to produce 1D concentration profiles.

All deployments were successful at each site. Site I and H contain varying amounts of sand that affected the sediment's ability to lie flush to the probe membrane window. Perspex screens were used at site H and I to push the sediment onto the probe face.

Sampling, DET gels

Table 1 Gel core, deployment, retrieval times and file ID. Time in GMT

Station	Event Core ID	Date & Time gel deployed	Date & Time gel retrieved	Gel ID	Comments
A	088	10/08/2015 09:50	11/08/2015 12:00	DY034_Fe_2D_01 DY034_Fe_2D_02	Scanned @ 10 and 15 minutes
51°12.6567		10/08/2015 09:50	11/08/2015 12:00	DY034_Alk_2D_01 DY034_Alk_2D_02	Scanned @ 10 and 15 minutes
6°8.01810		10/08/2015 09:50	11/08/2015 12:30	DY034_Fe_2D_03 DY034_Fe_2D_04	Scanned @ 10 and 15 minutes
		10/08/2015 09:50	11/08/2015 12:30	DY034_Alk_2D_03 DY034_Alk_2D_04	Scanned @ 10 and 15 minutes
		10/08/2015 09:50	11/08/2015 12:30	DY034_PO4_DGT_1	

		10/08/2015 09:50	11/08/2015 12:30	DY034_PO4_DGT_2	
				DY034_Fe_1D_01	WP3-10 minute scan
				DY034_Fe_1D_02	WP3-15 minute scan
I	393	21/08/2015 13:30	22/08/2015 13:30	DY034_Alk_2D_09 DY034_Alk_2D_10	Scanned @ 10 and 15 minutes
$50^o34.57704$		21/08/2015 13:30	22/08/2015 14:05	DY034_Fe_2D_09 DY034_Fe_2D_10	Scanned @ 10 and 15 minutes
$7^o6.30240$					
		21/08/2015 13:30	22/08/2015 14:35	DY034_PO4_DGT_C	
		16/05/2015 14:00	22/08/2015 14:35	DY034_PO4_DGT_D	
H	276	18/08/2015 13:00	19/08/2015 13:50	DY034_Fe_2D_05 DY034_Fe_2D_06	Scanned @ 10 and 15 minutes
$50^o31.28742$		18/08/2015 13:00	19/08/2015 13:50	DY034_Alk_2D_05 DY034_Alk_2D_06	Scanned @ 10 and 15 minutes
$7^o2.03772$		18/08/2015 13:00	19/08/2015 14:30	DY034_Alk_2D_07 DY034_Alk_2D_08	Scanned @ 10 and 15 minutes
		18/08/2015 13:00	19/08/2015 14:30	DY034_Fe_2D_07 DY034_Fe_2D_08	Scanned @ 10 and 15 minutes
		18/08/2015 13:00	19/08/2015 15:00	DY034_PO4_DGT_A	
		18/05/2015 13:00	19/08/2015 15:00	DY034_PO4_DGT_B	

3. Flow through reactors – Remineralisation of organic matter in permeable sediments

Sandy, permeable marine sediments found in shelf seas have been found to and exhibit substantial respiration rates and contribute significantly to dinitrogen production (Rao et al, 2007). Sediment incubations were conducted using flow through reactors to examine these processes of remineralisation.

Method

Surface sediment (>5 cm) was collected from benthic site G from 7 NIOZ cores (Table 2).

Table 2 Event information for FTR's.

Event	Latitude	Longitude
138	51°4.42428	6°35.02152
139	51°4.42608	6°35.02380
141	51°4.42608	6°35.02410
143	51°4.42248	6°35.02260
147	51°4.4200	6°35.023
148	51°4.41972	6°35.02260
149	51°4.41954	6°35.02248

Only surface sediment was collected in an attempt to mimic the natural environment and the advective processes associated with permeable sediments. Sediment was homogenised and placed into 3, 15 cm clear acrylic tubes with an internal diameter of 8.1 cm. Care was taken to ensure that the sediment was well packed and no large pockets of air remained. Fittings to the top and bottom of the tube were placed sealing the sediment in. To the bottom of the reactors a line in from a carboy containing aerated bottom seawater (event 132; 51°04.35, 06°34.87 at 60 m) collected under trace metal clean conditions and filtered at 0.2 mm was fitted. Using a peristaltic pump, seawater was continuously pumped through the sediment cores at a flow rate of 1 ml min^{-1}. Initial measurements were made from the influent seawater for oxygen (Unisense, flow through oxygen microsensor) and pH (Unisense, flow through pH microsensor) and samples were collected for nutrients (analysed on board by Carolyn Harris), total and reduced iron (analysed on board by Jess Klar) and DOC (to be analysed by the University of Portsmouth). Additional samples were also collected for Vas Kitidis from PML for analysis of O_2/Ar and N_2/Ar to monitor respiration and denitrification. The same suite of measurements/samples collected, were made from the outflow at time points over the course of two and half weeks.

After dismantling the columns at the end of the experiment, a 30 ml sediment sample from the top and bottom of each column were taken for microbial analysis by PLM.

In order to carry out further laboratory based incubations extra sediment (Table 2) from Site G and bottom water (Event: 474, 51°4.365 6°34.85, 91m depth) were taken to be stored in the dark at 9°C. The water and sediment were left unaerated although the sediment was daily stirred.

Sampling, FTRs

Table 3 Sampling information for FTR's. Time points in GMT

				Samples Taken			
Date	**Time point**	**Time**	**Column**	**Nutrients**	**DOC**	**Fe**	**N_2/Ar & O_2/Ar**
12/08/2015	T0	18:30	CARBOY	FTR_T0_CARBOY	DY034_DOC_028	T0 CARBOY	313
	T1	19:30	A	FTR_T1_A	DY034_DOC_029	T1 A	314
			B	FTR_T1_B	DY034_DOC_030	T1 B	315
			C	FTR_T1_C	DY034_DOC_031	T1 C	316
13/08/2015	T2	08:25	A	FTR_T2_A	DY034_DOC_033	T2 A	318
			B	FTR_T2_B	DY034_DOC_034	T2 B	319
			C	FTR_T2_C	DY034_DOC_035	T2 C	320
		09:17	CARBOY	T2_CARBOY	DY034_DOC_032	T2 CARBOY	317
	T3	18:15	A	FTR_T3_A	DY034_DOC_037	T3 A	321
			B	FTR_T3_B	DY034_DOC_038	T3 B	322
			C	FTR_T3_C	DY034_DOC_039	T3 C	323
14/08/2015	T4	06:55	CARBOY	T4_CARBOY	DY034_DOC_040	T4 CARBOY	324
		08:16	A	FTR_T4_A	DY034_DOC_041	T4 A	325
			B	FTR_T4_B	DY034_DOC_042	T4 B	326
			C	FTR_T4_C	DY034_DOC_043	T4 C	327
	T5	18:25	A	FTR_T5_A	DY034_DOC_045	T5 A	328
			B	FTR_T5_B	DY034_DOC_046	T5 B	329
			C	FTR_T5_C	DY034_DOC_047	T5 C	330
15/08/2015	T6	09:17	A	FTR_T6_A	DY034_DOC_048	T6 A	331
			B	FTR_T6_B	DY034_DOC_049	T6 B	332
			C	FTR_T6_C	DY034_DOC_050	T6 C	333
		09:57	CARBOY	T6_CARBOY	DY034_DOC_051	T6 CARBOY	334

				Samples Taken			
Date	Time point	Time	Column	Nutrients	DOC	Fe	N_2/Ar & O_2/Ar
	T7	18:30	A	FTR_T7_A	DY034_DOC_052	T7 A	335
			B	FTR_T7_B	DY034_DOC_053	T7 B	336
			C	FTR_T7_C	DY034_DOC_054	T7 C	337
16/08/2015	T8	08:00	A	FTR_T8_A	DY034_DOC_055	T8 A	338
			B	FTR_T8_B	DY034_DOC_056	T8 B	339
			C	FTR_T8_C	DY034_DOC_057	T8 C	340
			CARBOY	T8_CARBOY	DY034_DOC_058	T8 CARBOY	341
	T9	18:25	A	FTR_T9_A	DY034_DOC_059	T9 A	342
			B	FTR_T9_B	DY034_DOC_060	T9 B	343
			C	FTR_T9_C	DY034_DOC_061	T9 C	344
17/08/2015	T10	16:00	A	FTR_T10_A	DY034_DOC_062	T10 A	345
			B	FTR_T10_B	DY034_DOC_063	T10 B	346
			C	FTR_T10_C	DY034_DOC_064	T10 C	347
		17:00	CARBOY	T10_CARBOY	DY034_DOC_065	T10 CARBOY	348
18/08/2015	T11	08:00	A	FTR_T11_A	DY034_DOC_067	T11 A	350
			B	FTR_T11_B	DY034_DOC_068	T11 B	351
			C	FTR_T11_C	DY034_DOC_069	T11 C	352
			CARBOY	T11_CARBOY	DY034_DOC_066	T11 CARBOY	349
19/08/2015	T12	09:10	A	FTR_T12_A	DY034_DOC_098	T12 A	354
			B	FTR_T12_B	DY034_DOC_099	T12 B	355
			C	FTR_T12_C	DY034_DOC_100	T12 C	356
		08.00	CARBOY	T12_CARBOY	DY034_DOC_097	T12 CARBOY	353
20/08/2015	T13	14:10	A	FTR_T13_A	DY034_DOC_102	T13 A	358
			B	FTR_T13_B	DY034_DOC_103	T13 B	359

				Samples Taken			
Date	**Time point**	**Time**	**Column**	**Nutrients**	**DOC**	**Fe**	**N_2/Ar & O_2/Ar**
			C	FTR_T13_C	DY034_DOC_104	T13 C	360
		13.30	CARBOY	T13_CARBOY	DY034_DOC_101	T13 CARBOY	357
21/08/2015	T14	08:45	A	FTR_T14_A	DY034_DOC_106	T14 A	362
			B	FTR_T14_B	DY034_DOC_107	T14 B	363
			C	FTR_T14_C	DY034_DOC_108	T14 C	364
		08:30	CARBOY	T14_CARBOY	DY034_DOC_105	T14_CARBOY	361
22/08/2015	T15	08:45	A	FTR_T15_A	DY034_DOC_137	T15 A	366
			B	FTR_T15_B	DY034_DOC_138	T15 B	367
			C	FTR_T15_C	DY034_DOC_139	T15 C	368
		08:25	CARBOY	T15_CARBOY	DY034_DOC_365	T15_CARBOY	365
23/08/2015	T16	14.00	A	FTR_T16_A	DY034_DOC_141	T16 A	370
			B	FTR_T16_B	DY034_DOC_142	T16 B	371
			C	FTR_T16_C	DY034_DOC_143	T16 C	372
		13:45	CARBOY	T16_CARBOY	DY034_DOC_140	T16_CARBOY	369
24/08/2015	T17	08:30	CARBOY	T17_CARBOY	DY034_DOC_144	T17_CARBOY	373
		09:00	A	FTR_T17_A	DY034_DOC_145	T17 A	374
			B	FTR_T17_B	DY034_DOC_146	T17 B	375
			C	FTR_T17_C	DY034_DOC_147	T17 C	376
					DOC_BLANK 01 & 02		
25/08/2015	T18	08:00	CARBOY	T18_CARBOY	DY034_DOC_148	T18_CARBOY	377
		08:05	A	FTR_T18_A	DY034_DOC_149	T18_A	378
			B	FTR_T18_B	DY034_DOC_150	T18_B	379
			C	FTR_T18_C	DY034_DOC_151	T18_C	380
					DOC_Blank_02 & 03		
26/08/2015	T19	08:05	CARBOY	T19_CARBOY	DY034_DOC_152	T19_CARBOY	381

				Samples Taken			
Date	Time point	Time	Column	Nutrients	DOC	Fe	N_2/Ar & O_2/Ar
		08:15	A	FTR_T19_A	DY034_DOC_153	T19_A	382
			B	FTR_T19_B	DY034_DOC_154	T19_B	383
			C	FTR_T19_C	DY034_DOC_155	T19_C	384
27/08/2015	T20	08:15	CARBOY	T20_CARBOY	DY034_DOC_156	T20_CARBOY	385
		08:30	A	FTR_T20_A	DY034_DOC_157	T20_A	386
			B	FTR_T20_B	DY034_DOC_158	T20_B	387
			C	FTR_T20_C	DY034_DOC_159	T20_C	388
28/08/2015	T21	08:10	CARBOY	T21_CARBOY	DY034_DOC_160	T21_CARBOY	389
		08:30	A	FTR_T21_A	DY034_DOC_161	T21_A	390
			B	FTR_T21_B	DY034_DOC_162	T21_B	391
			C	FTR_T21_C	DY034_DOC_163	T21_C	392
29/08/2015	T22	8:00	CARBOY	T22_CARBOY	DY034_DOC_164	T22_CARBOY	393
		08:15	A	FTR_T22_A	DY034_DOC_165	T22_A	394
			B	FTR_T22_B	DY034_DOC_166	T22_B	395
			C	FTR_T22_C	DY034_DOC_167	T22_C	396

Additional Samples Collected

In addition to the above work, 10 cm cores were collected from each site (Table 4) apart from Candyfloss. These were frozen at -20°C and will be analysed at the University of Portsmouth for organic carbon, organic nitrogen and phosphorus speciation (following Ruttenberg et al, 1992).

Table 4 Subcore event information

Event	Site	Core ID	Latitude and Longitude
159	G	A	51°4.4410 6°35.020
173	G	B	51°4.401 6°35.023
026	A	A	51°12.6780 6°7.8663

064	A	B	51°12.695	6°8.013
369	I	A&B	50°34.596	7°6.235
229	H	A	50°31.3344	7°2.066
234	H	B	50°31.329	7°2.067

Extra sediment was taken from site A, I and H for resuspension experiments (See Anouska Panton cruise report for event details) and filtered (0.2 µm) bottom water (Site I, event 476, 50°34.348 7°6.244 at 105m depth).

References

Bennett, W. W., D.T. Welsh, A. Serriere, J. G. Panther and P. R. Teasdale (2015). A colorimetric DET technique for the high-resolution measurement of two-dimensional alkalinity distributions in sediment porewaters. *Chemosphere*, **119**, 547 – 552.

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Dočekalová, H., Clarisse, O., Salomon, S., & Wartel, M. (2002). Use of constrained DET probe for a high resolution determination of metals and anions distribution in the sediment pore water. Talanta, (57), 145-155.

Pagès, A., Teasdale, P.R.,. Robertson, D., Bennett, W.W., Schafer, J., and Welsh, D.T. (2011).

Representative measurement of two-dimensional reactive phosphate distributions and codistributed iron(II) and sulphide in seagrass sediment porewaters. *Chemosphere*, **85**, 1256-1261.

Panther, J.G., Teasdale,P.R., Bennett,W.W., Welsh, D.T., Zhao,H (2010) Titanium Dioxide based DGT techique for in situ measurement of dissolved reactive phosphate in fresh and marine waters. *Environmental Science and Technology*. (44), 9419-9424

17. Sediment incubations and microprofiling

Natalie Hicks

Introduction

Benthic carbon cycling plays a disproportionally important role on the continental margins. Intense recycling of organic matter in the sediment supplies the overlying water with nutrients and inorganic carbon which can be re-used for primary production. Furthermore, continental shelf sediments have been proven to be one of the most important sinks for carbon globally. Once buried in the sediment, carbon is removed from the marine carbon cycle over geological time scales.

The aim of the work on the SSB cruises is to quantify how much of the inorganic and organic carbon is remineralised in the sediments and released back into the overlying water, and how much remains buried in the sediments. This includes a seasonal study of the four main benthic sites (Sites A, G, H and I), representing four different sediment types in the Celtic Sea (mud, sandy mud, muddy sand and sand) as their different properties will affect their sequestering and remineralisation capacity. This work has been completed on the DY034 cruise, bringing to a close the final sampling fieldwork within the SSB consortium.

Methods and Results

Sediment incubations – 6 NIOZ cores (10 cm i.d.) were collected from each of the 4 main stations (Benthic A, G, H, I) and incubated for ~30 hr at in situ temperature in the CT room (Fig 17.1). Water samples were taken from the overlying water (for Dissolved Inorganic Carbon (DIC), Total Alkalinity (TA) and Dissolved Organic Carbon (DOC)) before the cores were closed with a tight fitting lid and incubated. Each core was individually stirred using a magnetic stirrer system, and the oxygen uptake (Total Oxygen Uptake – TOU) was measured over time by an internal oxygen optode (using Firesting technology by Pyroscience) in each of the 6 cores to estimate respiration rates at the respective site.

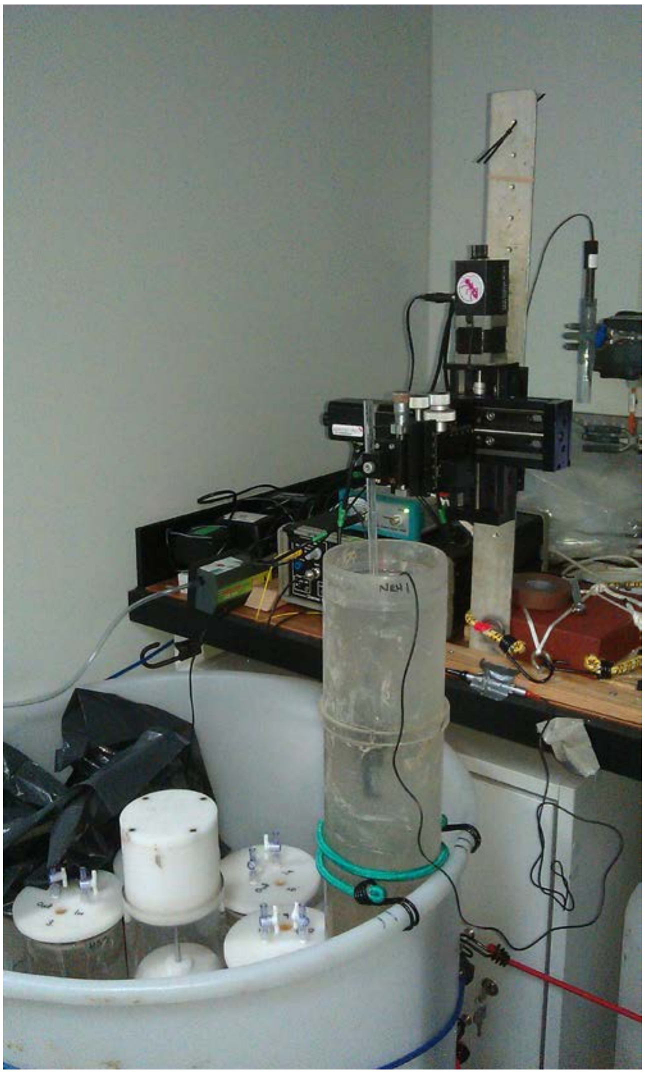


Figure 17.1. Showing the sediment incubation and profiling setup in the CT room.

At the end of each incubation period, water samples were again taken from each core (DIC, TA, and DOC) to quantify the efflux of these parameters from the sediment to the overlying water. Total Oxygen Uptake (TOU) rates were calculated from the continuous Firesting measurements, and these show clear differences between the four benthic sites (see Fig. 17.2), with lowest uptake rates measured in the sandy site (Station G). The muddy sites show the highest oxygen uptake rate, which is expected.

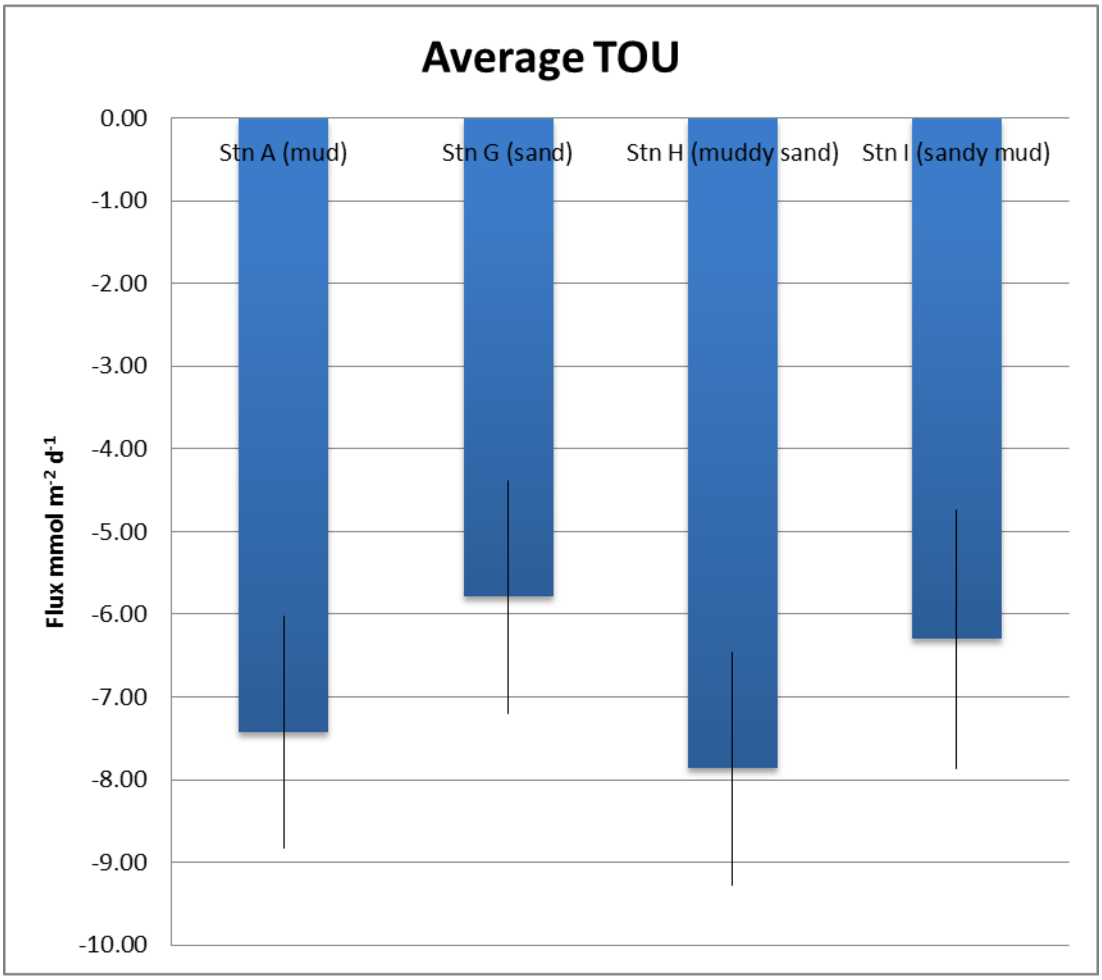


Figure 17.2. Total Oxygen Uptake (TOU) rates for the four main benthic sites measured on DY034 (n = 6 for each site). The lowest TOU seen in the sandy site (Station G).

Microprofiling -After the flux incubations, the cores were re-aerated using an aquarium pump and air stone prior to oxygen micro-profiling. Four to five oxygen microprofiles (Fig. 17.3), were taken in each of the 6 sediment cores to study the penetration depth and distribution of oxygen in the respective sediment type. A very fine microelectrode with a tip of 50 µm was used in steps of 200 µm until the oxygen dropped to zero, with the exception of the sandy site (Station G), where a 500 µm microelectrode was used in 1000 µm increments (due to the breakage of previous 50 µm sensors in this sediment). From these profiles a Diffusive Oxygen Uptake (DOU) will be calculated, reflective of the microbial contribution to the oxygen uptake. Comparison of the DOU and TOU will quantify the importance of the faunal contribution to the overall oxygen flux within each sediment type / study site. In general, deeper oxygen penetration was seen in the sandy sediment (Station G), with shallower depths in the muddy station (A) and the muddy/sandy mixed sediments (Stations H and I), as seen in Fig. 17.3. This is similar to the trend seen in previous cruises, although the actual Oxygen Penetration Depth (OPD) changes with season.

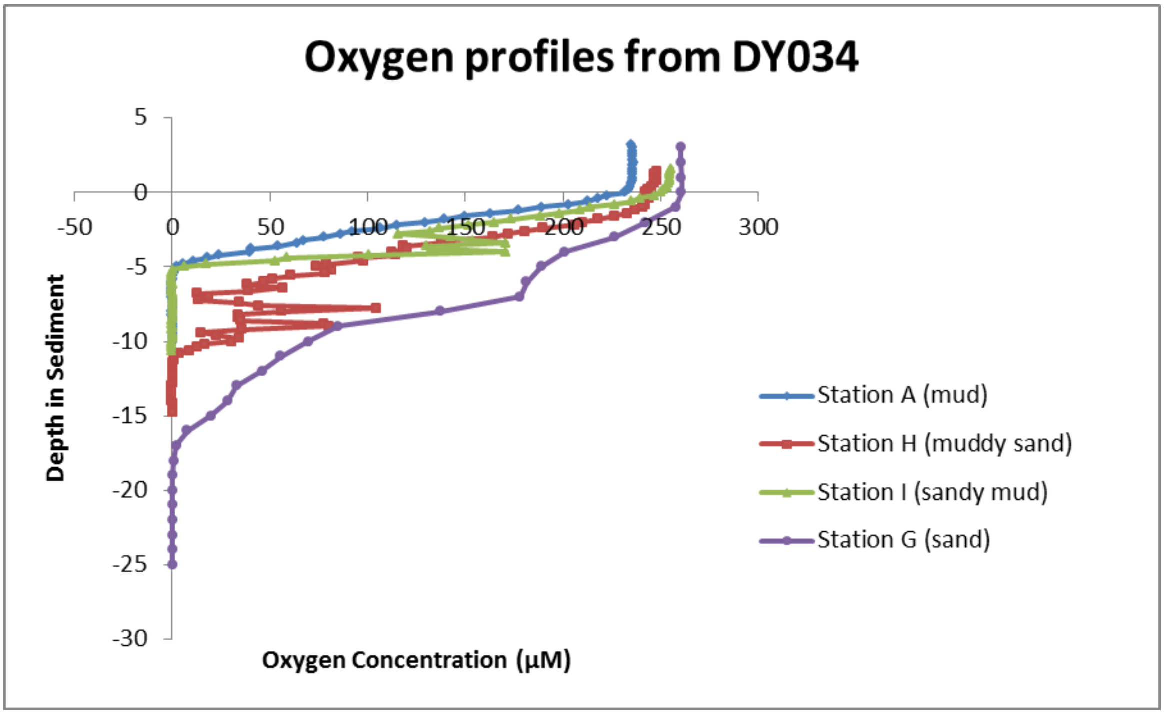


Figure 17.3. Examples of oxygen microprofiles measured during DY034, representing the oxygen distribution and oxygen penetration depth (OPD) within each site. The deepest OPD was measured in the sandy site (Station G). and the shallowest in the muddy site (Station A). Stations H and I show evidence of macrofaunal burrows, with changes in oxygen concentration at lower depths.

Sediment solid phase – 3 undisturbed megacores (10 cm i.d.) were collected from each of the 4 process stations using the NIOZ corer. The cores were then sliced down to 25 cm depth (Interval: 0.5-1, 1-1.5, 1.5-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-17, 17-19, 19-21, 21-23, 23-25) and frozen in plastic (polyethylene) bags for later analysis of solidphase POC, PIC, ^{210}Pb and grainsize back at SAMS. These parameters will be used to sediment accumulation rates (from ^{210}Pb), and ultimately burial rates of organic and inorganic carbon in the sediments (using the sediment accumulation rates together with the downcore POC and PIC concentrations).

Candyfloss site – As in the previous cruises (DY021 and DY030), an extra station at 'Candyfloss' was sampled and three cores were collected via NIOZ coring. These were sliced as per the main station cores, and will be taken back to SAMS in the event there is an opportunity and funding available for further analysis of PIC, POC, grainsize and $^{Pb}210$.

Future analysis

Following the completion of the cruises, all solid phase (sediment) samples collected during all cruises are to be analysed at SAMS. This will be instrumental in determining carbon turnover rates. In addition, DOC flux samples from the water column in the incubation core set up are also ready for analysis. The DIC/TA samples are completed from previous cruises, so the samples from DY034 are the final samples to be analysed. This data will provide a complete picture on the benthic carbon cycling properties of sediment in the Celtic Sea.

18. Ecological mapping

Kirsty Morris, Maaten Furlong, Alvaro Lopez, David White, David Paxton and Henry Ruhl

Objectives

Throughout the cruise Autosub3 completed 11 missions (Table 18.1) covering the four Celtic sea Benthic sites (A,G,H and I) previously identified . The main objectives of the study were to collect both Bathymetric and side scan data of the four benthic study sites and beyond to allow further characterisation of the site. A photographic survey of each site should be completed to aid in the characterisation of sediments both within the survey box and in its surrounding area, allowing the assessment of the benthic megafaunal community. Ultimately this will aid in the assessment of the carbon utilisation of the benthic community within the area, and allow a comparison to the results obtained from Autosub6000 during the 2014 cruise DY008.

Mission planning

Surveys were split into 2 missions 1) Sidescan and Bathymetric 2) Imaging, with one of each type to be completed per benthic station. Each survey was designed to contain a minimum of 6 lines at 150 m spacing. Bathymetric segments were flown at an altitude of 50 m with the sidescan (410 khz) occurring at an altitude of 15 m and the images an altitude of 2.5 m with a capture rate of 1 per second. All lines were 5 km in length.

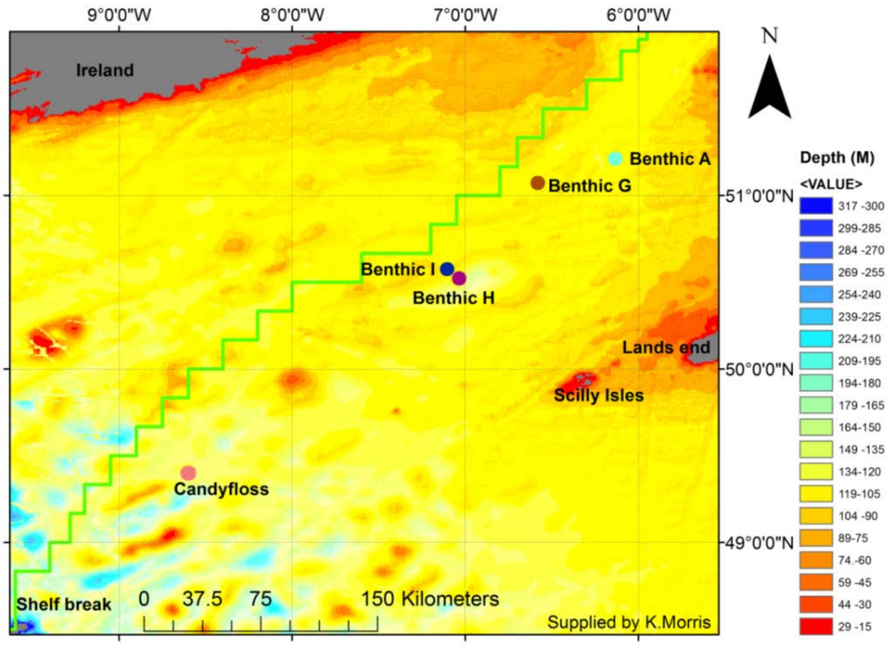


Figure 18.1. Position of the Benthic survey areas in relation to Ireland and the Scilly Isles.

Table 18.1. Missions which took place during DY034 Successful mission highlighted in bold letters.

Mission No	**Site**	**Date**	**Bathymetry collected**	**Side scan collected**	**No of 'usable' images**	**Image Altitude set**	**Comments**
459	Benthic A	8/8/15	N	**N**	N/A	N/A	Mission was unsuccessful as a result of ballasting issues resulting in the dive being aborted
460	Benthic A	9/8/15	N	**N**	N/A	N/A	Mission was unsuccessful as a result of ballasting issues whilst circling at depth in low power mode resulting in the dive being aborted
461	Benthic G	10/8/15	N	**N**	N/A	N/A	AUV did not appear to be flying correctly and thus the mission was abandoned to prevent a further dive abortion.
462	Benthic G	11/8/15	N	**N**	N/A	N/A	AUV leak sensor showed an apparent fault and thus the sub was recovered to prevent any damage occurring
463	Benthic A	12/8/15	N	**N**	N/A	N/A	Mission was unsuccessful as a result of the port side stern plane being lose and preventing the AUV from diving correctly
464	Benthic G	14/8/15	N	**Y**	N/A	N/A	Bathymetry not collected due to error at set up.
465	Benthic H & Benthic I	18/8/15	**Y**	**Y**	N/A	N/A	Bathymetry not collected at site H due to error during surfacing. Side scan successfully collected for both stations
466	Benthic I	20/8/15	N	N	**~72,000**	2.5	Limit cycling in the sub may reduce the no of usable images following full inspection
467	Benthic H	24/8/15	N	N	**~36,000**	2.5	As above, also some rocks had high relief causing potential collision hazards
468	Benthic G	26/8/15	**Y**	N	**~36,000**	2.5	As above
469	Benthic A	20/05/15	**Y**	**Y**		2.5	Small test run for images indicated the high turbidity preventing any further imagery missions in this area.

General summary

Out of the total 11 deployments 6 resulted in successful data collection missions (Table 18.1). This resulted in Bathymetric and sidescan data being collected from benthic sites, A, G and H. It was only possible to collect sidescan from site I due to an error with the bathymetric multibeam sensor. Images were successfully collected form all stations, however, at Benthic A this was only from a test deployment with no actual image deployment occurring as a result of high turbidity levels in the water.

Site breakdown

Bathymetric and sidescan data collected for Benthic A indicated that the area had a flat and soft bottom with relatively numerous trawl marks and other liner demarcations. Imagery from this area also indicated that there was a large amount of suspended material in the water column, preventing the camera from being able to visualise the seabed (Fig. 18.1)

Figure 18.1. Example of image captured from Site A, illustrating the inability to see the seabed.

Benthic G Bathymetry and sidescan indicated a soft bottom with a few trawl lines and the indication of a few rocky patches in the area. The sidescan data also showed the presence of sand waves on the seabed. Imaging from this area indicated a reduced level of suspended particle in the water allowing for clear visualisation of the seabed (Fig. 18.2).

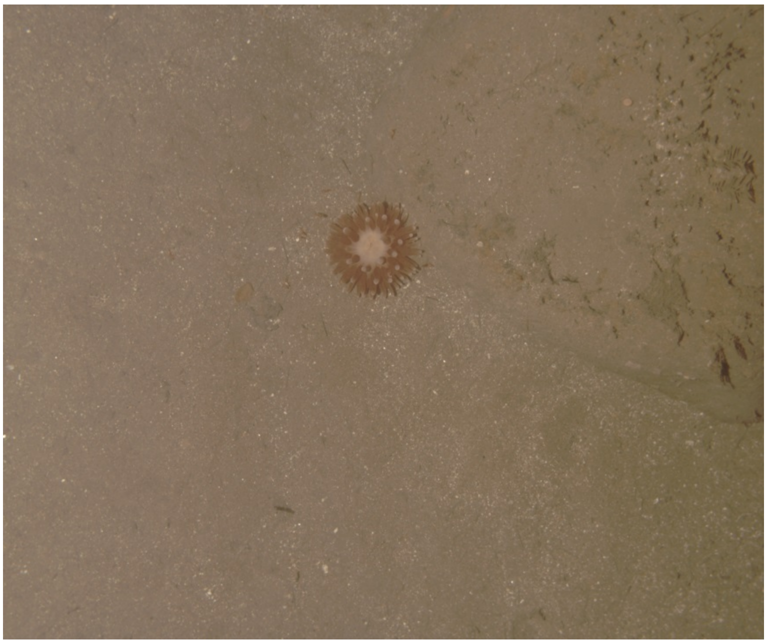


Figure 18.2. Example of image captured from Site G, illustrating image clarity, rocky outcrops and example anemone captured from the station.

Benthic H Bathymetry and sidescan indicated soft bottom with large areas of rocky outcrop throughout the survey area. A single trawl line was also visualised. The images captured from this station had a minor issue with a small partial visual obstruction that appeared in front of the lens or flash (Fig.18.3).

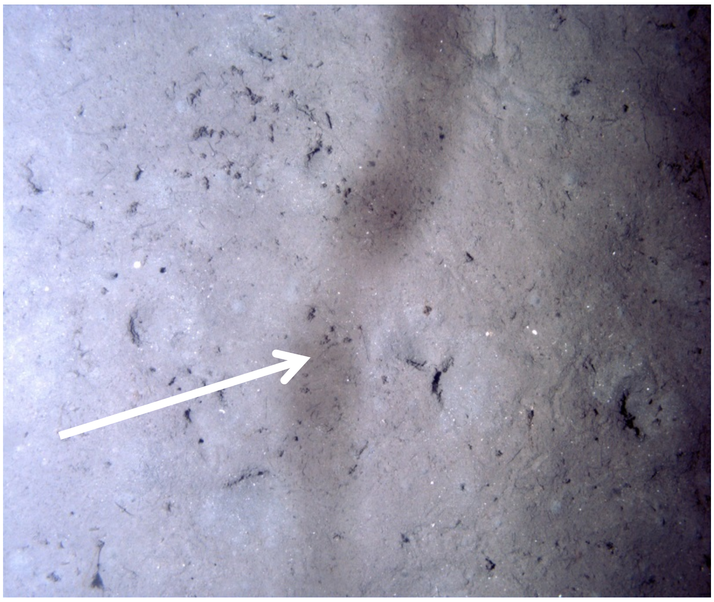


Figure 18.3. Example of colour corrected image captured from Site H, illustrating the impact of the obstruction in the image highlight by the arrow.

Benthic I Bathymetry and sidescan indicated soft bottom with some patches of rocky outcrop throughout the survey area, some trawl lines were also visualised. Images captured were of good quality for the area (Fig. 18.4).

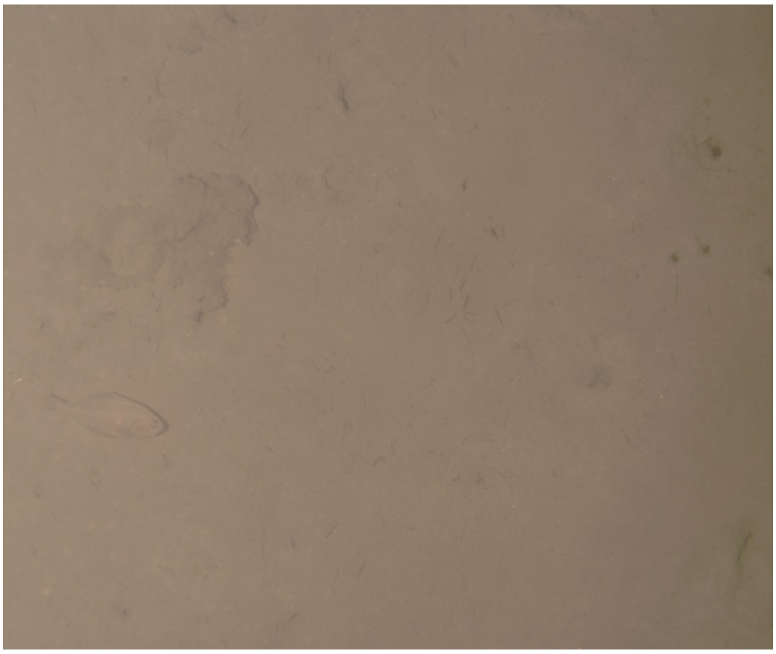


Figure 18.4. Example image captured from Site I, illustrating the clarity of the raw images when ~2.3 m from the seabed.

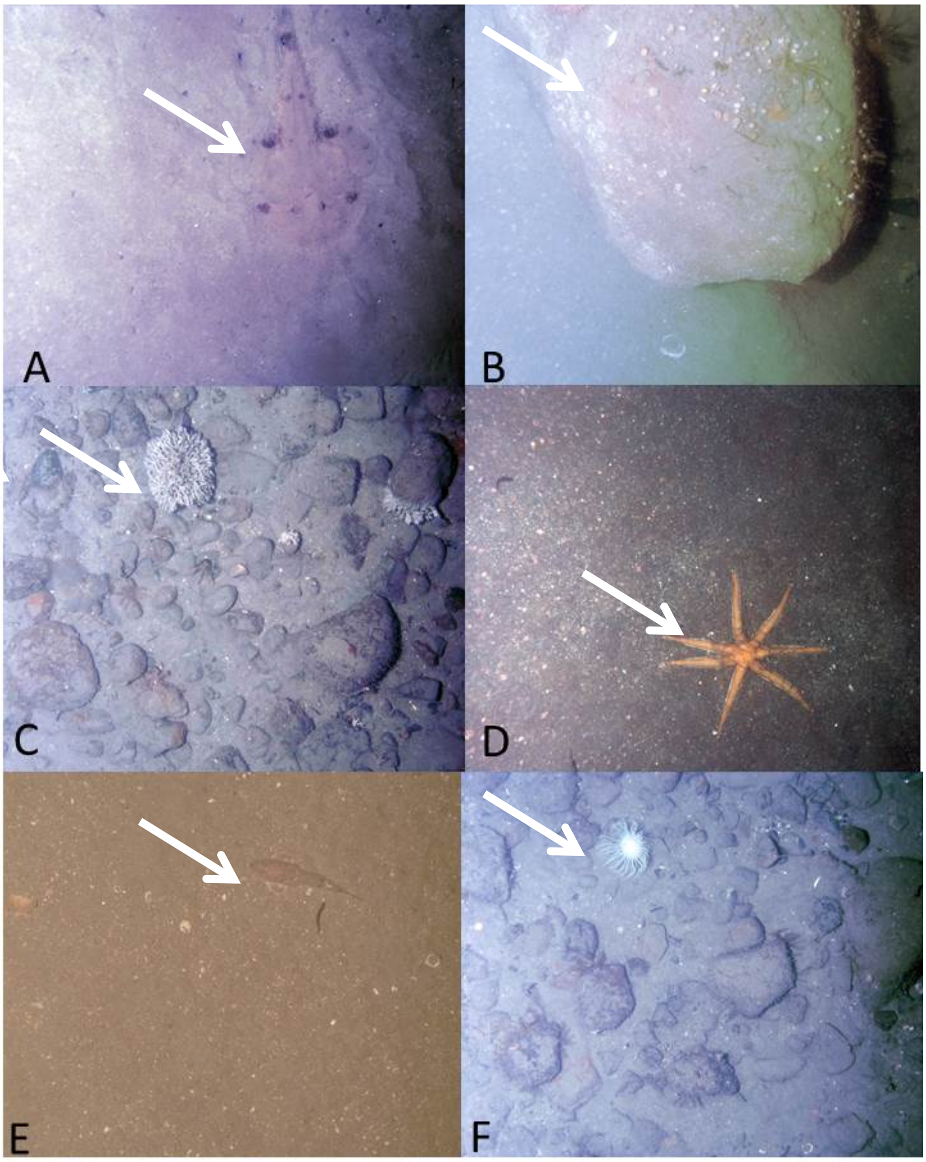


Figure 18.5. Example raw images obtained from Autosub3 throughout the cruise. A) Monkfish, B) Rocky community including Devonshire cup corals, C) rocky community including ross coral, D) Seven armed star fish, E) Dragonette, F)Sea anemone. Arrows indicate the location of the identified organism.

19. Autosub3 technical report

Overview

RRS *Discovery* cruise DY034 was the final of three Autosub cruises in 2015 which formed part of the NERC Shelf Seas Biogeochemistry program. The operations location focused on four sites in the centre Celtic Sea to the South of Ireland: Benthic A, G, H and I. See Figure 18.1 above. The plan was to deploy Autosub3 to run sidescan multibeam and a camera survey missions within an area 5 km x 1.05 km at each of the four sites. The primary sensors were:

- EM2000 multibeam swath bathymetry at 50 m altitude, 150 m track spacing.
- Edgetech High Frequency (410kHz) side-scan sonar survey at 15 m altitude, 150 m track spacing.
- Autosub camera image survey at 2.5 m altitude depending on a 75 m track spacing.
- Seabird 911 CTD with transmissometer and a Wetlabs BBRTD.

Vehicle Configuration

Table 19.1. Autosub3 DY034 configuration details. Further details of the CTD setup and the camera and lens specifications can be found in later sections.

Sensors used	Sub configuration
• RDI workhorse ADCP 300kHz upwards and downwards. • Seabird SBE9+ CTD with dual TC sensors, Wetlabs transmissometer and Wetlabs BBRTD. • Edgetech 2200-M 120KHz/410KHz dual frequency sidescan sonar (no sub bottom profiler) • Kongsberg EM2000 Multibeam Swath bathymetry sonar. • Autosub Camera system: 1 x camera and flash.	• Rear winglets set at 4º pitched downwards. • ~13kg Positive buoyancy. • 26 battery packs • Old Autosub LARS used

Figure 19.1. Autosub3 being launched for Mission 468

Deployment Team

Maaten Furlong – AUV Lead

Dave Paxton – AUV mechanical Lead

Dave White – AUV systems

Alvaro Lopez Lorenzo – AUV software trainee

Mission Summaries: During DY034 the AUV undertook 12 separate survey missions. The first five were aborted very quickly due to a combined ballasting and slipping control plane issue. Once these issues had been resolved the subsequent AUV missions delivered a large amount of high quality data. A mission by mission summary of the deployments is given in Table 19.1, and the coverage per site is given in Table 19.2.

Table 19.2. Summary of the AUV deployments as part of DY034

Mission	Area	Date	Distance	Notes on the deployment and data
459	A	8/8/15	0 km	AUV aborted as the nose was too heavy due to a ballasting error (See fault list)
460	A	9/8/15	0 km	AUV aborted as the nose was too heavy due to a ballasting error (See fault list)
461	G	10/8/15	0 km	AUV was recovered as it was still badly ballasted, the ballast was adjusted and the AUV redeployed. The AUV aborted again due to ballasting errors (see fault list)
462	G	11/8/15	0 km	When the AUV was deployed there was a leak sensor fault, and the vehicle was recovered (see fault list)
463	A	12/8/15	0 km	The AUV aborted again due to a slipping control plane
464	G	14/8/15 - 15/8/15	90 km	HF side scan and MBES survey of site G. Unfortunately the EM2000 had been deactivated prior to the mission start, and so only Side scan data was gathered. The AUV aborted at the end of the mission due to the ballasting issue not being fully corrected.
Battery Change – Battery load 2				
465	H & I	18/8/15 – 20/8/15	211 km	Sidescan survey and MBES of sites H & I. The MBES stopped after the Site H survey. The reason for this is unknown.
Battery Change – Battery load 3				
466	I	20/8/15 - 21/8/15	93 km	Camera survey @ 2.5m ~ 70k images taken.
467	H	24/8/15	46 km	Camera survey @ 2.5m ~ 36k images taken. Unfortunately a jelly fish tendril (?) was caught on the lens mid mission which reduced the image quality
468	G	26/8/15- 27/8/15	90 km	Camera and photo survey.
Battery Change – Battery load 4				
469	A	28/8/15 - 29/8/15	75 km	Sidescan survey and MBES of plus a short camera test run. The camera test run revealed that no useful images could be gathered

Table 19.3. AUV data gathered by site

Site	MBES	Side scan	Camera
A (Muddy)	30 km (M469)	30 km (M469)	1 km 1,000 images (too turbid) (M469)
G (Sandy)	40 km (M468)	40 km (M464)	40km 36,000 images (M468)
H (Sandy Mud)	40 km (M465)	40 km (M465)	40km 36,000? Images (M467)
I (Muddy Sand)	x	40 km (M465)	80 km 72,000 images (M466)

The early deployments of the AUV were severely hampered by the ballasting and control plane issue. Once these had been resolved the AUV worked well with only a few errors producing a loss of data. In total the AUV constituted a major part of the core data collection requirements.

Side Scan Sonar Performance

The side scan sonar performed well in the mission and provided very high resolution data of the seabed, and clearly showed the different characteristic of the sites. Example sections from all four sites are shown below.

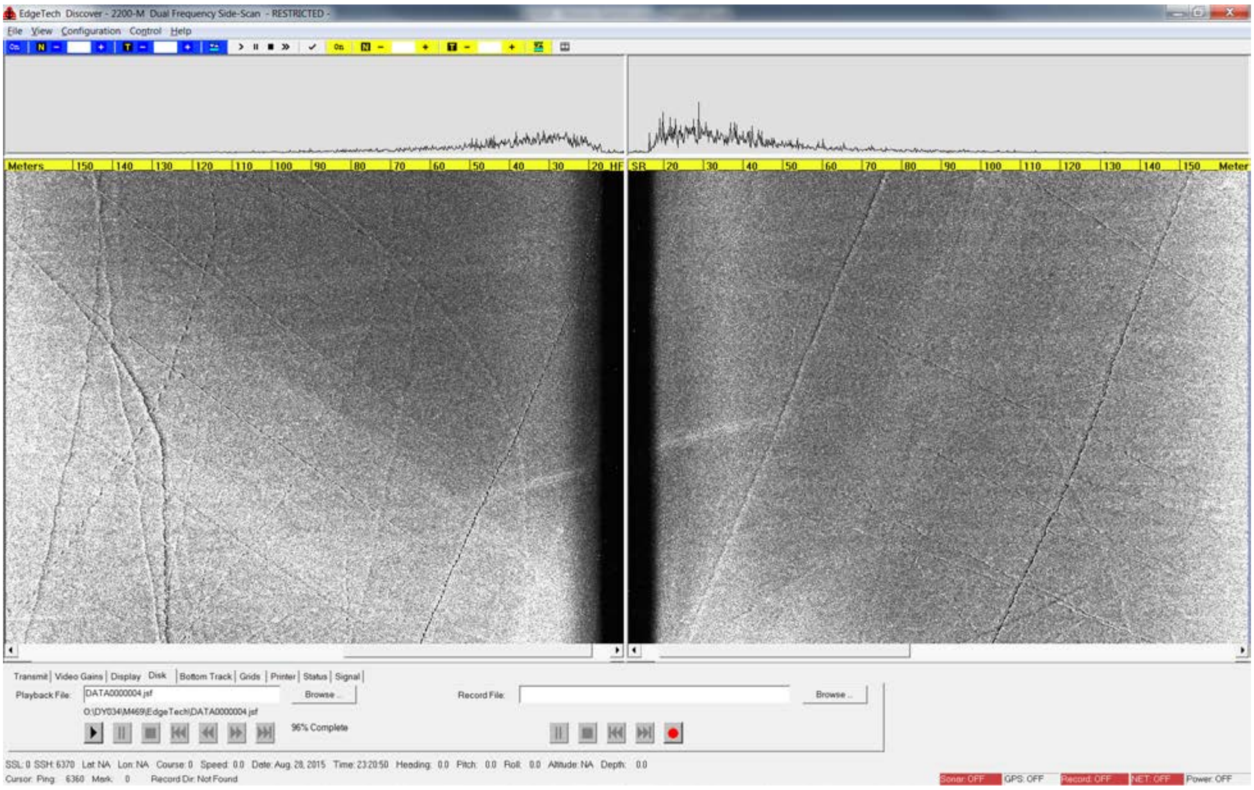


Figure 19.2. Screen dump from the EdgeTech software showing trawl marks at Site A (muddy)

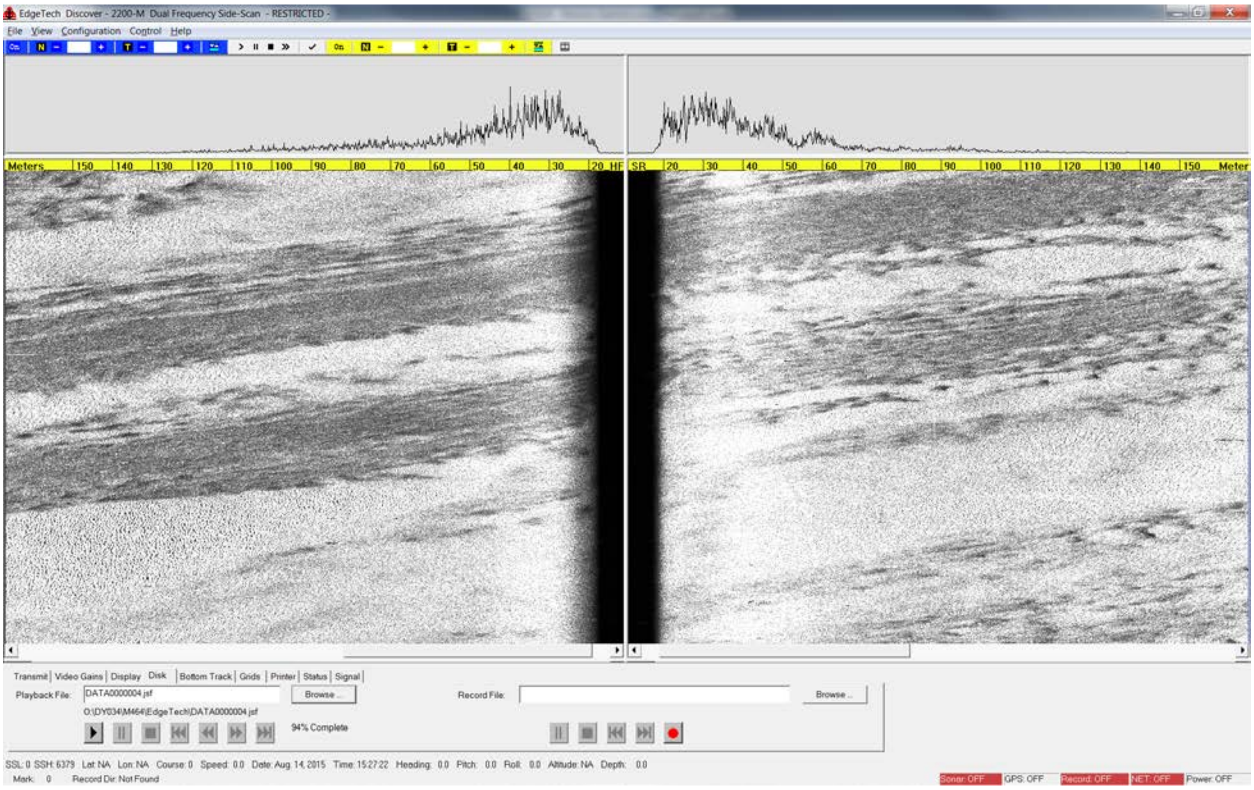


Figure 19.3. Screen dump from the EdgeTech software showing sand ripples at Site G (sandy)

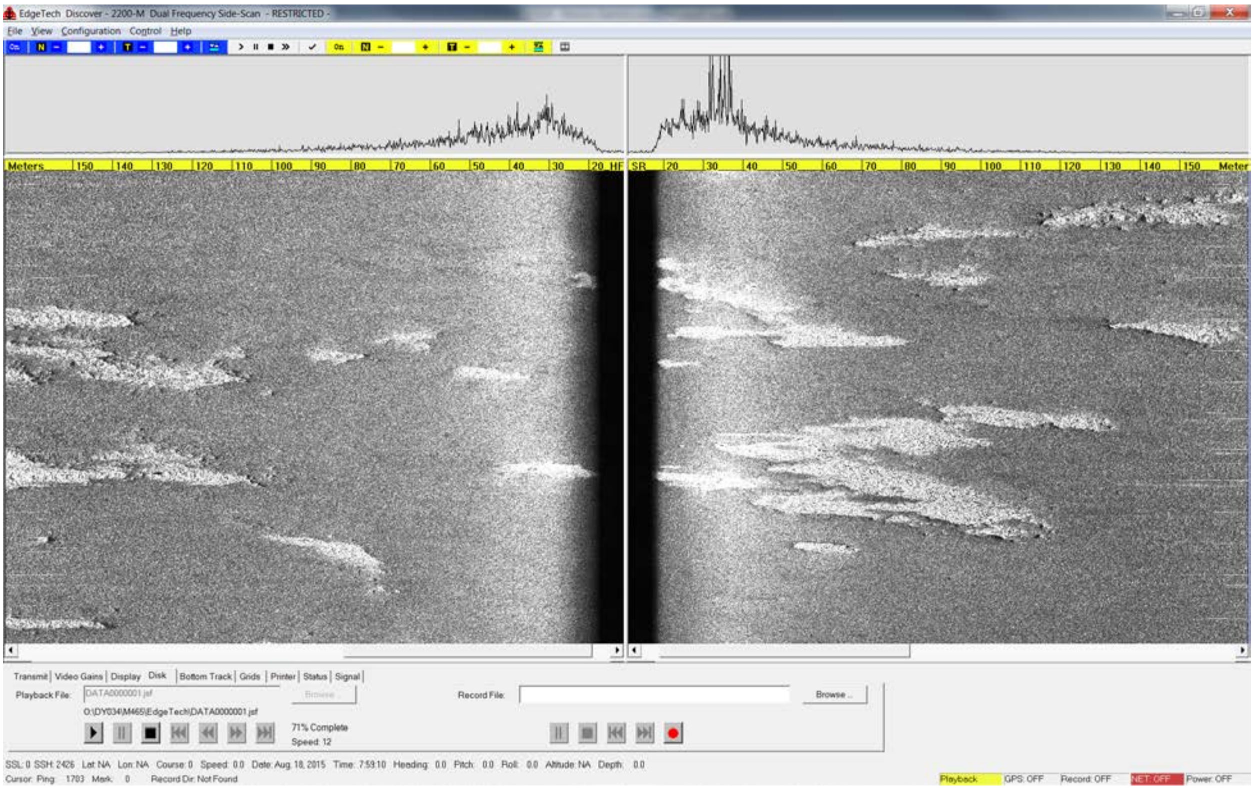


Figure 19.4. Screen dump from the EdgeTech software showing rocky outcrops at Site H (muddy-sand)

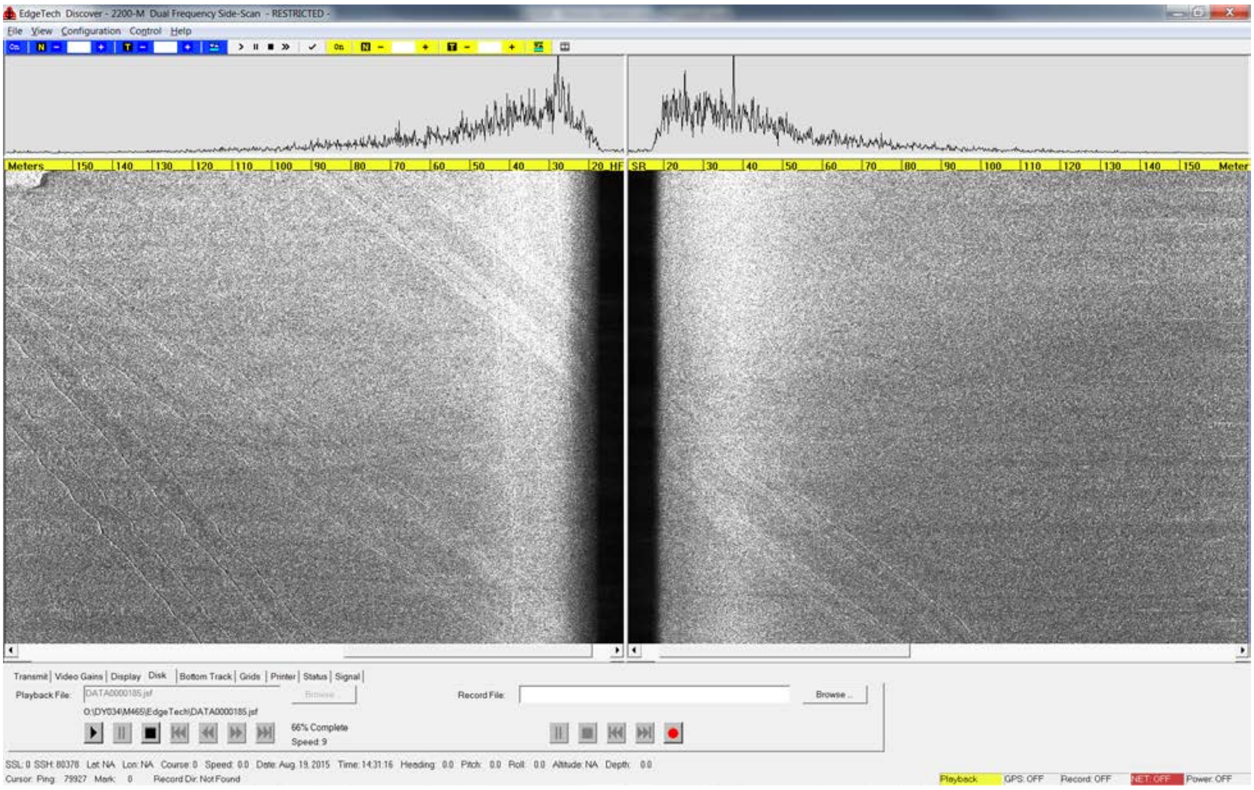


Figure 19.5. Screen dump from the EdgeTech software showing trawl marks at Site I (sandy-mud)

EM2000 Coverage

The raw EM2000 data was processed to give a ‘first glance’ quality assessment using the Caris Bathymetric software package. The data was plotted to give an indication of the terrain in the survey area to highlight potential obstacles for the lower level camera missions. The terrain was found to be exceptionally flat and so very little relief could be seen. The lack of tide correction in the processing was also very apparent with significant step changes between the survey lines.

Camera Image Data

During the DY034 campaign the AUV collected ~135,000 images at four sites. Of these, the images from site A were unusable due to the high turbidity. Some example images are shown in the figure overleaf.

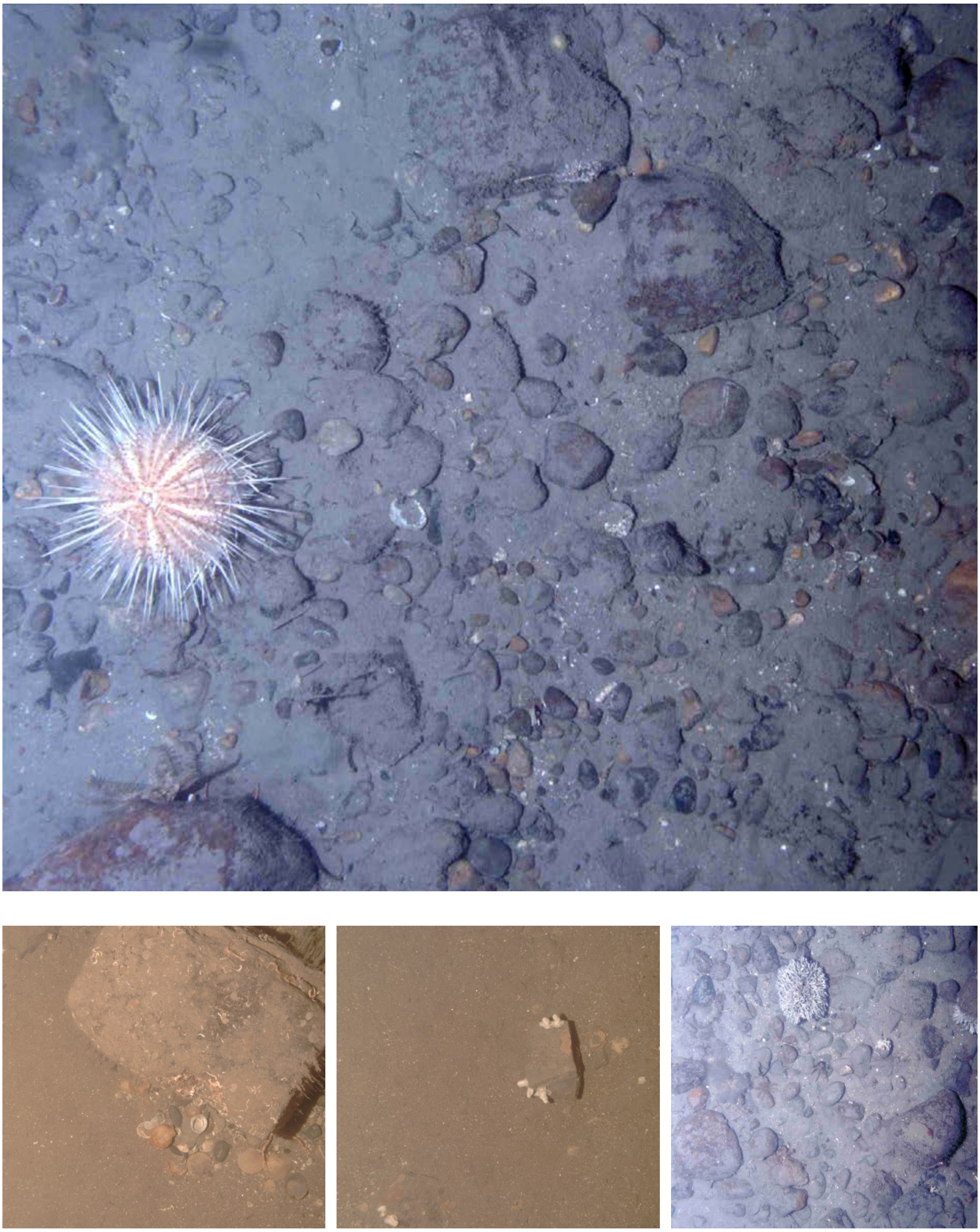


Figure 19.6. Example Autosub3 camera images

Figure 19.7. Launch, Relocation and Recovery as per all SSB cruises. Left: Acoustic Tracking and Telemetry Fish and PES winch. Right: Launch and Recovery System.

Linkquest USBL & Modem The Linkquest tracking and telemetry were functional, as expected given the local conditions – 100 m water depth. The Digital telemetry and USBL tracking worked for ranges up to approximately 1 km.

Sonardyne Acoustic Beacon During the cruise the Autosub3 vehicle was fitted with a sixth generation WMT beacon borrowed from the NMFSS computing group. This beacon was giving horizontal ranges to ~1 km when used with the ship's port side standard head and Ranger 2 software. The performance was significantly better than that of the standalone LXT system used on previous cruises, and also outperformed the Linkquest system for tracking performance. It is important to note that the depth readings from the beacon were incorrect, one assumes due to the shallow water refraction.

Launch and Recovery During the cruise the weather was generally good, however, there were times when the AUV was launched in more extreme weather. During this cruise launches were restricted to 4.0 m, significant wave height and 15 m/s winds and recoveries restricted to 3.0 m significant wave height and 15 m/s winds. Although it is possible to recover in more challenging conditions, the increase in risk of damage to the vehicle meant that exceeding these conditions was actively avoided. During the cruise we both deployed and recovered at the extremes of these recommended values.

Ship and Lab Systems Installation (Same as DY021)

Figure 19.8. Container aft deck port side forward. Gantry port side under the A frame. Iridium Antenna on top

Figure 19.9. Main lab area forward, port side. Left image station in order form left: tracking and telemetry, sonar control, mission management. Right image in order left to right: 2x data processing then Iridium communications.

The Autosub local area network was run from the main lab to the monkey island and to the container. On the monkey island were the two Bullet wireless Ethernet access points and a Digiport Ethernet-Serial adapter to connect the Argos Gonio receiver.

Ethernet to Monkey Island

Initially the monkey island was connected with an external run using our own Cat5 cable. This was later replaced with a route patched through the ships bussed Cat5 network and this was set up at the end of the DY021 and left in place for subsequent cruises.

Figure 19.10. The Monkey Island Cat5 patch arrives in the computer IT office patch box.

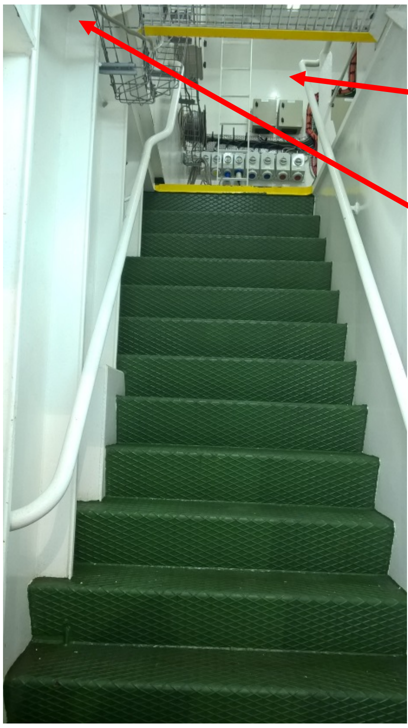
Ethernet to Container

DY030 utilised a direct Cat5e cable run from the main lab to the container as the solution from DY021 could not be made to work. This cable has been left installed on the ship.

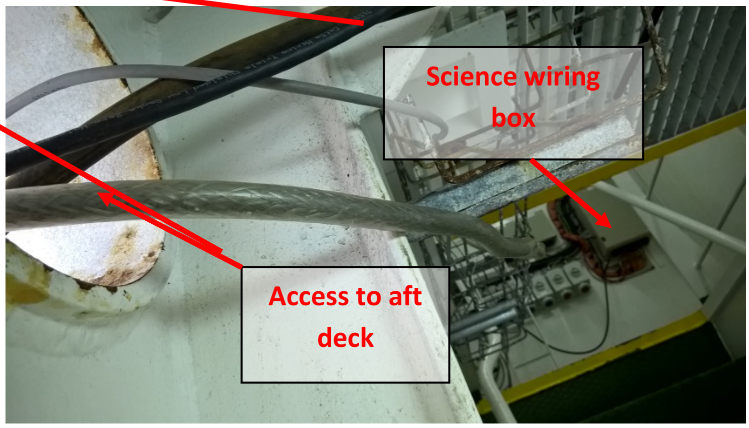
Initially for DY021 the container Ethernet was patched through using the underway sensor monitor network connection in the port turret under the A-frame. This was adequate but required a long wire across the deck that had to be removed to allow crane access to the deck space. This route would be useful in the future if the container in is located further aft, nearer the A-Frame.

Route 1 Via Upper Container Deck

Figure 19.11. Future routing to the container will be via a Switch box in the upper deck container space. This was set up and tested at the end of the cruise and left in place for subsequent cruises.



Up the stairs on the right is a scientific wiring connection box. This is routed to the bussed Cat5 in the main lab.



Bussed Connection in main lab.

Route 2 Via Port A-Frame Turret

Figure 19.12. Rear port turret and connector no. INF-R7-25-27.

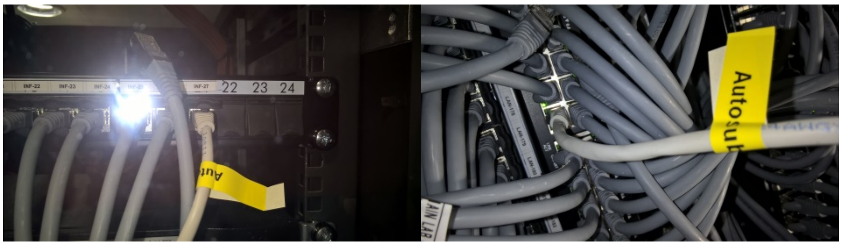


Figure 19.13. INF-R7-25-27 routed to the server room INF-27 Rack 3 bay 1 (left picture) and patched to Main lab socket LAN-179 Rack 3 bay 4 (right picture).

Faults and Issues

AUV Ballasting

The first series of AUV missions on DY034 were beset with ballast and trim problems. This resulted in the AUV failing to control its depth correctly and aborting. This abort behaviour was implemented as a result of the loss of the AUV during DY021 and was designed to cause the AUV to quickly abort if it had collided with the seabed.

The ballasting records for the cruise were limited and so it was difficult to diagnose the problem. Also the approach used to estimate the required ballasting changes from the flight characteristic were confounded by the slipping control plane identified in mission 463. This slipping control plane was almost certainly responsible for the slower convergence to the correct trim and ballast. A list of the ballast and trim changes are shown in Table 19.4.

Table 19.4. Ballast and Trim changes during the early missions.

Mission	Changes	Net Torque change	Buoyancy Change	Notes
M459	As delivered			Couldn't maintain depth and so aborted
M460	Removed the two nose lead weights 3.55kg @ -280,250,-225mm 4.75Kg @ -400,250,-225mm	117	+78N	Could maintain depth at speed, but once it slowed down and circled later in the mission it aborted
M461A	Pushed battery tube 4 packs, 50mm as there was no tray in the tube Moved Argos (4.22kg) back ~4m	357	+78N	Was not flying properly so was recovered and re-ballasted
M461B	Moved 1.8 kg of lead forward ~4m Increased motor power to 250W	291.5	+78N	Was not flying properly, but it was decided to speed up the AUV to see the effects.

M461C	Increased motor power to 300W	291.5	+78N	Worse than going slower (*almost certainly a dive plan problem*)
M461D		291.5	+78N	Failed to dive and aborted (*almost certainly due to the control plane problem*)
M462	Moved 2.23 kg of lead from the tail to the nose	210.5	+78N	Leaks sensor indicator went low so AUV was recovered and the rear mast was ripped off losing the Xeos beacon
M463		210.5	+78N	Aborted as it failed to dive. The port side rear control plane had slipped which had caused the dive problem
M464	Xeos removed, but lead was added to replace the weight lost from the Xeos.	212	+78N	Flew reasonably well although it looks like the AUV is too buoyant, and so the weight removed after M459 looked like it was necessary

After mission 464 the AUV underwent a battery change and was re-ballasted to approximately the correct setup. From this point on the AUV flew well for the remainder of the missions.

Control Plane Moving

During mission 463 the AUV aborted as it failed to control its depth adequately. Given that the ballasting had been adjusted this should not be possible for the vehicle, so there was some other explanation for this behaviour.

After recovering the AUV it was noted that the port side rear control plane was significantly higher than the starboard control plane, as seen in Figures 19.14 & 19.15. As the recovery went extremely well there were no lines caught around the control plane, it would indicate that the control plane had slipped during the mission and this is the likely cause of the failure to dive.

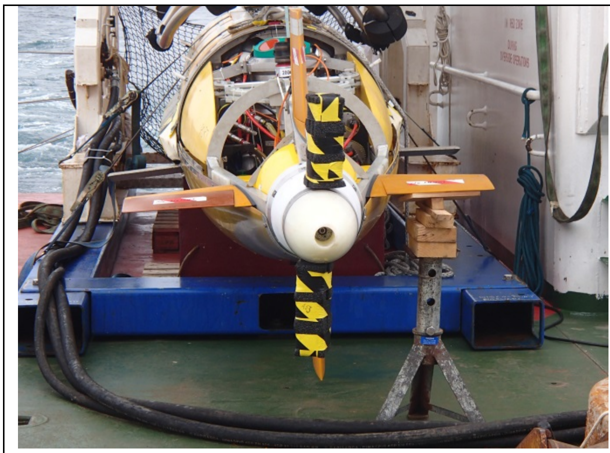
Figure 19.14. M463 post recovery dive plane angles.

The torque required to move the control planes relative to each other was then tested by holding the starboard control plane fixed and then moving the port side plane. It was found that the port side plane was very easy to move by hand. The problem was traced to the outboard portion of the shaft/fin coupling (see Figure 19.16).

Figure 19.15. Port side coupling outer portion was slipping during M463 (note the bolts removed in this picture were in place during the deployment)

On further testing of the couplings it was found that the clamp was positioned so that the left three bolt holes clamped onto the inboard shaft and only the outboard bolt clamped onto the fin shaft. This would result in the clamp not being able to properly grip the outboard shaft if it was slightly smaller than the inboard one.

The clamp was readjusted and tightened to make sure that the shafts were correctly coupled together, and the new system tested using the setup shown in the images below. This involved placing a weight on the port side wing while preventing the starboard wing from moving. Seven kg of lead was balanced 360 mm from the pivot point (~25 Nm of torque), and no slipping was observed.

	
Starboard side wing support	Loading the port side wing

Low Level Depth Control Limit Cycling

During the low level camera runs the AUV consistently experience a significant oscillation in altitude. Although set at a target altitude of 2.5 m this oscillation resulted in the AUV cycling between 1.9 m and 3.5 m altitude as shown in Figure 19.17.

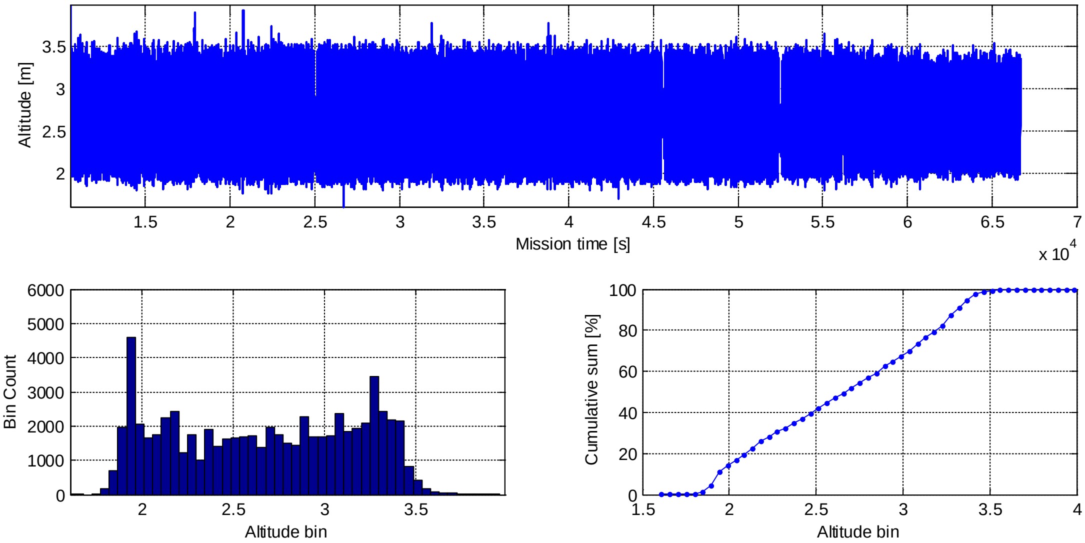


Figure 19.16. Altitude control behaviour during the 2.5 m altitude camera run of Mission 466. The top plot shows the altitude vs mission time, the lower left image shows the altitude distribution, and the lower right image shows the cumulative sum vs altitude

This oscillation was not seen during the side scan survey mission run at 15 m altitude. The difference in performance can be readily seen in Figure 19.18.

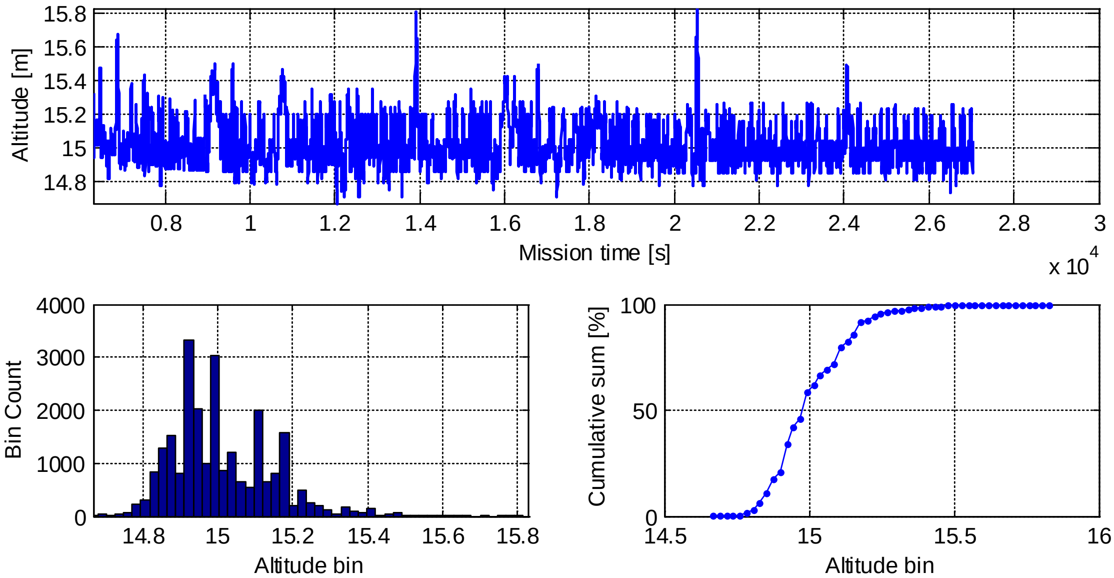


Figure 19.17. Altitude control behaviour during the 15 m altitude side scan survey of Mission 469.

The large spikes in the altitude control are associated with the AUV turning. Given that the limit cycling was not apparent in the side scan or multi-beam surveys two short runs at 6 m and 4.5 m altitude were put into the beginning of Mission 467 before the start of the camera survey. This was done to establish the effect of altitude on the oscillation and the results are shown in Figure 19.19. As can be seen neither the 6 m nor the 4.5 m altitude runs show the oscillation. Thus, it is considered highly likely that this oscillatory behaviour is associated with the Doppler Velocity Log (DVL). It is possible that an alternative configuration of the device would reduce this effect, but further investigation into this problem would be required to confirm this.

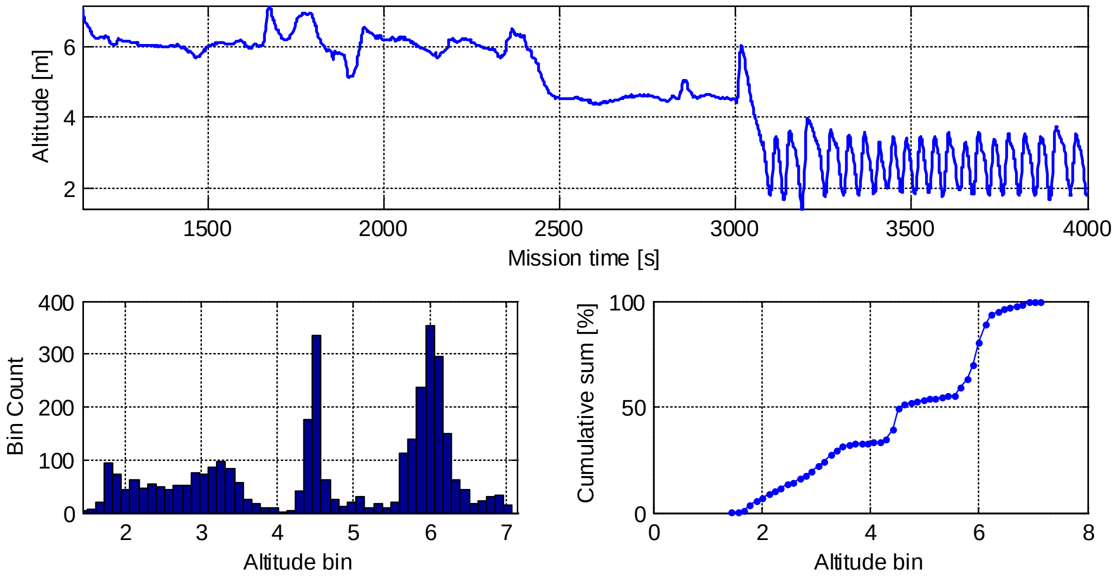


Figure 19.18. Altitude control behaviour during a 6 m, 4.5 m and 2.5 m altitude test at the start of Mission 467.

Other issues

Leak Sensor - The AUVs leak sensor indicated a fault during mission 462, which resulted in the recovery of the AUV. This was traced to the bare wiring of the leak sensor touching the pressure tube and causing an internal short. Once rectified no more problems were observed.

Xeos Beacon – Loss - During the recovery on mission 462 the recovery a number of grapples got stuck on the AUV. This caused the recovery lines to get twisted around the rear mast holding the Wifi and Xeos beacon head. During the recovery the entire mast was snapped off and the Xeos beacon head was lost.

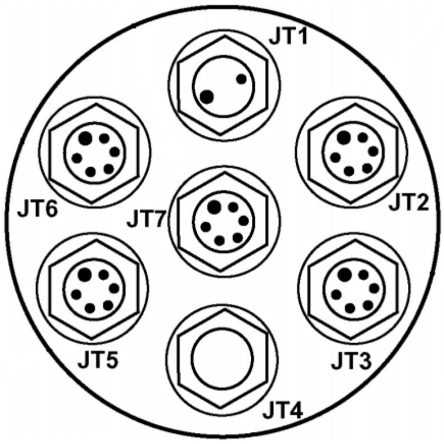
Novatech Iridium Beacon Setup - The setup of the new Novatech Iridium beacon meant that it was not giving messages after the AUV had been launched. This was due to the wash-over issues experienced by the beacon. Re-configuring the beacon mean that messages were sent.

Novatech Argos Beacon - The new Novatech Argos Beacon failed to give messages after it had been deployed. This was assumed to be the result of wash over. Raising the beacon did not produce an clear benefits and also significantly increased the potential for the beacon to get snagged by a recovery line. If this happened the battery tube could pivot about the panel attachment point and the lower portion would move potentially causing damage internally. Thus, the system was replaced with the original internal Argos system.

Figure 19.19. CTD setup and configuration files.

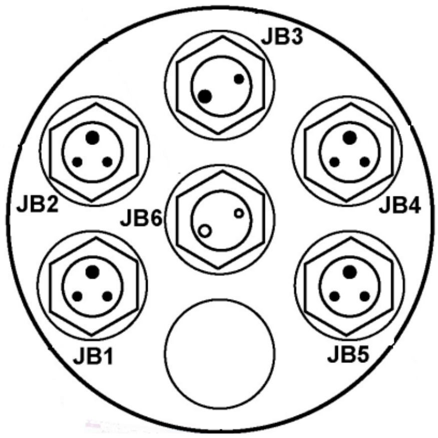
Top End Cap

#	Type	Serial
JT1	Blanked	
JT2	Blanked	
JT3	Transmissometer	CST979DR
JT4	Blanked	
JT5	BBRTD	BBRTD-168
JT6	Blanked	
JT7	Lonworks	



Bottom End Cap

#	Type	Serial
JB1	C1 (Port)	04-2937
JB2	T1 (Port)	03-4458
JB3	Pumps	05-3690 & 05-3665
JB4	T2 (Starboard)	03-5617
JB5	C2 (Starboard)	04-4308
jB6	Blanked	NA



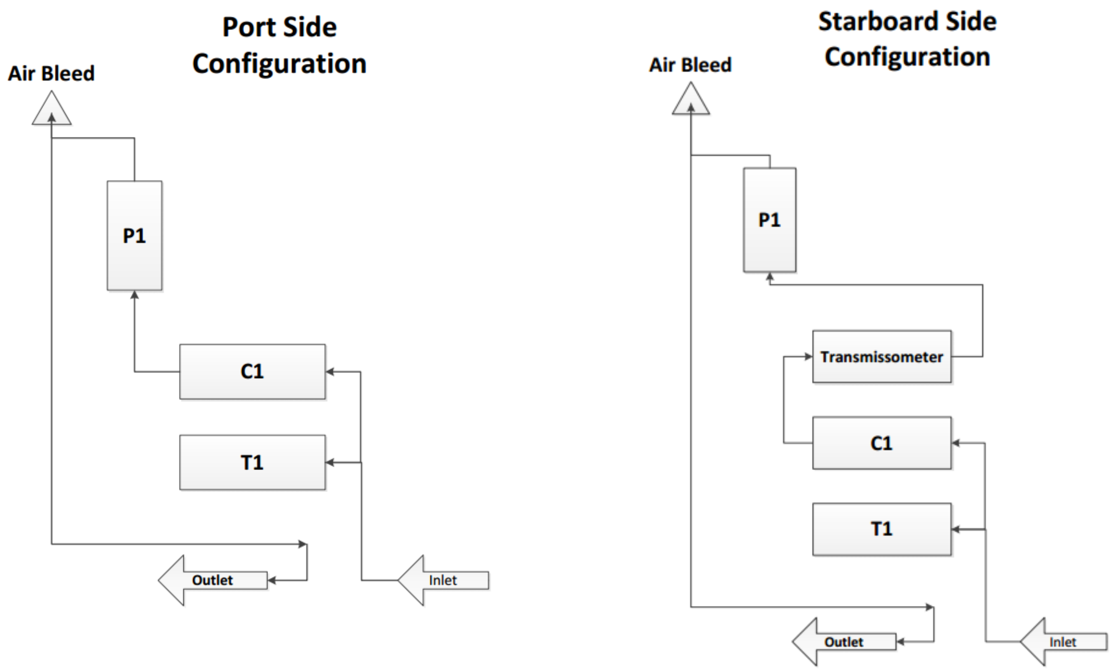


Figure 19.20. Plumbing Configurations.

Autosub Camera & Flash specification

Table 19.5. Details of the single camera used on Autosub3.

Camera model	Grasshopper2 GS2-GE-50S5C
Camera vendor	Point Grey Research
Sensor	Sony ICX625AQ (2/3" 2448x2048 CCD)
Resolution	2448x2048 (5 Mega pixels)
Image pixel format	PIXEL_FORMAT_RAW8
Bayer tile format	GBRG
Firmware version	1.15.3.0
Firmware build time	Wed Sep 01 22:20:12 2010
GigE version	1.2
Orientation	Vertical – down.
Lens	12.5mm, F2.7, focal range 2.25m in air, 3m in water
Image capture rate	1Hz
Image storage capacity	approx. 2 days at 1Hz image capture
Logger software version	4.10

20. Gliders

David White and Alvaro Lorenzo Lopez

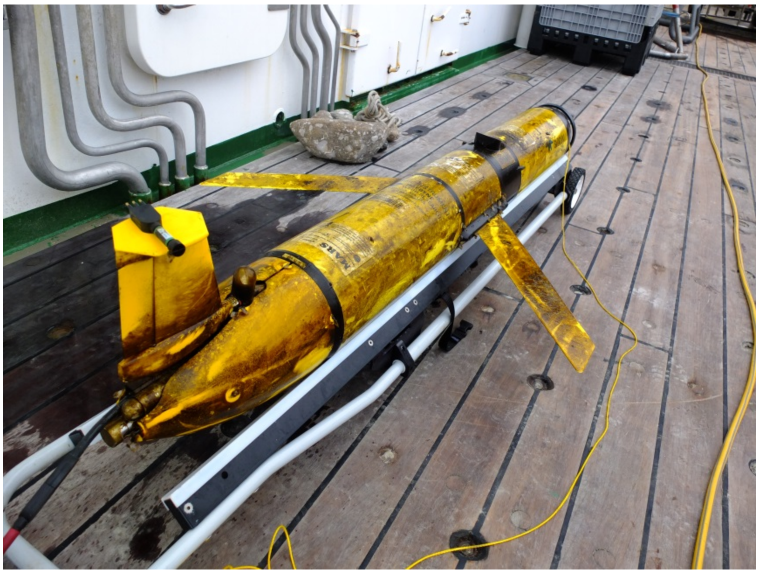


Figure 20.1. Slocum glider.

Summary

Three gliders were recovered for SSB and Sensors on Gliders: Seaglider 1kA SG533 ‘Canopus’, 200m Slocum unit_306 ‘Zephyr’ and unit_399 ‘Raleigh’. Three gliders were deployed for MASSMO2 phases a and b: 200m Slocums unit_419 ‘Fortyniner’, unit_544 and unit_545.

Table 20.2. Glider deployments and recoveries.

Date	Time UTC	GLIDER	LATITUDE	LONGITUDE	Station No.	CTD CALIB. CAST(S)
10 Aug 15	09:48	200m Slocum unit_419 MASSMO Deployment	51° 04.15’ N	006° 34.47’ W	119	120
16 Aug 15	06:00	200m Slocum unit_306 SSB Recovery	50° 33.352’ N	007° 00.323’ N	215B	216,217,218
22 Aug 15	08:50	1kA Seaglider SG533 SSB Recovery	48° 31.343’ N	009° 44.408’ W	403	402
22 Aug 15	17:58	200m Slocum unit_399 SSB Recovery	49° 29.324’ N	008° 35.997’ W	405	404, 406
24 Aug 15	18:30	200m Slocum unit_544 Deployment	50° 34.172’ N	007° 07.349’ W	461	463
24 Aug 15	18:35	200m Slocum unit_545 Deployment	50° 34.172’ N	007° 07.349’ W	462	463

On-board computing and remote access

The Freewave antenna on the starboard gantry could see the gliders at a reasonable range in the water, as long as the ship's superstructure was not in the way. This includes inside the hangar.

Access to the dockserver and glider terminal was poor at busy internet times, using the conventional windows software i.e. WinScp for file access, Putty for tunnelling and direct access to the java terminal program through the dockserver. Email notifications from the basestation and dockserver suffered due to the delays introduced by AMS.

Use of a virtual machine speeded up the SSH tunnel and allowed the glider terminal to be used most of the time, with vastly increased stability. Piloting over iridium from the ship would be feasible if this configuration continues to work. Telephone access to the shore was also poor, but use of the WhatsApp texting App proved the best means of instant communication.

Deployment and recovery notes

The Slocum gliders were deployed using the MARS deployment bridle form the aft pedestal crane. There were some minor issues where gear stored against the rail was in the way but generally it worked well. The glider is hoisted in the bridle, and the pins removed at the rail. The crane extends as far as the release lines will reach, lowered to the water and the catches released.

The first Slocum was recovered by grappling the nose release float then hoisting inboard using the Rexroth on the bullhorn. This provided insufficient height, and the lift had to be stopped off and lifted on board by tying a second loop in the line. Subsequent recoveries were on the P-frame. The Seaglider was lassoed using the carbon fibre pole and line, then lifted using a karabiner on the bight of the line which was tied off on deck.

Sensor fouling

Both shallow Slocums were coated in brown slime with moderate colonies of gooseneck barnacles up to 15 mm in size. The copper face on the WetLabs instruments showed pink, indicating it has been active and there was no discernible fouling on those sensors. The Optode appeared to be lightly fouled in the same way as the PAR and to a similar degree. The CTD inlet and outlet were surrounded by barnacles but not blocked. The PAR sensor on unit_399 was covered in a layer of brown slime somewhat less than 1mm thick. The photograph shows the PAR with a small amount of slime removed for comparison.

Figure 20.2. The Seaglider showed much less fouling as expected, with the PAR sensor clean and little or no slime over the other sensors and upper surface, and with only 2 or 3 tiny barnacles on board. The optical sensors were unfouled.

21. NOC benthic lander technical report

Chris Balfour and Megan Williams

During DY034 the NOC Liverpool (NOCL) mini-STABLE lander was deployed four times. The suite of sensors fitted to the lander are listed in Table 21.1 and labelled pictures of the lander and sensor configuration are shown in Figs. 21.1 and 21.2. The remaining information in this section is a tabulation of an initial preliminary review of the instrumentation data return for each deployment.

Table. 21.1 NOCL benthic survey lander sensor details

Sensor	Brief description
Sequoia LISST 100X	Laser in-situ transmissometry for particle size distribution
Sequoia LISST HOLO	Holographic sediment imaging camera
Marine Electronics 3D ripple profiler	Acoustic seabed imaging sonar
Satlantic Suna	Optical nutrient sensor
FSI/Teledyne Citadel NXIC CTD	CTD with a shielded inductive conductivity cell
Nortek Aquadopp HR	High resolution downwards facing velocity meter
Aquatec Aquascat1000R	Acoustic downwards facing sensor for sediment particle size and concentration measurements.
Upward facing 1200KHz RDI ADCP	Acoustic Doppler current profiler in a gimbal, upward facing
McLane RAS 100 water sampler	24 x 100ml water sample bags for nutrient measurement and 24 suspended particulate matter (SPM) inline filters,
Unisense eddy correlation/flux sensing system	High resolution dissolved oxygen micro-sensor, Aanderaa optode reference dissolved oxygen sensor and a Nortek Vector high speed acoustic water velocity meter.
Teledyne Benthos XT6001 (x 2)	Acoustic range finder (pinger) + backup recovery spooler release with two acoustics for redundancy

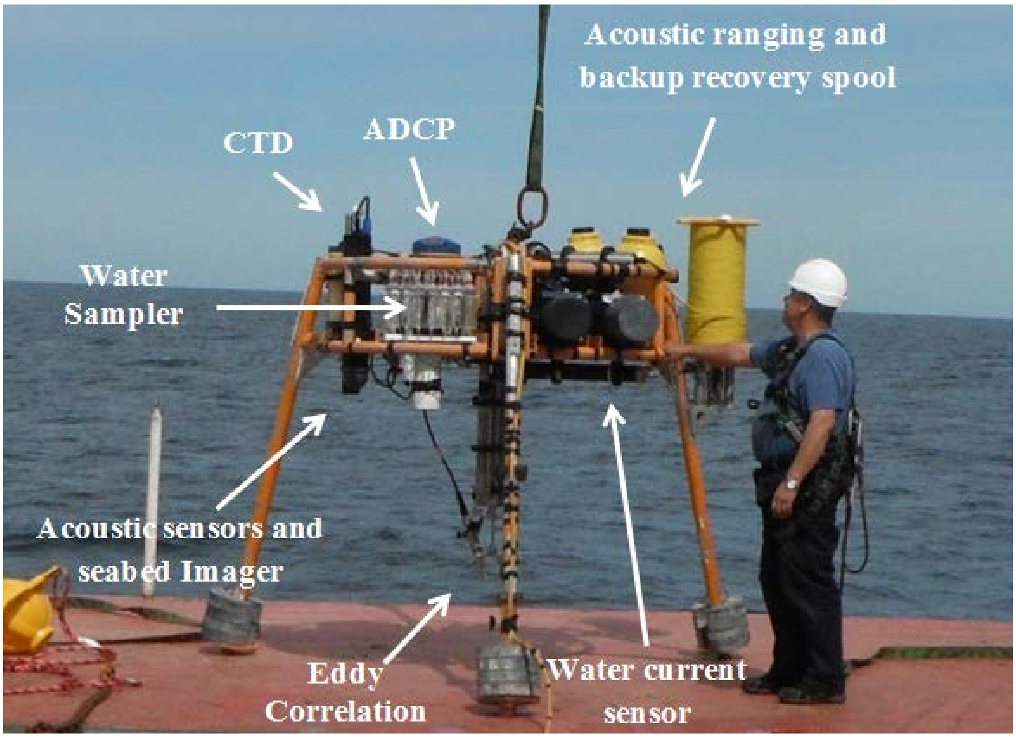


Figure 21.1 Basic layout of the NOCL mini-STABLE benthic survey lander

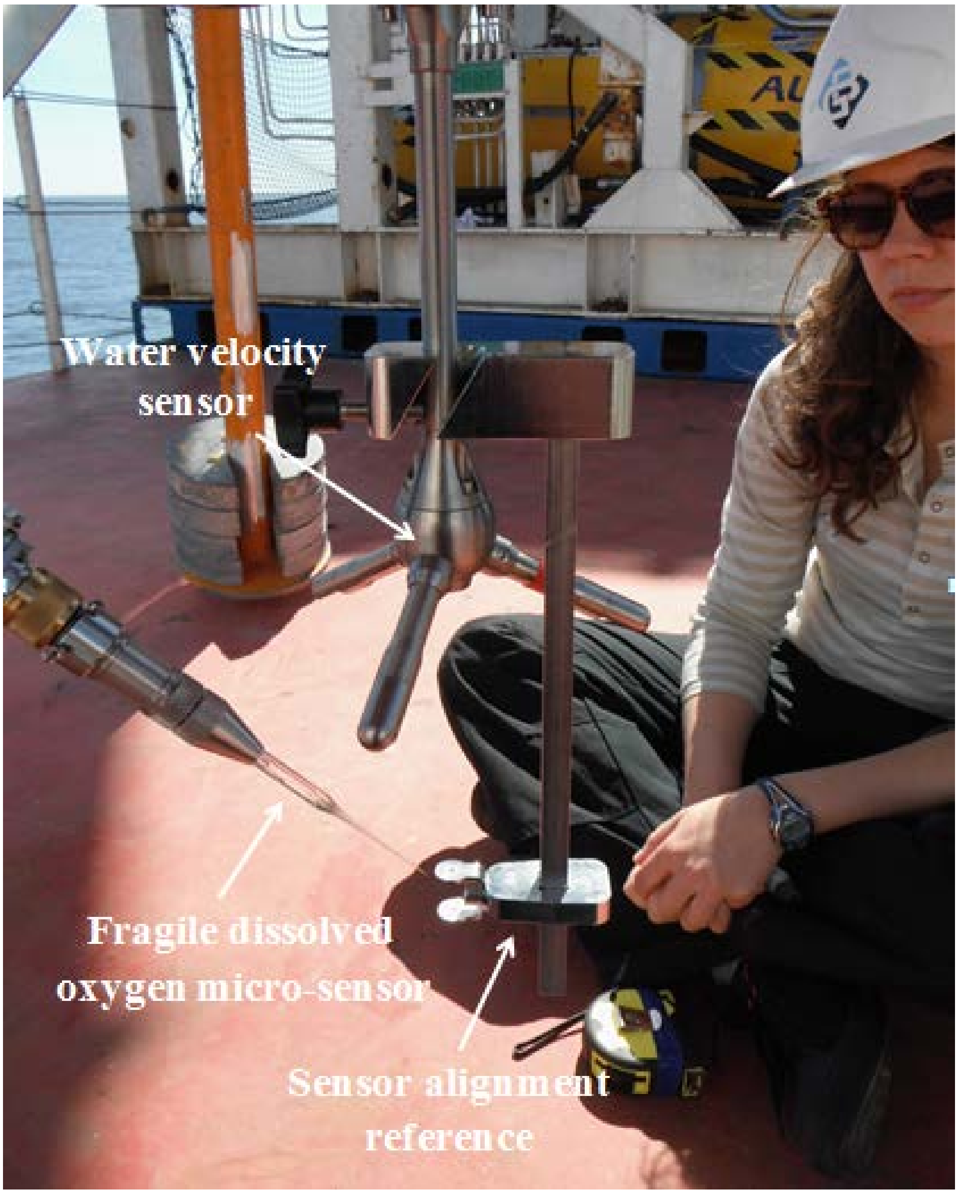


Figure 20.2 Eddy correlation sensor alignment

Summary of Recovered Data Sets – Deployment 1

Deployment at DY034 benthic site G, 51° 04.16406'N, 6° 36.63974'W, from 08/08/15 at 14:02 to 14:00 on 10/08/15. The nominal water depth was 99m.

Instrument	Preliminary data quality check
McLane RAS 100	Full water sample return and filter recovery.
1200KHz RDI ADCP	Full data return
Eddy Correlation	Full data return
3D Ripple Profiler	Full data return
LISST 100X	Full data return
LISST HOLO	Images not recorded due to an instrument configuration problem.
FSI (CTD) + Suna	Full data return
AQUASCAT 1000	Full data return
NORTEK AQUADOP	Full data return

Summary of Recovered Data Sets – Deployment 2

Deployment at DY034 benthic site A, 51° 12.56160'N, 6° 8.21418'W, from 11:14 on 13/08/15 to 19:15 on 15/08/15, 51°. The nominal water depth was 107m

Instrument	Preliminary data quality check
McLane RAS 100	Did not collect any samples due to a fault with the unit.
1200KHz RDI ADCP	Full data return
Eddy Correlation	Full data return
3D Ripple Profiler	Full data return
LISST 100X	Full data return
LISST HOLO	Full data return
FSI (CTD) + Suna	Full data return
AQUASCAT 1000	Full data return
NORTEK AQUADOP	Full data return

Summary of Recovered Data Sets – Deployment 3

Deployment at DY034 benthic site H, 51° 31.2496'N, 7° 2.03952'W from 08:30 on 19/08/15 to 08:00 on 21/08/15. The nominal water depth was 108m.

Instrument	Preliminary data quality check
McLane RAS 100	Full water sample return and filter recovery.
1200KHz RDI ADCP	Full data return
Eddy Correlation	Full data return
3D Ripple Profiler	Full data return
LISST 100X	Full data return
LISST HOLO	Full data return
FSI (CTD) + Suna	Full data return
AQUASCAT 1000	Full data return
NORTEK AQUADOP	Full data return

Summary of Recovered Data Sets – Deployment 4

Deployment at DY034 benthic site I, 50° 34.47018"N, 7° 06.30348"W, from 16:10 on 24/08/15 to 07:00 on 30/08/15. The nominal water depth was 109m.

Instrument	Preliminary data quality check
McLane RAS 100	Full water sample return and filter recovery.
1200KHz RDI ADCP	Full data return
Eddy Correlation	Full data return
3D Ripple Profiler	Full data return
LISST 100X	Full data return
LISST HOLO	Full data return
FSI (CTD) + Suna	Full data return
AQUASCAT 1000	Full data return
NORTEK AQUADOP	Full data return

22. Resuspension experiments

Charlotte EL Thompson, Anouska Panton, Sarah Reynolds, Lesley Chapman-Greig

In-Core Resuspension

The Core MiniFlume (CMF) is a small annular flume designed to fit into a NIOZ box core barrel (Thompson *et al*, 2013). It is 20 cm in diameter, and consists of two acrylic tubes that form a 4.5cm wide working channel with water depth of 20-25 cm. A rotating lid turns 4 equidistant paddles, which are used to induce a flow within the flume. Fully calibrated, the flume is used to apply a shear stress to the bed in an increasing step-wise manner until and beyond the point where the bed begins to erode and resuspension occurs (Thompson *et al*, 2013).

During the cruise, 6 entire cores were taken from sites A, H and I complete with barrels and shoes, to minimise disturbance. These were oxygenated and stored in a chilled container (at bottom water temperature) for a minimum of 12 hours to allow settlement of any sediment material resuspended during collection. One core was used to establish the physical stability of the bed and determine the critical erosion threshold. Once established, three cores were used to determine fluxes of inorganic nutrients, dissolved organic carbon (DOC), suspended particulate matter (SPM) and particulate carbon (CHN) during the resuspension experiments. GEL probes were inserted into one the remaining NIOZ cores, see Sarah Reynolds report for details. The additional two cores are used as backups in case of core-collapse/unsuitable surface, and where time/conditions allowed were used for replication of the physical stability experiment. In-core resuspension cannot be carried out for Benthic G, as a head of water cannot be maintained for sufficient time on advective sediments.

Post resuspension, the un-disturbed area in the centre of the core was used to collect sub-cores to be used for Particle Size Analysis (PSA: 10 cm diameter) and Bulk Density (BD: 50 ml syringe core). These were frozen for analysis in the laboratory.

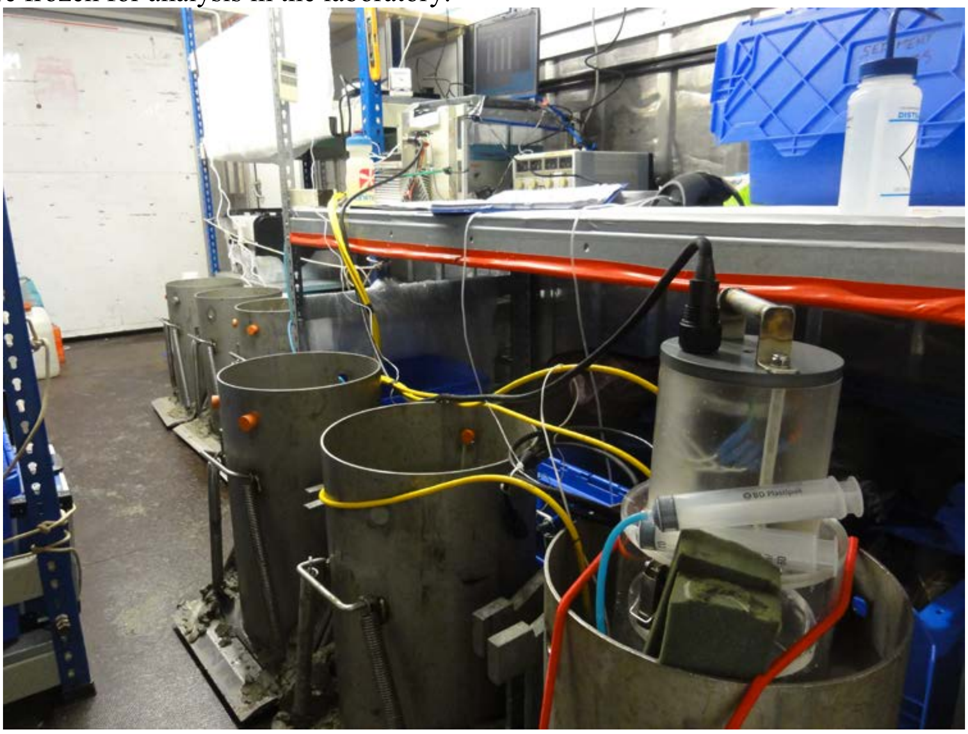


Figure 1: Core Mini Flume in place during the resuspension experiments

Core Mini Flume (CMF) – NIOZ core deployments

BENTHIC A

Event 086 NIOZ core

On bed: 9/8/15 22:57 GMT; 51°12.65706 N, 6°8.01888 W

Depth: 106.4 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	127	-	56	1	1
T20	-	026	54	2	2
T40	176	-	52	3	3
T60	-	028	54	4	4
T80	148	-	54	5	5
T100	-	018	56	6	6
T120	113	-	59	7	7
T140	-	030 + 029	22 + 22	8	8
T160	169 + 114	-	18 + 27	9	9

Event 084 NIOZ core

On bed: 9/8/15 22:30 GMT; 51°12.65772 N, 6°8.01906 W

Depth: 105.3 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	149	-	53	10	10
T20	-	019	54	11	11
T40	142	-	53	12	12
T60	-	027	51	13	13
T80	121	-	54	14	14
T100	-	025	50	15	15
T120	156	-	48	16	16

T140	-	031 + 032	28 + 22	17	17
T160	120 + 115	-	20 + 30	18	18

<u>Event 123 NIOZ core</u>

On bed: 11/8/15 00:52 GMT; 51°12.60366 N, 6°7.89996 W

Depth: 105.9 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	162	-	54	19	19
T20	-	033	54	20	20
T40	129	-	51	21	21
T60	-	034	54	22	22
T80	163	-	52	23	23
T100	-	035	48	24	24
T120	177	-	53	25	25
T140	-	036 + 037	20 + 20	26	26
T160	155 + 122	-	20 + 16	27	27

BENTHIC H

<u>Event 278 NIOZ core</u>

On bed: 18/8/15 02:58 GMT; 50°31.29468 N, 7°2.02056 W

Depth: 105.5 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	178	-	52	70	28
T20	-	038	50	71	29
T40	183	-	51	72	30
T60	-	039	51	73	31
T80	179	-	40	74	32

T100	-	040 + 041	19 + 20	75	33
T120	134 + 137	-	16 + 15	76	34
T140	-	042 + 043	16 + 14	77	35
T160	192 + 193	-	11 + 12	78	36

Event 277 NIOZ core

On bed: 18/8/15 02:42 GMT; 50°31.28862 N, 7°2.04870 W

Depth: 105.1 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	159	-	49	79	37
T20	-	044	50	80	38
T40	180	-	51	81	39
T60	-	045	52	82	40
T80	187	-	41	83	41
T100	-	046 + 047	19 + 21	84	42
T120	171 + 172	-	15 + 15	85	43
T140	-	048 + 049	14 + 15	86	44
T160	123 + 124	-	12 + 12	87	45

Event 281 NIOZ core

On bed: 18/8/15 03:42 GMT; 50°31.29840 N, 7°2.01930 W

Depth: 106.0 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	143	-	51	88	46
T20	-	050	51	89	47
T40	165	-	49	90	48
T60	-	051	51	91	49

T80	144	-	40	92	50
T100	-	052 + 053	21 +20	93	51
T120	116 + 152	-	16 + 15	94	52
T140	-	054 + 055	13 + 12	95	53
T160	117 + 118	-	11 + 10	96	54

BENTHIC I

Event 392 NIOZ core

On bed: 20/8/15 21:23 GMT; 50°34.57518 N, 7°6.30180 W

Depth: 110.6 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	154	-	50	109	55
T20	-	057	50	110	56
T40	188	-	51	111	57
T60	-	056	50	112	58
T80	131	-	52	113	59
T100	-	058	50	114	60
T120	146	-	41	115	61
T140	-	059	32	116	62
T160	25	-	25	117	63

Event 391 NIOZ core

On bed: 20/8/15 21:07 GMT; 50°34.57080 N, 7°6.29976 W

Depth: 109.4 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	132	-	51	118	64
T20	-	060	51	119	65

T40	182	-	50	120	66
T60	-	097	50	121	67
T80	194	-	51	122	68
T100	-	096	52	123	69
T120	133	-	41	124	70
T140	-	088	31	125	71
T160	173	-	26	126	72

Event 396 NIOZ core

On bed: 20/8/15 22:23 GMT; 50°34.58556 N, 7°6.30138 W

Depth: 109.7 m

SPM/CHN filters and DOC/nutrient samples

Time step	SPM filter	CHN filter	Volume filtered	DOC sample	Nutrient sample
Tzero	138	-	50	127	73
T20	-	095	52	128	74
T40	147	-	51	129	75
T60	-	089	51	130	76
T80	166	-	50	131	77
T100	-	093	50	132	78
T120	174	-	39	133	79
T140	-	090	30	134	80
T160	125	-	22	135	81

References:

Thompson, C.E.L., Couceiro, F., Amos, C. and Fones, G.R. 2013. Shipboard measurements of sediment stability using a small annular flume – Core Mini Flume (CMF). Limnology and Oceanography, methods. 11, 604-615. DOI: 10.4319/lom.2013.11.604

23. Acknowledgements

We would like to thank the officers and engineers of RRS *Discovery*, the NMF technicians and crew who all when to great lengths to try to make things work for us and keep them working, and of course the catering team for good food to raise our spirits. NMF personnel provided excellent support under challenging conditions with the aim of delivering the maximum level of capability. Moreover, the SSB programme manager Professor Phillip Williamson, BMCC project lead Professor Martin Solan, and cruise PSO Dr. Henry Ruhl all wish to thank the SSB scientists, technicians and crews for their gracious dedication throughout the SSB cruise series.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**STNNBR**	**SITE**	**Gear Description**	**Start or bottom time & location**	**Time**		**Latitude**			**Longitude**			**Seafloor depth**
2					**Date (UTC)**	**Time (UTC)**	**Degrees**	**Minutes (integer)**	**Minutes (decimals)**	**Degrees**	**Minutes (integer)**	**Minutes (decimals)**	**Uncorrected (m)**
3	002	Benthic A	UCCTD	Start	07/08/2015	22:33	51	12	639	6	7	826	107
4	003	Benthic A	UCCTD	Start	08/08/2015	00:12	51	12	656	6	7	853	n/a
5	004	Benthic A	CTD	Start	08/08/2015	01:25	51	12	657	6	7	854	106
6	005	Benthic A	Nioz	Bottom	08/08/2015	02:52	51	12	656	6	7	853	105
7	006	Benthic A	Nioz	Bottom	08/08/2015	04:37	51	12	655	6	7	855	104
8	007	Benthic A	Nioz	Bottom	08/08/2015	04:54	51	12	654	6	7	855	104
9	008	Benthic A	Nioz	Bottom	08/08/2015	05:11	51	12	654	6	7	855	104
10	009	Benthic A	Nioz	Bottom	08/08/2015	05:26	51	12	655	6	7	856	104
11	010	Benthic A	Nioz	Bottom	08/08/2015	05:42	51	12	654	6	7	855	104
12	011	Benthic A	Nioz	Bottom	08/08/2015	05:55	51	12	655	6	7	855	104
13	012	Benthic A	Nioz	Bottom	08/08/2015	06:12	51	12	657	6	7	860	104
14	013	Benthic A	Nioz	Bottom	08/08/2015	06:29	51	12	657	6	7	860	104
15	014	Benthic A	Nioz	Bottom	08/08/2015	06:45	51	12	658	6	7	860	104
16	015	Benthic A	Nioz	Bottom	08/08/2015	07:02	51	12	657	6	7	860	104
17	016	Benthic A	Nioz	Bottom	08/08/2015	07:18	51	12	657	6	7	859	104
18	017	Benthic A	Nioz	Bottom	08/08/2015	08:20	51	12	662	6	7	867	105
19	018	Benthic A	Nioz	Bottom	08/08/2015	09:00	51	12	662	6	7	867	105
20	019	Benthic A	Nioz	Bottom	08/08/2015	09:15	51	12	663	6	7	864	105
21	020	Benthic A	Nioz	Bottom	08/08/2015	09:33	51	12	665	6	7	864	105
22	021	Benthic A	Nioz	Bottom	08/08/2015	09:47	51	12	666	6	7	862	106
23	022	Benthic A	Nioz	Bottom	08/08/2015	10:01	51	12	666	6	7	862	106
24	023	Benthic A	Nioz	Bottom	08/08/2015	10:16	51	12	670	6	7	865	106
25	024	Benthic A	Nioz	Bottom	08/08/2015	10:30	51	12	674	6	7	866	107
26	025	Benthic A	Nioz	Bottom	08/08/2015	10:44	51	12	678	6	7	866	107
27	026	Benthic A	Nioz	Bottom	08/08/2015	10:57	51	12	678	6	7	866	107
28	027	Benthic A	Nioz	Bottom	08/08/2015	11:10	51	12	678	6	7	866	107
29	028	Benthic A	Nioz	Bottom	08/08/2015	11:23	51	12	678	6	7	866	107
30	029	Benthic G	NOC bedframe	Start	08/08/2015	14:07	51	4	164	6	34	640	99
31	030	Benthic G	CTD	Start	08/08/2015	15:22	51	4	029	6	34	922	106
32	031	Benthic A	Autosub3	Start	08/08/2015	19:06	51	13	995	6	7	347	n/a
33	032	Benthic A	Nioz	Bottom	08/08/2015	20:47	51	12	685	6	8	013	104
34	033	Benthic A	Nioz	Bottom	08/08/2015	21:02	51	12	685	6	8	012	104
35	034	Benthic A	Nioz	Bottom	08/08/2015	21:18	51	12	685	6	8	013	104
36	035	Benthic A	Nioz	Bottom	08/08/2015	21:34	51	12	685	6	8	012	106

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
37	036	Benthic A	Nioz	Bottom	08/08/2015	21:46	51	12	685	6	8	013	106
38	037	Benthic A	Nioz	Bottom	08/08/2015	22:02	51	12	687	6	8	012	106
39	038	Benthic A	Nioz	Bottom	08/08/2015	22:16	51	12	688	6	8	012	106
40	039	Benthic A	Nioz	Bottom	08/08/2015	22:31	51	12	686	6	8	010	106
41	040	Benthic A	Nioz	Bottom	08/08/2015	22:46	51	12	686	6	8	011	107
42	041	Benthic A	Nioz	Bottom	08/08/2015	23:00	51	12	684	6	8	009	106
43	042	Benthic A	Nioz	Bottom	09/08/2015	00:18	51	12	689	6	8	013	107
44	043	Benthic A	Nioz	Bottom	09/08/2015	00:33	51	12	689	6	8	013	107
45	044	Benthic A	Nioz	Bottom	09/08/2015	00:47	51	12	689	6	8	012	107
46	045	Benthic A	Nioz	Bottom	09/08/2015	01:03	51	12	690	6	8	013	107
47	046	Benthic A	Nioz	Bottom	09/08/2015	01:22	51	12	692	6	8	013	107
48	047	Benthic A	Nioz	Bottom	09/08/2015	01:36	51	12	692	6	8	013	107
49	048	Benthic A	Nioz	Bottom	09/08/2015	01:54	51	12	690	6	8	010	106
50	049	Benthic A	Nioz	Bottom	09/08/2015	02:08	51	12	689	6	8	011	106
51	050	Benthic A	Nioz	Bottom	09/08/2015	02:24	51	12	690	6	8	010	106
52	051	Benthic A	Nioz	Bottom	09/08/2015	02:41	51	12	689	6	8	010	106
53	052	Benthic A	Nioz	Bottom	09/08/2015	03:00	51	12	692	6	8	011	106
54	053	Benthic A	Nioz	Bottom	09/08/2015	03:14	51	12	693	6	8	009	106
55	054	Benthic A	Nioz	Bottom	09/08/2015	03:36	51	12	693	6	8	010	105
56	055	Benthic A	Nioz	Bottom	09/08/2015	03:51	51	12	695	6	8	010	105
57	056	Benthic A	Nioz	Bottom	09/08/2015	04:04	51	12	695	6	8	012	105
58	057	Benthic A	Nioz	Bottom	09/08/2015	04:18	51	12	695	6	8	009	105
59	058	Benthic A	Nioz	Bottom	09/08/2015	04:41	51	12	698	6	8	012	105
60	059	Benthic A	Nioz	Bottom	09/08/2015	04:56	51	12	698	6	8	013	105
61	060	Benthic A	Nioz	Bottom	09/08/2015	05:10	51	12	697	6	8	011	105
62	061	Benthic A	Nioz	Bottom	09/08/2015	05:25	51	12	696	6	8	008	104
63	062	Benthic A	Nioz	Bottom	09/08/2015	05:39	51	12	698	6	8	011	104
64	063	Benthic A	Nioz	Bottom	09/08/2015	05:53	51	12	697	6	8	011	105
65	064	Benthic A	Nioz	Bottom	09/08/2015	06:13	51	12	695	6	8	013	104
66	065	Benthic A	Nioz	Bottom	09/08/2015	06:26	51	12	696	6	8	014	104
67	066	Benthic A	Nioz	Bottom	09/08/2015	06:48	51	12	701	6	8	012	104
68	067	Benthic A	NIOZ	Bottom	09/08/2015	07:03	51	12	697	6	8	013	104
69	068	Benthic A	Megacorer	Bottom	09/08/2015	08:18	51	12	701	6	8	012	105
70	069	Benthic A	Megacorer	Bottom	09/08/2015	08:50	51	12	699	6	8	011	105

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
71	070	Benthic A	Megacorer	Bottom	09/08/2015	09:15	51	12	698	6	8	011	105
72	071	Benthic A	Megacorer	Bottom	09/08/2015	10:14	51	12	702	6	8	017	105
73	072	Benthic A	SPI	Start	09/08/2015	11:19	51	12	67	6	8	01	107
74	073	Benthic A	SPI	Start	09/08/2015	12:10	51	12	780	6	7	838	107
75	074	Benthic A	Autosub3	Start	09/08/2015	13:41	51	14	026	6	7	575	n/a
76	075	Benthic A	SPI	Start	09/08/2015	16:24	51	12	726	6	8	048	106
77	076	Benthic A	SPI	Start	09/08/2015	17:09	51	12	547	6	8	171	105
78	077	Benthic A	SPI	Start	09/08/2015	18:17	51	12	550	6	7	802	104
79	078	Benthic A	CTD	Start	09/08/2015	19:02	51	12	561	6	7	802	104
80	079	Benthic A	SMBA	Bottom	09/08/2015	20:13	51	12	742	6	8	024	104
81	080	Benthic A	SMBA	Bottom	09/08/2015	20:28	51	12	740	6	8	070	104
82	081	Benthic A	SMBA	Bottom	09/08/2015	20:51	51	12	743	6	8	019	104
83	082	Benthic A	SMBA	Bottom	09/08/2015	21:09	51	12	743	6	8	019	105
84	083	Benthic A	SMBA	Bottom	09/08/2015	21:25	51	12	743	6	8	020	105
85	084	Benthic A	NIOZ	Bottom	09/08/2015	22:30	51	12	658	6	8	019	105
86	085	Benthic A	NIOZ	Bottom	09/08/2015	22:42	51	12	657	6	8	019	106
87	086	Benthic A	NIOZ	Bottom	09/08/2015	22:57	51	12	657	6	8	019	106
88	087	Benthic A	NIOZ	Bottom	09/08/2015	23:14	51	12	657	6	8	019	105
89	088	Benthic A	NIOZ	Bottom	09/08/2015	23:29	51	12	657	6	8	018	106
90	089	Benthic A	NIOZ	Bottom	09/08/2015	23:45	51	12	657	6	8	018	106
91	090	Benthic A	NIOZ	Bottom	10/08/2015	00:48	51	12	655	6	8	019	107
92	091	Benthic A	NIOZ	Bottom	10/08/2015	01:03	51	12	656	6	8	019	107
93	092	Benthic A	NIOZ	Bottom	10/08/2015	01:21	51	12	654	6	8	019	107
94	093	Benthic A	NIOZ	Bottom	10/08/2015	01:35	51	12	651	6	8	018	107
95	094	Benthic A	NIOZ	Bottom	10/08/2015	01:49	51	12	651	6	8	018	108
96	095	Benthic A	NIOZ	Bottom	10/08/2015	02:05	51	12	659	6	8	019	107
97	096	Benthic A	NIOZ	Bottom	10/08/2015	02:19	51	12	648	6	8	018	107
98	097	Benthic A	NIOZ	Bottom	10/08/2015	02:34	51	12	649	6	8	019	107
99	098	Benthic A	NIOZ	Bottom	10/08/2015	02:49	51	12	649	6	8	020	107
100	099	Benthic A	NIOZ	Bottom	10/08/2015	03:04	51	12	646	6	8	020	107
101	100	Benthic A	NIOZ	Bottom	10/08/2015	03:20	51	12	644	6	8	020	107
102	101	Benthic A	NIOZ	Bottom	10/08/2015	03:35	51	12	644	6	8	021	107
103	102	Benthic A	NIOZ	Bottom	10/08/2015	03:50	51	12	644	6	8	020	106
104	103	Benthic A	NIOZ	Bottom	10/08/2015	04:04	51	12	641	6	8	020	106

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
105	104	Benthic A	NIOZ	Bottom	10/08/2015	04:18	51	12	641	6	8	020	106
106	105	Benthic A	NIOZ	Bottom	10/08/2015	04:33	51	12	641	6	8	020	106
107	106	Benthic A	NIOZ	Bottom	10/08/2015	04:49	51	12	639	6	8	021	106
108	107	Benthic A	NIOZ	Bottom	10/08/2015	05:04	51	12	639	6	8	020	106
109	108	Benthic A	NIOZ	Bottom	10/08/2015	05:18	51	12	636	6	8	020	106
110	109	Benthic A	NIOZ	Bottom	10/08/2015	05:31	51	12	636	6	8	021	105
111	110	Benthic A	NIOZ	Bottom	10/08/2015	05:46	51	12	633	6	8	020	105
112	111	Benthic A	NIOZ	Bottom	10/08/2015	05:59	51	12	633	6	8	020	105
113	112	Benthic A	NIOZ	Bottom	10/08/2015	06:17	51	12	638	6	8	020	105
114	113	Benthic A	NIOZ	Bottom	10/08/2015	06:31	51	12	630	6	8	020	104
115	114	Benthic A	NIOZ	Bottom	10/08/2015	06:47	51	12	625	6	8	020	105
116	115	Benthic A	NIOZ	Bottom	10/08/2015	07:01	51	12	625	6	8	020	105
117	116	Benthic A	NIOZ	Bottom	10/08/2015	07:15	51	12	625	6	8	020	105
118	117	Benthic A	NIOZ	Bottom	10/08/2015	07:29	51	12	625	6	8	021	104
119	118	Benthic A	NIOZ	Bottom	10/08/2015	07:46	51	12	623	6	8	021	104
120	119	Benthic G	Glider	n/a	10/08/2015	10:41	51	4	200	6	34	500	n/a
121	120	Benthic G	CTD	Start	10/08/2015	11:14	51	4	251	6	34	641	100
122	121	Benthic G	Autosub3	Start	10/08/2015	16:02	51	5	702	6	34	458	n/a
123	122	Benthic G	Autosub3	Start	10/08/2015	19:00	51	5	646	6	34	574	n/a
124	123	Benthic A	NIOZ	Bottom	11/08/2015	00:52	51	12	604	6	7	899	106
125	124	Benthic A	NIOZ	Bottom	11/08/2015	01:10	51	12	602	6	7	899	106
126	125	Benthic A	CHEM SPI	Bottom	11/08/2015	01:42	51	12	602	6	7	900	n/a
127	126	Benthic A	CHEM SPI	Start	11/08/2015	02:47	51	12	595	6	7	913	106
128	127	Benthic A	Trawl	Start	11/08/2015	06:01	51	12	803	6	8	248	105
129	128	Benthic A	Trawl	Start	11/08/2015	07:07	51	13	800	6	8	203	105
130	129	Benthic A	Trawl	Start	11/08/2015	08:10	51	12	567	6	8	020	104
131	130	Benthic A	Trawl	Start	11/08/2015	09:17	51	12	984	6	8	447	130
132	131		Guard Buoy	Recovery									
133	132	Benthic G	UCCTD	Start	11/08/2015	15:32	51	4	346	6	34	874	101
134	133	Benthic G	CTD	Start	11/08/2015	16:31	51	4	345	6	34	868	100
135	134	Benthic G	CTD	Start	11/08/2015	17:36	51	4	344	6	34	862	100
136	135	Benthic G	CHEM SPI	Start	11/08/2015	18:48	51	4	425	6	35	014	100
137	136	Benthic G	Autosub3	Start	11/08/2015	20:52	51	5	723	6	34	393	n/a
138	137	Benthic G	CHEM SPI	Start	11/08/2015	22:05	51	4	427	6	35	012	98

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
139	138	Benthic G	NIOZ	Bottom	11/08/2015	23:21	51	4	423	6	35	022	99
140	139	Benthic G	NIOZ	Bottom	11/08/2015	23:35	51	4	426	6	35	024	100
141	140	Benthic G	NIOZ	Bottom	11/08/2015	23:48	51	4	426	6	35	024	99
142	141	Benthic G	NIOZ	Bottom	12/08/2015	00:01	51	4	426	6	35	024	99
143	142	Benthic G	NIOZ	Bottom	12/08/2015	00:14	51	4	426	6	35	024	100
144	143	Benthic G	NIOZ	Bottom	12/08/2015	01:19	51	4	422	6	35	023	101
145	144	Benthic G	NIOZ	Bottom	12/08/2015	01:33	51	4	423	6	35	023	101
146	145	Benthic G	NIOZ	Bottom	12/08/2015	01:46	51	4	423	6	35	023	101
147	146	Benthic G	NIOZ	Bottom	12/08/2015	01:59	51	4	423	6	35	022	100
148	147	Benthic G	NIOZ	Bottom	12/08/2015	02:14	51	4	420	6	35	023	101
149	148	Benthic G	NIOZ	Bottom	12/08/2015	02:26	51	4	420	6	35	023	101
150	149	Benthic G	NIOZ	Bottom	12/08/2015	02:39	51	4	420	6	35	022	101
151	150	Benthic G	NIOZ	Bottom	12/08/2015	02:53	51	4	420	6	35	023	101
152	151	Benthic G	NIOZ	Bottom	12/08/2015	03:07	51	4	417	6	35	023	101
153	152	Benthic G	NIOZ	Bottom	12/08/2015	03:19	51	4	418	6	35	023	101
154	153	Benthic G	NIOZ	Bottom	12/08/2015	03:33	51	4	413	6	35	022	101
155	154	Benthic G	NIOZ	Bottom	12/08/2015	03:46	51	4	413	6	35	020	101
156	155	Benthic G	NIOZ	Bottom	12/08/2015	04:01	51	4	413	6	35	020	101
157	156	Benthic G	NIOZ	Bottom	12/08/2015	05:57	51	4	413	6	35	020	100
158	157	Benthic G	NIOZ	Bottom	12/08/2015	06:18	51	4	413	6	35	020	100
159	158	Benthic G	NIOZ	Bottom	12/08/2015	06:30	51	4	413	6	35	020	100
160	159	Benthic G	NIOZ	Bottom	12/08/2015	06:44	51	4	410	6	35	020	100
161	160	Benthic G	NIOZ	Bottom	12/08/2015	06:56	51	4	410	6	35	020	99
162	161	Benthic G	NIOZ	Bottom	12/08/2015	07:10	51	4	410	6	35	020	99
163	162	Benthic G	NIOZ	Bottom	12/08/2015	07:36	51	4	408	6	35	020	99
164	163	Benthic G	NIOZ	Bottom	12/08/2015	07:48	51	4	408	6	35	020	99
165	165	Benthic G	NIOZ	Bottom	12/08/2015	08:06	51	4	404	6	35	019	99
166	166	Benthic G	NIOZ	Bottom	12/08/2015	08:18	51	4	405	6	35	020	99
167	167	Benthic G	NIOZ	Bottom	12/08/2015	08:30	51	4	405	6	35	020	98
168	168	Benthic G	NIOZ	Bottom	12/08/2015	08:42	51	4	406	6	35	023	98
169	169	Benthic G	NIOZ	Bottom	12/08/2015	08:54	51	4	406	6	35	023	98
170	170	Benthic G	NIOZ	Bottom	12/08/2015	09:07	51	4	406	6	35	023	98
171	171	Benthic G	NIOZ	Bottom	12/08/2015	09:20	51	4	406	6	35	024	98
172	172	Benthic G	NIOZ	Bottom	12/08/2015	09:34	51	4	401	6	35	023	98

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
173	173	Benthic G	NIOZ	Bottom	12/08/2015	09:47	51	4	401	6	35	023	98
174	174	Benthic G	NIOZ	Bottom	12/08/2015	09:59	51	4	401	6	35	022	98
175	175	Benthic G	NIOZ	Bottom	12/08/2015	10:13	51	4	401	6	35	023	98
176	176	Benthic G	NIOZ	Bottom	12/08/2015	10:26	51	4	406	6	35	023	98
177	177	Benthic G	NIOZ	Bottom	12/08/2015	10:37	51	4	401	6	35	023	98
178	178	Benthic G	NIOZ	Bottom	12/08/2015	10:49	51	4	401	6	35	023	98
179	179	Benthic G	NIOZ	Bottom	12/08/2015	11:00	51	4	396	6	35	023	98
180	180	Celtic Deep	CTD	Start	12/08/2015	11:52	51	7	390	6	34	576	97
181	181	Benthic A	Autosub3	Start	12/08/2015	18:32	51	14	053	6	7	549	n/a
182	182	Benthic G	NIOZ	Bottom	13/08/2015	00:14	51	4	390	6	35	029	98
183	183	Benthic G	NIOZ	Bottom	13/08/2015	00:26	51	4	390	6	35	034	99
184	184	Benthic G	NIOZ	Bottom	13/08/2015	00:40	51	4	418	6	35	033	99
185	185	Benthic G	NIOZ	Bottom	13/08/2015	00:59	51	4	418	6	35	033	99
186	186	Benthic G	NIOZ	Bottom	13/08/2015	01:14	51	4	420	6	35	033	100
187	187	Benthic G	NIOZ	Bottom	13/08/2015	01:27	51	4	420	6	35	033	100
188	188	Benthic G	NIOZ	Bottom	13/08/2015	01:41	51	4	423	6	35	033	100
189	189	Benthic G	SMBA	Bottom	13/08/2015	02:57	51	4	424	6	35	031	101
190	190	Benthic G	SMBA	Bottom	13/08/2015	03:12	51	4	424	6	35	031	101
191	191	Benthic G	SMBA	Bottom	13/08/2015	03:28	51	4	427	6	35	031	101
192	192	Benthic G	SMBA	Bottom	13/08/2015	03:43	51	4	427	6	35	031	102
193	193	Benthic G	SMBA	Bottom	13/08/2015	04:04	51	4	429	6	35	030	101
194	194	Benthic G	SMBA	Bottom	13/08/2015	04:18	15	4	429	6	35	030	101
195	195	Benthic G	SPI	Start	13/08/2015	05:06	51	4	482	6	35	087	101
196	196	Benthic G	SPI	Start	13/08/2015	05:56	51	4	212	6	35	081	101
197	197	Benthic G	SPI	Start	13/08/2015	06:45	51	4	349	6	34	866	101
198	198	Benthic G	SPI	Start	13/08/2015	07:36	51	4	483	6	34	654	99
199	199	Benthic G	SPI	Start	13/08/2015	08:28	51	4	210	6	34	654	98
200	200	Benthic A	NOC bedframe	Start	13/08/2015	11:20	51	12	562	6	8	214	104
201	201	Benthic A	CTD	Start	13/08/2015	12:47	51	12	755	6	7	966	105
202	202	Benthic G	CTD	Start	13/08/2015	15:50	51	4	357	6	34	897	101
203	203	Benthic G	Trawl	Start	13/08/2015	17:25	51	3	210	6	34	634	101
204	204	Benthic G	Trawl	Start	13/08/2015	18:40	51	4	418	6	35	948	100
205	205	Benthic G	Trawl	Start	13/08/2015	19:37	51	4	325	6	34	813	100
206	206	Benthic G	Autosub3	Start	14/08/2015	13:43	51	5	713	6	34	394	n/a

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
207	207	Celtic Deep	SmartBuoy	n/a	15/08/2015	13:15	51	8	255	6	33	643	99
208	208	Benthic A	CTD	Start	15/08/2015	16:09	51	12	821	6	8	219	107
209	209	Benthic A	Trawl	Start	15/08/2015	20:08	51	12	749	6	7	902	106
210	210	Benthic H	SMBA	Bottom	16/08/2015	02:28	50	31	214	7	1	905	106
211	211	Benthic H	SMBA	Bottom	16/08/2015	02:44	50	31	214	7	1	909	107
212	212	Benthic H	SMBA	Bottom	16/08/2015	03:01	50	31	216	7	1	915	107
213	213	Benthic H	SMBA	Bottom	16/08/2015	03:13	50	31	216	7	1	915	108
214	214	Benthic H	SMBA	Bottom	16/08/2015	03:28	50	31	217	7	1	919	108
215	215	Benthic H	SMBA	Bottom	16/08/2015	04:07	50	31	218	7	1	923	108
216	215b	Benthic H	Glider	n/a	16/08/2015	06:00	50	33	352	7	0	323	n/a
217	216	Benthic H	UCCTD	Start	16/08/2015	06:13	50	33	490	7	0	075	109
218	217	Benthic H	UCCTD	Start	16/08/2015	07:00	50	31	260	7	2	300	109
219	218	Benthic H	CTD	Start	16/08/2015	08:10	50	31	280	7	2	280	108
220	219	Benthic H	NIOZ	Bottom	16/08/2015	09:51	50	31	346	7	2	067	106
221	220	Benthic H	NIOZ	Bottom	16/08/2015	10:03	50	31	345	7	2	067	105
222	221	Benthic H	NIOZ	Bottom	16/08/2015	10:19	50	31	345	7	2	068	105
223	222	Benthic H	NIOZ	Bottom	16/08/2015	10:33	50	31	340	7	2	067	105
224	223	Benthic H	NIOZ	Bottom	16/08/2015	10:46	50	31	340	7	2	067	105
225	224	Benthic H	NIOZ	Bottom	16/08/2015	11:00	50	31	340	7	2	067	105
226	225	Benthic H	NIOZ	Bottom	16/08/2015	11:15	50	31	340	7	2	066	104
227	226	Benthic H	NIOZ	Bottom	16/08/2015	11:27	50	31	340	7	2	067	105
228	227	Benthic H	NIOZ	Bottom	16/08/2015	11:40	50	31	340	7	2	067	105
229	228	Benthic H	NIOZ	Bottom	16/08/2015	11:52	50	31	334	7	2	067	104
230	229	Benthic H	NIOZ	Bottom	16/08/2015	12:05	50	31	334	7	2	066	104
231	230	Benthic H	NIOZ	Bottom	16/08/2015	12:19	50	31	335	7	2	067	104
232	231	Benthic H	NIOZ	Bottom	16/08/2015	12:34	50	31	332	7	2	067	105
233	232	Benthic H	NIOZ	Bottom	16/08/2015	12:47	50	31	332	7	2	067	104
234	233	Benthic H	NIOZ	Bottom	16/08/2015	13:00	50	31	332	7	2	067	105
235	234	Benthic H	NIOZ	Bottom	16/08/2015	13:16	50	31	329	7	2	067	105
236	235	Benthic H	NIOZ	Bottom	16/08/2015	13:30	50	31	329	7	2	067	105
237	236a	Benthic H	NIOZ	Bottom	16/08/2015	13:42	50	31	329	7	2	067	105
238	236b	Benthic H	NIOZ	Bottom	16/08/2015	13:55	50	31	329	7	2	067	105
239	236c	Benthic H	NIOZ	Bottom	16/08/2015	14:07	50	31	329	7	2	067	106
240	236d	Benthic H	NIOZ	Bottom	16/08/2015	14:20	50	31	329	7	2	067	104

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
241	237	Benthic H	Megacorer	Bottom	16/08/2015	14:57	50	31	329	7	2	057	106
242	238	Benthic H	Megacorer	Bottom	16/08/2015	15:20	50	31	329	7	2	069	107
243	239	Benthic H	Megacorer	Bottom	16/08/2015	15:43	50	31	329	7	2	067	107
244	240	Benthic H	Megacorer	Bottom	16/08/2015	15:56	50	31	329	7	2	067	105
245	241	Benthic H	Megacorer	Bottom	16/08/2015	16:12	50	31	325	7	2	065	108
246	242	Benthic H	Megacorer	Bottom	16/08/2015	16:38	50	31	304	7	2	039	108
247	243	Benthic H	Megacorer	Bottom	16/08/2015	16:56	50	31	300	7	2	042	108
248	244	Benthic H	Megacorer	Bottom	16/08/2015	17:20	50	31	313	7	2	046	109
249	245		NO EVENT										
250	246		NO EVENT										
251	247		NO EVENT										
252	248	Benthic H	NIOZ	Bottom	16/08/2015	18:21	50	31	307	7	2	040	109
253	249	Benthic H	NIOZ	Bottom	16/08/2015	18:34	50	31	309	7	2	041	108
254	250	Benthic H	NIOZ	Bottom	16/08/2015	18:47	50	31	309	7	2	040	108
255	251	Benthic H	NIOZ	Bottom	16/08/2015	19:00	50	31	307	7	2	041	108
256	252	Benthic H	NIOZ	Bottom	16/08/2015	19:12	50	31	307	7	2	041	109
257	253	Benthic H	NIOZ	Bottom	16/08/2015	19:24	50	31	308	7	2	042	108
258	254	Benthic H	NIOZ	Bottom	16/08/2015	19:38	50	31	314	7	2	058	108
259	255	Benthic H	NIOZ	Bottom	16/08/2015	19:52	50	31	312	7	2	058	108
260	256	Benthic H	NIOZ	Bottom	16/08/2015	20:04	50	31	312	7	2	058	108
261	257	Benthic H	NIOZ	Bottom	16/08/2015	20:20	50	31	309	7	2	058	108
262	258	Benthic H	NIOZ	Bottom	17/08/2015	21:04	50	31	296	7	2	038	108
263	259	Benthic H	NIOZ	Bottom	17/08/2015	21:17	50	31	296	7	2	038	107
264	260	Benthic H	NIOZ	Bottom	17/08/2015	21:33	50	31	298	7	2	038	107
265	261	Benthic H	NIOZ	Bottom	17/08/2015	21:48	50	31	298	7	2	037	107
266	262	Benthic H	NIOZ	Bottom	17/08/2015	22:03	50	31	298	7	2	040	107
267	263	Benthic H	NIOZ	Bottom	17/08/2015	22:16	50	31	298	7	2	040	106
268	264	Benthic H	NIOZ	Bottom	17/08/2015	22:31	50	31	300	7	2	030	107
269	265	Benthic H	NIOZ	Bottom	17/08/2015	22:44	50	31	300	7	2	030	106
270	266	Benthic H	NIOZ	Bottom	17/08/2015	22:57	50	31	299	7	2	030	106
271	267	Benthic H	NIOZ	Bottom	17/08/2015	23:15	50	31	299	7	2	024	105
272	268	Benthic H	NIOZ	Bottom	17/08/2015	23:26	50	31	301	7	2	027	105
273	269	Benthic H	NIOZ	Bottom	17/08/2015	23:40	50	31	293	7	2	019	105
274	270	Benthic H	NIOZ	Bottom	17/08/2015	23:53	50	31	293	7	2	019	105

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
275	271	Benthic H	NIOZ	Bottom	18/05/2015	00:06	50	31	293	7	2	019	105
276	272	Benthic H	NIOZ	Bottom	18/05/2015	00:30	50	31	288	7	2	021	105
277	273	Benthic H	NIOZ	Bottom	18/05/2015	00:43	50	31	288	7	2	021	105
278	274	Benthic H	NIOZ	Bottom	18/05/2015	02:00	50	31	285	7	2	038	105
279	275	Benthic H	NIOZ	Bottom	18/05/2015	02:13	50	31	285	7	2	038	105
280	276	Benthic H	NIOZ	Bottom	18/05/2015	02:28	50	31	287	7	2	038	105
281	277	Benthic H	NIOZ	Bottom	18/05/2015	02:42	50	31	289	7	2	049	105
282	278	Benthic H	NIOZ	Bottom	18/05/2015	02:58	50	31	295	7	2	021	106
283	279	Benthic H	NIOZ	Bottom	18/05/2015	03:12	50	31	296	7	2	020	106
284	280	Benthic H	NIOZ	Bottom	18/05/2015	03:26	50	31	296	7	2	020	106
285	281	Benthic H	NIOZ	Bottom	18/05/2015	03:42	50	31	298	7	2	019	106
286	282	Benthic H	SPI	Start	18/05/2015	04:30	50	31	202	7	1	909	107
287	283	Benthic H	SPI	Start	18/05/2015	05:22	50	31	199	7	2	337	108
288	284	Benthic H & I	Autosub3	Start	18/05/2015	06:38	50	31	404	7	0	010	n/a
289	285	Benthic H	SPI	Start	18/05/2015	08:24	50	31	332	7	2	127	108
290	286	Benthic H	SPI	Start	18/05/2015	09:02	50	31	459	7	2	332	108
291	287	Benthic H	SPI	Start	18/05/2015	09:44	50	31	457	7	1	921	107
292	288	Benthic I	SPI	Start	18/05/2015	11:17	50	34	668	7	6	142	107
293	289	Benthic I	SPI	Start	18/05/2015	12:12	50	34	453	7	6	182	107
294	290	Benthic I	SPI	Start	18/05/2015	13:04	50	34	567	7	6	326	107
295	291	Benthic I	SPI	Start	18/05/2015	13:55	50	34	442	7	6	518	107
296	292	Benthic I	SPI	Start	18/05/2015	14:44	50	34	669	7	6	509	107
297	292b	Benthic H	UCCTD	Start	18/05/2015	16:06	50	31	230	7	1	560	107
298	293	Benthic H	CTD	Start	18/05/2015	17:10	50	31	240	7	1	970	108
299	294	Benthic H	CHEM SPI	n/a	18/05/2015	18:43	50	31	268	7	2	016	n/a
300	295	Benthic H	CHEM SPI	n/a	18/05/2015	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
301	296		NO EVENT										
302	297	Benthic H	NIOZ	Bottom	18/05/2015	21:04	50	31	265	7	2	014	108
303	298	Benthic H	NIOZ	Bottom	18/05/2015	21:18	50	31	265	7	2	015	108
304	299	Benthic H	NIOZ	Bottom	18/05/2015	21:30	50	31	265	7	2	015	107
305	300	Benthic H	NIOZ	Bottom	18/05/2015	21:44	50	31	262	7	2	014	107
306	301	Benthic H	NIOZ	Bottom	18/05/2015	21:57	50	31	262	7	2	015	107
307	302	Benthic H	NIOZ	Bottom	18/05/2015	22:11	50	31	260	7	2	014	107
308	303	Benthic H	NIOZ	Bottom	18/05/2015	22:25	50	31	260	7	2	014	107

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
309	304	Benthic H	NIOZ	Bottom	18/05/2015	22:37	50	31	260	7	2	014	107
310	305	Benthic H	NIOZ	Bottom	18/05/2015	22:50	50	31	257	7	2	014	106
311	306	Benthic H	NIOZ	Bottom	18/05/2015	23:04	50	31	267	7	2	012	106
312	307	Benthic H	NIOZ	Bottom	18/05/2015	23:18	50	31	274	7	2	016	106
313	308	Benthic H	NIOZ	Bottom	18/05/2015	23:32	50	31	272	7	2	017	105
314	309	Benthic H	NIOZ	Bottom	18/05/2015	23:46	50	31	272	7	2	017	105
315	310	Benthic H	NIOZ	Bottom	18/05/2015	23:58	50	31	272	7	2	017	105
316	311	Benthic H	NIOZ	Bottom	19/08/2015	00:13	50	31	272	7	2	017	105
317	312	Benthic H	NIOZ	Bottom	19/08/2015	00:28	50	31	269	7	2	017	105
318	313	Benthic H	NIOZ	Bottom	19/08/2015	00:41	50	31	270	7	2	017	105
319	314	Benthic H	NIOZ	Bottom	19/08/2015	00:55	50	31	269	7	2	017	105
320	315	Benthic H	NIOZ	Bottom	19/08/2015	02:06	50	31	272	7	2	026	105
321	316	Benthic H	NIOZ	Bottom	19/08/2015	02:19	50	31	272	7	2	026	105
322	317	Benthic H	NIOZ	Bottom	19/08/2015	02:36	50	31	269	7	2	027	105
323	318	Benthic H	NIOZ	Bottom	19/08/2015	02:49	50	31	269	7	2	025	105
324	319	Benthic H	NIOZ	Bottom	19/08/2015	03:03	50	31	269	7	2	025	105
325	320	Benthic H	NIOZ	Bottom	19/08/2015	03:17	50	31	267	7	2	024	106
326	321	Benthic H	NIOZ	Bottom	19/08/2015	03:30	50	31	266	7	2	024	106
327	322	Benthic H	NIOZ	Bottom	19/08/2015	03:46	50	31	264	7	2	024	106
328	323	Benthic H	NIOZ	Bottom	19/08/2015	03:59	50	31	263	7	2	022	106
329	324	Benthic H	NIOZ	Bottom	19/08/2015	04:11	50	31	263	7	2	022	106
330	325	Benthic H	NIOZ	Bottom	19/08/2015	04:25	50	31	261	7	2	022	107
331	326	Benthic H	NIOZ	Bottom	19/08/2015	04:39	50	31	260	7	2	022	107
332	327	Benthic H	NIOZ	Bottom	19/08/2015	04:54	50	31	258	7	2	024	107
333	328	Benthic H	NOC bedframe	Start	19/08/2015	08:21	50	31	243	7	2	040	108
334	329	Benthic H	CTD	Start	19/08/2015	09:35	50	31	05	7	2	33	107
335	330	Benthic I	UCCTD	Start	19/08/2015	12:12	50	34	56	7	6	29	107
336	331	Benthic I	CTD	Start	19/08/2015	13:05	50	34	56	7	6	29	107
337	332	Benthic I	SMBA	Bottom	19/08/2015	18:25	50	34	556	7	6	231	110
338	333	Benthic I	SMBA	Bottom	19/08/2015	18:42	50	34	557	7	6	231	110
339	334	Benthic I	SMBA	Bottom	19/08/2015	18:52	50	34	559	7	6	231	110
340	335	Benthic I	SMBA	Bottom	19/08/2015	19:03	50	34	560	7	6	232	111
341	336	Benthic I	SMBA	Bottom	19/08/2015	19:14	50	34	564	7	6	233	110
342	337	Benthic I	SMBA	Bottom	19/08/2015	19:28	50	34	566	7	6	232	111

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
343	338	Benthic I	NIOZ	Bottom	19/08/2015	20:27	50	34	566	7	6	233	110
344	339	Benthic I	NIOZ	Bottom	19/08/2015	20:42	50	34	566	7	6	233	110
345	340	Benthic I	NIOZ	Bottom	19/08/2015	20:53	50	34	566	7	6	233	110
346	341	Benthic I	NIOZ	Bottom	19/08/2015	21:07	50	34	567	7	6	230	110
347	342	Benthic I	NIOZ	Bottom	19/08/2015	21:20	50	34	566	7	6	231	110
348	343	Benthic I	NIOZ	Bottom	19/08/2015	21:35	50	34	569	7	6	231	110
349	344	Benthic I	NIOZ	Bottom	19/08/2015	21:49	50	34	569	7	6	231	110
350	345	Benthic I	NIOZ	Bottom	19/08/2015	22:03	50	34	572	7	6	231	109
351	346	Benthic I	NIOZ	Bottom	19/08/2015	22:15	50	34	572	7	6	234	109
352	347	Benthic I	NIOZ	Bottom	19/08/2015	22:31	50	34	574	7	6	233	109
353	348	Benthic I	NIOZ	Bottom	19/08/2015	22:43	50	34	575	7	6	233	109
354	349	Benthic I	NIOZ	Bottom	19/08/2015	22:57	50	34	576	7	6	233	108
355	350	Benthic I	NIOZ	Bottom	20/08/2015	00:32	50	34	576	7	6	234	107
356	351	Benthic I	NIOZ	Bottom	20/08/2015	00:44	50	34	576	7	6	234	108
357	352	Benthic I	NIOZ	Bottom	20/08/2015	00:57	50	34	577	7	6	235	108
358	353	Benthic I	NIOZ	Bottom	20/08/2015	01:09	50	34	576	7	6	236	107
359	354	Benthic I	NIOZ	Bottom	20/08/2015	01:26	50	34	580	7	6	236	107
360	355	Benthic I	NIOZ	Bottom	20/08/2015	01:38	50	34	580	7	6	235	107
361	356	Benthic I	NIOZ	Bottom	20/08/2015	01:52	50	34	580	7	6	235	107
362	357	Benthic I	NIOZ	Bottom	20/08/2015	02:04	50	34	580	7	6	235	107
363	358	Benthic I	NIOZ	Bottom	20/08/2015	02:20	50	34	582	7	6	235	107
364	359	Benthic I	NIOZ	Bottom	20/08/2015	02:33	50	34	582	7	6	235	107
365	360	Benthic I	NIOZ	Bottom	20/08/2015	02:49	50	34	585	7	6	235	107
366	361	Benthic I	NIOZ	Bottom	20/08/2015	03:01	50	34	585	7	6	235	107
367	362	Benthic I	NIOZ	Bottom	20/08/2015	03:14	50	34	585	7	6	236	107
368	363	Benthic I	NIOZ	Bottom	20/08/2015	03:29	50	34	588	7	6	236	107
369	364	Benthic I	NIOZ	Bottom	20/08/2015	03:42	50	34	588	7	6	236	107
370	365	Benthic I	NIOZ	Bottom	20/08/2015	06:30	50	34	593	7	6	236	109
371	366	Benthic I	NIOZ	Bottom	20/08/2015	06:46	50	34	590	7	6	235	110
372	367	Benthic I	NIOZ	Bottom	20/08/2015	06:59	50	34	591	7	6	235	110
373	368	Benthic I	NIOZ	Bottom	20/08/2015	07:14	50	34	590	7	6	235	110
374	369	Benthic I	NIOZ	Bottom	20/08/2015	07:30	50	34	596	7	6	235	110
375	370	Benthic I	NIOZ	Bottom	20/08/2015	07:44	50	34	596	7	6	235	110
376	371	Benthic I	NIOZ	Bottom	20/08/2015	08:00	50	34	596	7	6	235	110

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
377	372	Benthic I	NIOZ	Bottom	20/08/2015	08:11	50	34	596	7	6	235	110
378	373	Benthic I	NIOZ	Bottom	20/08/2015	08:27	50	34	601	7	6	235	110
379	374	Benthic I	NIOZ	Bottom	20/08/2015	08:41	50	34	601	7	6	235	110
380	375	Benthic I	NIOZ	Bottom	20/08/2015	08:53	50	34	601	7	6	235	110
381	376	Benthic I	NIOZ	Bottom	20/08/2015	09:08	50	34	602	7	6	235	110
382	377	Benthic I	NIOZ	Bottom	20/08/2015	09:20	50	34	601	7	6	235	110
383	378	Benthic I	NIOZ	Bottom	20/08/2015	09:32	50	34	601	7	6	234	110
384	379	Benthic I	NIOZ	Bottom	20/08/2015	09:48	50	34	609	7	6	242	110
385	380	Benthic I	NIOZ	Bottom	20/08/2015	10:01	50	34	609	7	6	241	109
386	381	Benthic I	NIOZ	Bottom	20/08/2015	10:12	50	34	610	7	6	242	110
387	382	Benthic I	NIOZ	Bottom	20/08/2015	10:26	50	34	615	7	6	242	110
388	383	Benthic I	NIOZ	Bottom	20/08/2015	10:37	50	34	615	7	6	242	109
389	384	Benthic I	NIOZ	Bottom	20/08/2015	10:49	50	34	615	7	6	241	108
390	385	Benthic I	NIOZ	Bottom	20/08/2015	11:01	50	34	615	7	6	242	109
391	386	Benthic I	CHEM SPI	Start	20/08/2015	12:24	50	34	567	7	6	304	107
392	387	Benthic I	Autosub3	Start	20/08/2015	15:50	50	35	928	7	5	847	n/a
393	388	Benthic I	CTD	Start	20/08/2015	19:12	50	34	57	7	6	30	110
394	389	Benthic I	NIOZ	Bottom	20/08/2015	20:38	50	34	568	7	6	301	111
395	390	Benthic I	NIOZ	Bottom	20/08/2015	20:51	50	34	568	7	6	301	110
396	391	Benthic I	NIOZ	Bottom	20/08/2015	21:07	50	34	571	7	6	300	109
397	392	Benthic I	NIOZ	Bottom	20/08/2015	21:23	50	34	575	7	6	302	111
398	393	Benthic I	NIOZ	Bottom	20/08/2015	21:38	50	34	577	7	6	302	110
399	394	Benthic I	NIOZ	Bottom	20/08/2015	21:54	50	34	580	7	6	303	110
400	395	Benthic I	NIOZ	Bottom	20/08/2015	22:09	50	34	582	7	6	302	110
401	396	Benthic I	NIOZ	Bottom	20/08/2015	22:23	50	34	586	7	6	301	110
402	397	Benthic H	CTD	Start	21/08/2015	06:07	50	31	02	7	1	77	107
403	398	Benthic I	Megacorer	Bottom	21/08/2015	11:51	50	34	56984	7	6	26406	108
404	399	Benthic I	Megacorer	Bottom	21/08/2015	12:05	50	34	56972	7	6	26310	108
405	400	Benthic I	Megacorer	Bottom	21/08/2015	12:30	50	34	56990	7	6	26346	108
406	401	Benthic I	Megacorer	Bottom	21/08/2015	13:03	50	34	57026	7	6	26388	107.4
407	402	Shelf break	CTD	Start	22/08/2015	07:30	48	30	82	9	44	90	253
408	403	Candyfloss	Glider	n/a	22/08/2015	08:50	48	31	343	9	44	408	n/a
409	404	Candyfloss	CTD	Start	22/08/2015	16:25	49	23	698	8	35	267	146
410	405	Candyfloss	Glider	n/a	22/08/2015	17:58	49	29	324	8	35	997	n/a

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
411	406	Candyfloss	UCCTD	Start	22/08/2015	18:24	49	24	40	8	36	0	147
412	407	Candyfloss	SMBA	Bottom	22/08/2015	19:32	49	24	35286	8	35	97840	147.6
413	408	Candyfloss	SMBA	Bottom	22/08/2015	19:46	49	24	35274	8	35	97816	148.4
414	409	Candyfloss	SMBA	Bottom	22/08/2015	20:01	49	24	35286	8	35	97882	148
415	410	Candyfloss	SMBA	Bottom	22/08/2015	20:23	49	24	35178	8	35	97330	147.9
416	411	Candyfloss	SMBA	Bottom	22/08/2015	20:38	49	24	35184	8	35	97354	147.6
417	412	Candyfloss	NIOZ	Bottom	22/08/2015	22:01	49	24	42114	8	35	92830	149
418	413	Candyfloss	NIOZ	Bottom	22/08/2015	22:15	49	24	42120	8	35	92728	148.7
419	414	Candyfloss	NIOZ	Bottom	22/08/2015	22:29	49	24	42102	8	35	92254	147.7
420	415	Candyfloss	NIOZ	Bottom	22/08/2015	22:43	49	24	42132	8	35	92240	147.3
421	416	Candyfloss	NIOZ	Bottom	22/08/2015	22:59	49	24	42126	8	35	92338	147.5
422	417	Candyfloss	NIOZ	Bottom	22/08/2015	23:11	49	24	42144	8	35	91846	147.1
423	418	Candyfloss	NIOZ	Bottom	22/08/2015	23:27	49	24	42132	8	35	91846	148.4
424	419	Candyfloss	NIOZ	Bottom	22/08/2015	23:42	49	24	42090	8	35	91912	147.3
425	420	Candyfloss	NIOZ	Bottom	22/08/2015	23:57	49	24	41916	8	35	91714	146.3
426	421	Candyfloss	NIOZ	Bottom	23/08/2015	00:22	49	24	41964	8	35	91516	146.6
427	422	Candyfloss	NIOZ	Bottom	23/08/2015	00:37	49	24	41940	8	35	91456	147.3
428	423	Candyfloss	NIOZ	Bottom	23/08/2015	00:54	49	24	41958	8	35	91060	147.4
429	424	Candyfloss	NIOZ	Bottom	23/08/2015	02:17	49	24	41910	8	35	90976	146.9
430	425	Candyfloss	NIOZ	Bottom	23/08/2015	02:33	49	24	41922	8	35	90500	146.9
431	426	Candyfloss	NIOZ	Bottom	23/08/2015	02:49	49	24	41772	8	35	90676	147
432	427	Candyfloss	NIOZ	Bottom	23/08/2015	03:04	49	24	41616	8	35	90680	145.5
433	428	Candyfloss	NIOZ	Bottom	23/08/2015	03:20	49	24	41604	8	35	90274	145.8
434	429	Candyfloss	SPI	Start	23/08/2015	04:44	49	24	24114	8	35	56884	146
435	430	Candyfloss	SPI	Start	23/08/2015	05:53	49	23	69550	8	35	57592	146
436	431	Candyfloss	NIOZ	Bottom	23/08/2015	06:46	49	24	419	8	35	899	146
437	432	Candyfloss	NIOZ	Bottom	23/08/2015	07:03	49	24	418	8	35	899	147
438	433	Candyfloss	NIOZ	Bottom	23/08/2015	07:17	49	24	418	8	35	890	147
439	434	Candyfloss	NIOZ	Bottom	23/08/2015	07:33	49	24	418	8	35	891	147
440	435	Candyfloss	NIOZ	Bottom	23/08/2015	07:51	49	24	419	8	35	891	147
441	436	Candyfloss	NIOZ	Bottom	23/08/2015	08:05	49	24	410	8	35	891	147
442	437	Candyfloss	NIOZ	Bottom	23/08/2015	08:20	49	24	418	8	35	892	147
443	438	Candyfloss	NIOZ	Bottom	23/08/2015	08:35	49	24	418	8	35	890	147
444	439	Candyfloss	NIOZ	Bottom	23/08/2015	08:50	49	24	418	8	35	892	148

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**STNNBR**	**SITE**	**Gear Description**	**Start or bottom time & location**	**Time**		**Latitude**			**Longitude**			**Seafloor depth**
2					**Date (UTC)**	**Time (UTC)**	**Degrees**	**Minutes (integer)**	**Minutes (decimals)**	**Degrees**	**Minutes (integer)**	**Minutes (decimals)**	**Uncorrected (m)**
445	440	Candyfloss	NIOZ	Bottom	23/08/2015	09:03	49	24	418	8	35	891	147
446	441	Candyfloss	NIOZ	Bottom	23/08/2015	09:19	49	24	417	8	35	888	148
447	442	Candyfloss	NIOZ	Bottom	23/08/2015	09:34	49	24	417	8	35	887	149
448	443	Candyfloss	NIOZ	Bottom	23/08/2015	09:50	49	24	417	8	35	887	148
449	444	Candyfloss	NIOZ	Bottom	23/08/2015	10:04	49	24	417	8	35	889	148
450	445	Candyfloss	NIOZ	Bottom	23/08/2015	10:17	49	24	417	8	35	888	149
451	446	Candyfloss	NIOZ	Bottom	23/08/2015	10:36	49	24	417	8	35	887	148
452	447	Candyfloss	NIOZ	Bottom	23/08/2015	10:43	49	24	417	8	35	888	148
453	448	Candyfloss	NIOZ	Bottom	23/08/2015	10:57	49	24	417	8	35	884	148
454	449	Candyfloss	CTD	Start	23/08/2015	11:28	49	24	417	8	35	883	147
455	450	Candyfloss	SmartBuoy	Bottom	23/08/2015	13:26	49	24	200	8	36	222	146
456	451	Candyfloss	NOC bedframe	Start	23/08/2015	17:07	49	23	971	8	35	854	n/a
457	452	Candyfloss	CTD	Start	23/08/2015	18:15	49	23	87	8	35	971	146
458	453	Candyfloss	SPI	Start	23/08/2015	19:21	49	23	69082	8	36	42978	146
459	454	Candyfloss	SPI	Start	23/08/2015	20:21	49	24	22236	8	36	41544	147
460	455	Candyfloss	SPI	Start	23/08/2015	21:28	49	23	93358	8	36	01596	147
461	456	Candyfloss	Agassi trawl	Start	23/08/2015	23:01	49	23	60292	8	36	14490	147.2
462	457	Candyfloss	Agassi trawl	Start	24/08/2015	00:12	49	23	89158	8	35	98836	147
463	458	Candyfloss	Agassi trawl	Start	24/08/2015	02:09	49	23	90206	8	36	07008	146
464	459	Benthic H	Autosub3	Start	24/08/2015	13:34	50	31	4976	7	0	065	n/a
465	460	Benthic I	NOC bedframe	Start	24/08/2015	16:10	50	34	502	7	6	318	108
466	461	Benthic I	Glider	n/a	24/08/2015	18:30	50	34	172	7	7	349	n/a
467	462	Benthic I	Glider	n/a	24/08/2015	18:35	50	34	172	7	7	349	n/a
468	463	Benthic I	CTD	Start	24/08/2015	18:54	50	34	107	7	6	170	n/a
469	464	Benthic A	Agassi trawl	Start	25/08/2015	05:32	51	12	61860	6	7	93254	104.1
470	465	Benthic A	Agassi trawl	Start	25/08/2015	06:59	51	12	87606	6	7	77672	104.9
471	466	Benthic A	NIOZ	Bottom	25/08/2015	08:42	51	12	60180	6	7	98552	105
472	467	Benthic A	NIOZ	Bottom	25/08/2015	09:00	51	12	60180	6	7	98552	105
473	468	Benthic G	Autosub3	Start	26/08/2015	13:19	51	5	78184	6	34	54272	n/a
474	469	Benthic H	Agassi trawl	Start	26/08/2015	20:09	50	31	29702	7	2	12106	101
475	470	Benthic H	Agassi trawl	Start	26/08/2015	21:22	50	31	35558	7	1	86666	101
476	471	Benthic H	Agassi trawl	Start	26/08/2015	22:30	50	31	34628	7	1	90662	106
477	472	Celtic Deep	Cefas lander	n/a	27/08/2015	17:13	51	8	050	6	34	755	n/a
478	473	Benthic H	Autosub3	Start	28/08/2015	21:20	51	11	045	6	7	730	n/a

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1	STNNBR	SITE	Gear Description	Start or bottom time & location	Time		Latitude			Longitude			Seafloor depth
2					Date (UTC)	Time (UTC)	Degrees	Minutes (integer)	Minutes (decimals)	Degrees	Minutes (integer)	Minutes (decimals)	Uncorrected (m)
479	474	Benthic G	UCCTD	Start	29/08/2015	06:16	51	4	365	6	34	850	100
480	475	Benthic A	CTD	Start	29/08/2015	16:27	51	13	820	6	8	033	107
481	476	Benthic I	CTD	Start	30/08/2015	05:01	50	34	348	7	6	244	112
482	477	East of Haig Fras	Guard Buoy	n/a									
483	478	East of Haig Fras	CTD	Start	30/08/2015	10:07	50	35	728	7	1	119	104
484	479	East of Haig Fras	Cefas lander	n/a	30/08/2015	11:54	50	35	578	7	1	210	n/a
485	480	Benthic I	Trawl	Start	30/08/2015	13:30	50	34	639	7	6	308	107
486	481	Benthic I	Trawl	Start	30/08/2015	14:48	50	34	828	7	5	959	109
487	482	Benthic I	Trawl	Start	30/08/2015	16:08	50	34	708	7	6	150	110
488	483	CS2	UCCTD	Start	31/08/2015	08:21	48	34	246	9	30	577	202
489	484	CS2	CTD	Start	31/08/2015	09:54	48	34	246	9	30	577	200
490	485	n/a	NIOZ	Bottom	31/08/2015	13:47	48	21	467	9	41	173	1032
491	486	n/a	NIOZ	Bottom	31/08/2015	14:47	48	21	467	9	41	175	1042
492	487	n/a	Gravity core	Bottom	01/09/2015	16:31	50	13	357	4	11	350	n/a
493	488	n/a	Gravity core	Bottom	01/09/2015	16:48	50	13	357	4	11	350	n/a