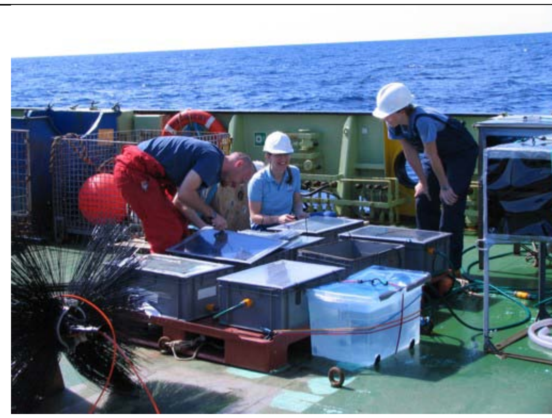
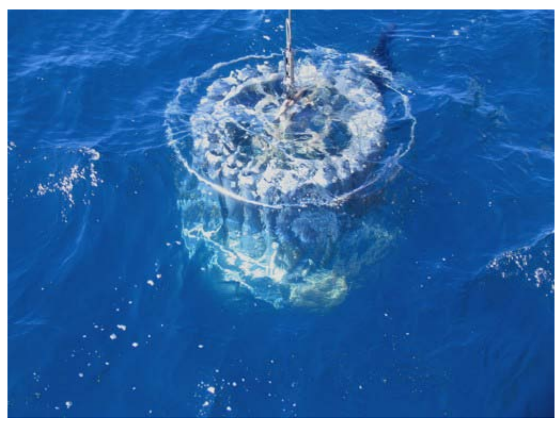
D352



Final Report



2nd June-26th June 2010

Celtic Sea Physics and Biogeochemistry

Jonathan Sharples

University of Liverpool

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1. Introduction.

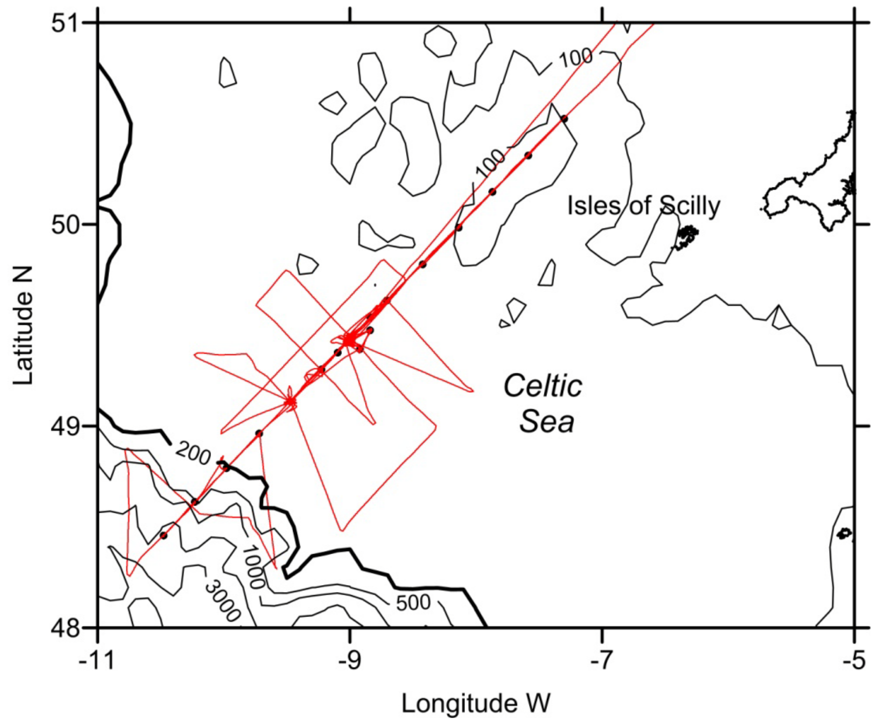
RRS Discovery cruise D352 was supported as part of a NERC Responsive Mode research project (“A Thermocline Nutrient Pump”, NE/F002432/1) awarded to Bangor University (Dr. Tom Rippeth) and the Proudman Oceanographic Laboratory (Prof. Jonathan Sharples, now at the University of Liverpool).

The focus of the project, and the cruise, is on the effects of wind stress at the sea surface driving inertial oscillations, and so causing shear and mixing across the thermocline of seasonally-stratified shelf seas. The inertial shear is thought to interact with shear set up by the tidal currents, leading to pulses of mixing at the base of the thermocline. The project also aims to investigate the mixing in the context of supplying nutrients to the sub-surface layer of phytoplankton commonly seen within the shelf seas in summer, and to assess any possible shifts in the phytoplankton ecology as a response to the supply of nutrients.

The cruise was planned around the use a free-fall turbulence profilers (Bangor University’s VMP500 and NOC’s VMP750) to measure rates of turbulent dissipation, moored instrumentation (ADCPs, temperature and chlorophyll loggers, McLane RAS water samplers, and meteorological sensors), long transects using Scanfish and the vessel hull-mounted ADCPs, and experiments on the water column biogeochemistry.

The cruise was very successful. Initially calm weather allowed all of the moorings to be deployed easily, and then 2 strong wind events (generally northerly force 7) passed through the region allowing intense work with the turbulence profilers to make the key measurements of the vertical turbulent mixing. While both profilers eventually succumbed to damage as a result of recoveries during poor sea states, the data collected was of very high quality and clearly showed the spikes in thermocline mixing that we were looking for. The parallel biogeochemistry experiments showed a response in the nutrient distributions, in particular with the nitracline being raised within the thermocline as a result of the mixing and a reduction in primary production (i.e. wind events tend to be cloudy).

2. Cruise Map.



Detail of the cruise track within the Celtic Sea.

3. D352 Cruise Narrative.

All times are ship time (BST)

2nd June (Wednesday)	
0900	Depart King George V dock, Clyde.
	Begin steam to Liverpool Bay.
1415	Shake-down CTD, CTD001.
	All sensors look fine. Sampled for salinities.
1615	Muster and boat drill.
3rd June (Thursday)	
0330	CTD002 Liverpool Bay
	SAPS, Day grabs, bongo net hauls.
0845	Begin steam to western Irish Sea.
1315	Begin mooring deployment in western Irish Sea
1324	Surface torroid in water.
1330	Torroid anchor away at 53° 45.08'N, 05° 29.92'W, depth=105m
1338	ADCP lander away at 53° 45.18'N, 05° 29.70'W, depth=104m
1410	CTD003, sampled for full nutrient profile.
1445	Begin steam to Celtic Sea IM1 position
	Weather: flat calm, sunny.
4th June (Friday)	
1630	CTD004 at IM2. Not sampled.
	Head for IM1.
1730	CTD005
1830	IM1 mooring deployment starts
2011	Toroid anchor away 49° 25.31'N, 08° 58.88'W, d=140m
2025	ADCP lander away 200m from toroid

	Heave-to – wait for pre-dawn CTD.
	Weather: wind 5-10 knots S'ly, slight swell, sunny.
5th June (Saturday)	
0330	CTD006 pre-dawn IM1
	SAPS, grabs, bongos. [SAPS wire found to be marked at 25m rather than 20m intervals, so both SAPS likely sampling below thermocline].
1115	IM1 mooring deployment continues – 2 guard buoys and 1 sub-surface ADCP (1136: 49° 25.1'N, 08° 59.2'W).
	NB: depths are all significantly deeper than inferred from the chart.
1145	IM1 complete. Steam to IM2.
1415	IM2 toroid anchor away: 49 27.92'M, 08 49.96'W, d=149m.
1423	IM2 ADCP lander away: 49 27.86'N, 08 50.10'W, d=148m
	Steam to IM3
1618	Toroid anchor away: 49 22.34'N, 08 54.77'W, d=136m
1627	ADCP lander away: 49 22.24'N, 08 55.02'W, d=137m
1649	Guard buoy away.
	Steam to 49 14.0'N, 09 17.7'W to begin Scanfish.
1900	Begin Scanfish deployment.
1915	Scanfish in water, paying out cable.
1945	Undulating to 100m.
	T and S obviously incorrect – likely cal file problem.
	Weather: wind < 5 knots, slight swell.
6th June (Sunday)	
0010	Scanfish recovered.
	Steam to IM1.
0330	CTDs 007, 008, 009.
0740	CTD009 complete.
0950	CTD010 for Scanfish calibration

	Scanfish lowered vertically (file: Scanfish_calib_1).
1040	Scanfish recovered.
	CTD011 for Scanfish calibration.
1135	T-Chl chain deployed.
1150	Vessel on NE-ward course past mooring IM1.
1500	Turn to tow SW-ward back to IM1.
1845	VMP first cast.
	Weather: NW 10-15 knots, sunny, am. Decreasing SW 5 – 10 knots pm.
7th June (Monday)	
0530	VMP paused for CTD012.
	VMP continues.
1610	CTD013
2320	CTD014
	Weather: SSW 25-30 knots, rain. Wind reduces to 15-20 knots, cloud clearing during morning. Wind shifting the W'ly during evening.
8th June (Tuesday)	
	Overnight patchy communication problems with the VMP.
0515	CTD015
2100	VMP finished.
2135	CTD016
	Tow T-Chl chain IM1-IM3-IM2-IM1
	Weather: W'ly 10-15 knots, moderate swell, showers, am. W'ly 5 knots , moderate swell, increasingly sunny pm.
9th June (Wednesday)	
0330	CTD017 IM1, SAPS (3), grabs, bongos.

0830	T-Chl chain recovered.
1230	CTD018 to 60m to collect DCM and surface water.
1315	Subs ADCP released.
1330	Subs ADCP recovered. ADCP swapped.
1430	Subs ADCP redeployed.
1700	CTD019
1800	VMP deployed.
	Weather: N'ly 10 knots, slight swell, sunny am; N'ly 15-20 knots pm; NE'ly 15-20 knots, slight swell evening.
10th June (Thursday)	
0200	CTD020
0530	CTD021
1315	CTD022
2100	VMP failure. Poor data and communication problems. VMP recovered for investigation. Station suspended. NOC VMP to be set up and Bangor VMP to be taken apart and checked (found some water had got in and shorted the power supply).
2315	CTD023
	Weather: NNE'ly 15-20 knots, slight swell, mainly cloudy am; NNE'ly 25 knots, moderate sea midday; NNE'ly 25-30 knots, rough sea pm
11th June (Friday)	
	NOC VMP750 set up, along with NOC hydraulic power unit and line thrower.
1100	CTD024
1200	VMP profiling begins with NOC VMP750
2115	CTD025, including 2 minute stops for ADCP data during upcast.

	Weather: N'ly 15-20 knots, moderate sea am; N'ly 20 knots, moderate sea pm; N'ly 15 knots, slight/moderate sea, evening.
12th June (Saturday)	
0250	VMP750 recovered
0330	CTDs 026, 027, 028 for water collection.
0900	Scanfish deployed.
	Towing though: 49 20.0'N, 10 12.7'W
	48 58.68'N, 10 00.0'W
	to SW3.
	Weather: N'ly 20 knots, slight sea, patchy sun am; N'ly 10-15 knots, slight sea, sunny pm.
13th June (Sunday)	
0200	Scanfish recovered.
0330	CTD029 Pre-dawn, SAPS, grabs, bongos.
1230	CTD030 to collect water from thermocline.
1330	Scanfish deployed to run: 49 20.0'N, 10 12.7'W to 49 21.0'N, 09 49.0'W to SW3.
2200	Recover Scanfish.
2300	CTD031
	Weather: WNW'ly 15-20 knots, slight/moderate sea, cloudy am; NW'ly 25-30 knots, rough sea pm; NW'ly 35 knots, rough evening.
14th June (Monday)	
0000	VMP station begins. Try Bangor VMP first. Fails.
	NOC VMP deployed. Good profiles, but on recovery prior to vessel re-

	positioning VMP takes a big knock against the vessel. Conductivity cell crushed. Water also leaked into the pressure housing. No more VMP work likely. Both instruments have taken in a small amount of water which appears to have blown a main sensor board.
0900	CTD032
1100	CTD033
1230	CTD034
1400	CTD035
1530	CTD036
1700	CTD037
1815	Scanfish deployed.
1845	On survey course. Heading through: 48° 28.7'N, 09° 04.0'W 48° 58.4'N, 08° 19.0'W 49° 45.7'N, 09° 28.7'W 49° 36.0'N, 09° 43.7'W 49° 00.3'N, 08° 49.1'W to IM1. Weather: N'ly 25-30 knots, rough sea am; N'ly 20-25 knots, rough sea pm;
15th June (Tuesday)	
0930	IM3 mooring spotted. IM1 visible on radar.
1020	Pass close to IM1 toroid. Weather: NE'ly 20-25 knots, rough sea, sunny am; N'ly 15 knots, slight sea, sunny pm.
16th June (Wednesday)	
0130	Scanfish recovered.
0330	CTD038

0430	CTD039
	Steam to NE2
0745	CTD040 at NE2
0950	CTD041 at NE3
1150	CTD042 at NE4
1400	CTD043 at NE5
1600	CTD044 at NE6
1815	CTD045 at NE7
	Steam back to IM1.
	Weather: N’ly 10 knots, clear skies, calm sea am; NE’ly 10-15 knots, calm sea, clear skies pm.
17th June (Thursday)	
0430	CTD046 at IM1
0800	Begin deployment of pump hose to 50 metres.
1020	Begin sampling from pump at 45 metres. Sample every 1 metre, waiting 7 minutes each time for flow to get through hose length.
1630	End pump sampling.
1800	Deploy Scanfish at IM1 to tow through 49° 09.5’ N, 08° 02.0’ W, NE2, to IM1 overnight.
	Weather: N’ly 10-15 knots, slight sea am; N’ly 10 knots, sunny, slight sea pm.
18th June	
(Friday)	Scanfish recovered
0600	CTD047 at IM1
0800	IM2 mooring recovery begins.
0915	Toroid recovered.
0945	All toroid mooring on deck.
1055	ADCP lander recovered.
1150	IM3 toroid on deck

1445	IM3 ADCP lander recovered.
1710	Heave to by IM1 for the night.
	Weather: NW'y 10 knots, slight sea and swell, sunny am; NW'ly 10 knots, slight sea and swell, hazy cloud pm.
19th June (Saturday)	
0600	CTD048
0745	CTD049
0830	Begin IM1 mooring recoveries.
	Guard buoys recovered first.
1130	Sub-surface ADCP on deck.
1315	ADCP lander on deck,
1345	Toroid on deck.
1500	Recoveries complete.
	Steam for SW2.
2130	CTD050 at SW2
2320	CTD051 at SW3
	Weather: N'ly 10 knots, slight sea and swell, cloudy am; NNE'ly 15-20 knots, slight/moderate sea, sunny pm;
20th June (Sunday)	
0120	CTD052 at SW4
0330	CTD053 at SW5 (pre-dawn)
0510	CTD054 at SW5
	SAPS, bongos
1315	CTD055 at SW6
1545	CTD056 at SW7
1850	Begin T-Chl chain tow back across towards shelf edge.

	Weather: NE'ly 5 knots, sunny, calm sea, slight swell; wind < 5 knots, smooth sea, slight swell, sunny pm.
21st June (Monday)	
0530	T-Chl chain recovered.
0600	CTD057
1100	Scanfish deployed. Data drops during deployment, but appears fine once the winch has finished veering cable out – assume a problem with the slip rings.
	Weather: light winds, calm seas, mostly sunny all day.
22nd June (Tuesday)	
0000	Make turn onto final long transect.
0530	Cross shelf edge.
2030	Short service held to put ashes of Michael Eric Glasher into the sea.
2345	Scanfish loses communication.
	Scanfish recovered 50° 38.0'N, 07° 06.0'W – likely re-termination required.
	Continue towards the Irish Sea.
	Weather: S'ly 10 knots, sunny am; S'ly 10 knots, patchy cloud pm.
23rd June (Wednesday)	
1500	Heave to off Fishguard to get TV reception for the England-Slovenia match and fix Scanfish.
2130	Continue steam to Irish Sea site 53° 0.0'N, 05° 11.0'W.
	Weather: SW'ly 10-15 knots, cloudy, calm/slight sea.

24th June (Thursday)	
0330	CTD058, SAPs, bongos, grabs.
1015	CTD059 to 60 metres only for a PAR profile.
1115	Scanfish deployed. Towing back through: 51° 55.0'N, 05° 52.0'W 51° 19.0'N, 06° 10.0'W to 50° 38.0'N, 07° 06.0'W Weather: W'ly 10 knots, calm sea, patchy cloud am; SW'ly 10 knots, sunny, slight swell pm.
25th June (Friday)	
0500	Scanfish recovered. Begin steam back to Avonmouth. Dolphins all over the place. Weather: S'ly 5 knots, hazy sun, calm am;

4. D352 CTD Acquisition and Processing (Jo Hopkins and Dave Teare)

A Seabird electronics 911 *plus* CTD (SBE 9 instrument, 11 *plus* deck unit), attached to a rosette with 24 x 10 litre Niskin bottles was deployed throughout the cruise. The CTD system comprised of the following equipment: Seabird 911+ CTD with dual pumped temperature and conductivity sensor pairs; a Seabird SBE43 dissolved oxygen sensor; Seabird SBE32 carousel with twenty-four OTE, externally sprung, ten litre water bottles; upward and downward looking TRDI 300 KHz workhorse ADCPs; Chelsea Instruments' Alphatracka transmissometer (10cm path length) and Aquatracka (fluorometer); a Tritech P200 altimeter; upward and downward looking 2 pi par light sensors (PML design); an IOS 10 KHz pinger and a Sonardyne location beacon. The secondary pair of temperature\conductivity sensors were mounted on the stabilisation vane the other pair, with the oxygen sensor, were mounted conventionally onto the CTD body. After the third cast the 300 KHz ADCPs were removed and a single downward looking high frequency ADCP fitted. See elsewhere in the report for information on this.

The CTD was interfaced with: a Chelsea Aquatracka 3 fluorometer to measure chlorophyll concentration; a Chelsea transmissometer for beam attenuation and transmission; a SeaBird 43 optode for oxygen concentration and saturation; and upward and downward looking PAR sensors designed and made by Plymouth Marine Laboratory.

In total 59 casts were taken on cruise D352. Dates, times and locations of each cast can be found in the table of station listings and maps of cast locations.

Station List

Depths are nominal and as recorded by CTD operator. Latitude and longitude are as recorded in the .cnv files and are taken from the NMEA feed. Time (GMT) as recorded in .cnv file.

CTD station	Date	Time (GMT)	Nominal Depth (m)	Latitude	Longitude
ctd001	02-Jun-10	13:11:47	100	55 27.58 N	005 01.92 W
ctd002	03-Jun-10	02:15:57	48	53 36.32 N	003 50.96 W
ctd003	03-Jun-10	13:06:16	105	53 45.31 N	005 29.82 W
ctd004	04-Jun-10	15:31:21	129	49 29.00 N	008 53.79 W
ctd005	04-Jun-10	16:36:44	137	49 25.58 N	008 58.47 W
ctd006	05-Jun-10	02:38:15	137	49 25.11 N	008 59.47 W

ctd007	06-Jun-10	02:31:40	142	49 25.12 N	008 58.16 W
ctd008	06-Jun-10	04:40:44	146	49 24.27 N	008 59.16 W
ctd009	06-Jun-10	06:19:12	137	49 24.00 N	009 00.34 W
ctd010	06-Jun-10	08:47:36	137	49 24.70 N	009 00.43 W
ctd011	06-Jun-10	09:41:02	137	49 25.00 N	009 00.63 W
ctd11a	06-Jun-10	09:58:54	137	49 25.09 N	009 00.67 W
ctd012	07-Jun-10	04:55:00	125	49 27.31 N	008 58.44 W
ctd013	07-Jun-10	15:06:38	133	49 25.80 N	008 59.63 W
ctd014	07-Jun-10	22:21:32	127	49 26.34 N	008 58.71 W
ctd015	08-Jun-10	04:12:44	127	49 26.80 N	008 58.15 W
ctd016	08-Jun-10	20:31:47	139	49 24.50 N	009 00.41 W
ctd017	09-Jun-10	02:35:24	135	49 25.55 N	008 59.73 W
ctd018	09-Jun-10	11:30:02	136	49 25.07 N	008 59.72 W
ctd019	09-Jun-10	15:50:11	137	49 25.57 N	009 00.32 W
ctd020	10-Jun-10	01:09:21	144	49 24.42 N	008 59.26 W
ctd021	10-Jun-10	04:24:08	136	49 26.05 N	008 57.35 W
ctd022	10-Jun-10	12:13:08	133.5	49 25.83 N	008 59.68 W
ctd023	10-Jun-10	22:09:54	133.5	49 25.53 N	009 00.88 W
ctd024	11-Jun-10	09:58:49	142	49 24.64 N	008 58.33 W
ctd025	11-Jun-10	20:04:10	134	49 25.88 N	009 00.04 W
ctd026	12-Jun-10	02:19:49	146.5	49 24.59 N	008 59.15 W
ctd027	12-Jun-10	04:30:44	137	49 24.91 N	008 57.84 W
ctd028	12-Jun-10	05:56:54	133	49 24.33 N	008 57.62 W
ctd029	13-Jun-10	02:28:23	159	49 06.94 N	009 27.42 W
ctd030	13-Jun-10	11:30:42	159.5	49 03.84 N	009 28.93 W
ctd031	13-Jun-10	22:03:40	159.5	49 07.05 N	009 29.07 W
ctd032	14-Jun-10	08:07:15	161	49 06.25 N	009 29.63 W
ctd033	14-Jun-10	10:04:53	157	49 06.22 N	009 25.73 W
ctd034	14-Jun-10	11:24:28	157	49 06.53 N	009 27.22 W
ctd035	14-Jun-10	12:59:15	158.5	49 06.93 N	009 28.46 W
ctd036	14-Jun-10	14:33:25	158.5	49 07.57 N	009 28.10 W
ctd037	14-Jun-10	15:59:43	161	49 07.90 N	009 27.68 W
ctd038	16-Jun-10	02:27:39	137	49 24.72 N	008 59.96 W
ctd039	16-Jun-10	04:22:53	122	49 25.98 N	009 02.06 W
ctd040	16-Jun-10	06:43:56	139	49 36.80 N	008 41.79 W
ctd041	16-Jun-10	08:48:07	143	49 47.40 N	008 24.95 W
ctd042	16-Jun-10	10:46:30	130	49 58.25 N	008 08.13 W
ctd043	16-Jun-10	12:56:52	99.5	50 08.93 N	007 52.13 W
ctd044	16-Jun-10	15:01:59	100	50 19.68 N	007 35.17 W
ctd045	16-Jun-10	17:10:41	106	50 31.02 N	007 17.94 W

ctd046	17-Jun-10	03:53:29	132	49 25.16 N	009 00.49 W
ctd047	18-Jun-10	06:57:24	137	49 25.52 N	009 00.52 W
ctd048	19-Jun-10	04:59:23	134	49 25.33 N	009 00.69 W
ctd049	19-Jun-10	06:32:13	122	49 26.05 N	009 02.22 W
ctd050	19-Jun-10	20:32:27	147	49 16.24 N	009 12.89 W
ctd051	19-Jun-10	22:20:16	147	49 06.81 N	009 27.34 W
ctd052	20-Jun-10	00:18:06	167	48 57.32 N	009 42.39 W
ctd053	20-Jun-10	02:26:24	189	48 46.98 N	009 58.00 W
ctd054	20-Jun-10	04:10:30	191	48 46.82 N	009 58.58 W
ctd055	20-Jun-10	12:14:00	558	48 37.29 N	010 13.20 W
ctd056	20-Jun-10	14:47:10	1844	48 26.89 N	010 27.71 W
ctd057	21-Jun-10	05:12:00	156	48 57.41 N	009 42.61 W
ctd058	24-Jun-10	02:34:24	104	52 59.96 N	005 10.96 W
ctd059	24-Jun-10	09:21:15	120	53 06.96 N	005 12.69 W

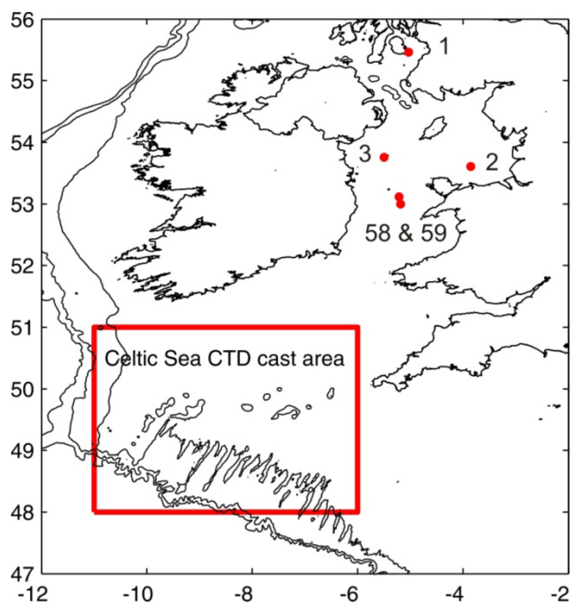


Figure 4.1 Location of casts 1-3 and 58-59. Black contours mark the 150m, 500m and 1000m isobaths.

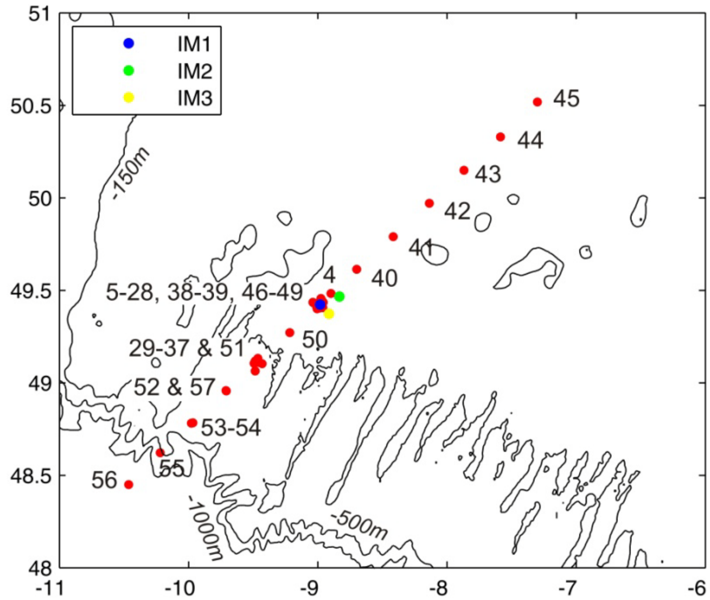


Figure 4.2 Map of Celtic Sea CTD casts. Black contours mark the 150m, 500m and 1000m isobaths.

Data Acquisition

CTD casts were recorded using the SeaBird data collection software SeaSave-Win32. The software output four files in the form ctd*nnn* (*nnn*= cast number) with the following extension:

- .hex (raw data file)
- .CON (configuration file)
- .bl (a record of bottle firing locations)
- .hdr (header file)

These were backed up onto the ships network.

Data Processing

The following SeaBird Software Processing, Version 7.18c (SBEDataProcessing-Win32) steps were performed.

<u>DatCnv:</u> A conversion routine to read in the raw CTD data file (.hex) containing data in engineering units output by the CTD hardware. Calibrations as appropriate through the instrument configuration file (.CON) are applied.

Data Setup options were set to the following:

Process scans to end of file: yes

Scans to skip: 0

Output format: ascii

Convert data from: upcast and downcast

Create file types: both bottle and data

Source of scan range data: bottle log .BL file

Scan range offset: -2.5 seconds

Scan range duration: 5 seconds

Merge separate header file: no

Selected output variables were:

- Scan count & Time elapsed (secs)
- Pressure, digiquartz (db)
- Primary and secondary temperature (ITS-90 °C) & temperature difference (2-1). (n.b. Primary and secondary sensors refer to CTD package instruments)
- Primary and secondary conductivity (S/m) & conductivity difference (2-1)
- Oxygen voltage, SBE 43 (V), oxygen concentration (ml/l), oxygen concentration (umol/kg), oxygen saturation (%)
- Beam attenuation (1/m) & beam transmission (%)
- Fluorescence (ug/l)
- Primary and secondary salinity (PSS-78)

- Density (kg/m^3) and sigma theta (kg/m^3)
- PAR/irradiance -up and down-welling (voltage channels 4 and 5 respectively)

A hysteresis correction using a window size of 2 seconds was made to the Oxygen. Two output files are generated: ctd*nnn*.cnv, a file including both the up and down casts, and ctdnnn.ros, a bottle file containing information from the instant each bottle was fired.

The header in each .cnv file was checked to ensure that the Station Number and Depth had been recorded. Any missing information was filled in.

Bottle Summary: Creates a file ctd*nnn*.btl with average, standard deviation, min and max values at bottle firings.

Data Setup options were set as follows:

Output min/max values for averaged variables: yes

Select Averaged Variables: All except time elapsed, scan counts and PAR

Select Derived Variables: Oxygen, salinity and density already selected in DatCnv so no others added

WildEdit: A program to remove pressure spikes. The data in ctd*nnn*.cnv is scanned twice and the standard deviation of a set number of scans is calculated. Values outside a set number of standard deviations of the mean are marked as bad.

The following settings were used:

Scan range: 100 scans

Standard deviation, pass 1: 2

Standard deviation, pass 2: 20

Exclude scans marked as bad: yes

Select WildEdit variables: pressure only

Output written to ctd*nnn*_We_.cnv.

Filter was run on the pressure channel to smooth out high frequency data (Low pass filter time constant set to 0.15 seconds).

Output written to ctd*nnn*_We_Ft.cnv.

AlignCTD was used for oxygen alignment. Through testing of casts 12, 50 and 56 (deep cast) for corrections of +2, +5, +6, +7 and +8 seconds a +7 second adjustment was determined to be optimal and applied to all casts.

Since the SBE deck unit was set to advance both the primary and secondary conductivity by +1.75 scans (equivalent to 0.073 seconds at 24Hz) no alignment was performed for conductivity.

Output written to ctd*nnn*_We_Ft_Al.cnv.

CellTM: The Cell Thermal Mass program removes the effect of thermal 'inertia' on the conductivity cells. The thermal anomaly amplitude α was set to 0.03 and the thermal anomaly time constant $1/\beta$ to 7 for both cells.

Output written to ctd*nnn*_We_Ft_Al_Ctm.cnv.

Loopedit: Flagging of scans where pressure slows down or reverses and identification and flagging of the surface soak.

Minimum velocity type: Fixed minimum velocity

Minimum CTD velocity: 0 m/s

Remove surface soak: Yes

Use deck pressure as pressure offset: No

Exclude scans marked as bad: Yes

The surface soak depth, minimum surface soak and maximum surface soak were determined from visual inspection of the data.

Output written to ctd*nnn*_We_Ft_Al_Ctm_Le.cnv.

n.b. No soak was removed from cast 11a. Recording began at approx. 2.5 db, the CTD was held at this depth for 40 seconds and then lowered.

Derive: This is run once all the adjustments to the data have been made. The final oxygen, salinity and density values etc are determined.

Derived variables selected:

Oxygen concentration (ml/l), oxygen saturation (%), oxygen concentration (umol/kg)

Salinity primary and secondary (PSS-78)

Density (kg/m^3) & Density (sigma-theta, kg/m^3)

Output written to ctd*nnn*_We_Ft_Al_Ctm_Dr.cnv (original channels remain).

BinAverage: This program was run to average the 25Hz data into 1db and 2db bins. This was output to ctd*nnn*_We_Ft_Al_Ctm_Dr_1db.cnv and ctd*nnn*_We_Ft_Al_Ctm_Dr_2db.cnv

Bin Type	Pressure, db
Bin Size	1 or 2
Include No. of scans per bin	No
Exclude scans marked as bad	Yes
Scans to skip over	0
Cast to process	Up and down

CTD Problems

During the data processing a problem with the quality of CTD data was noted. Large spikes in the temperature profile were seen as the CTD passed through the pycnocline (Figure 4.3). This was a feature of both the primary and secondary sensors and a feature also noted in the conductivity.

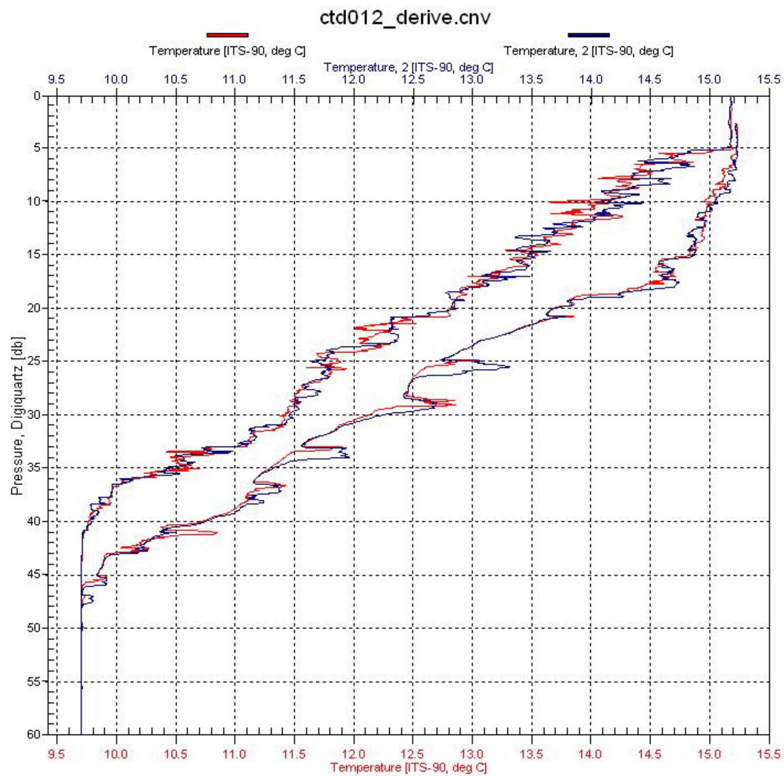


Figure 4.3 Primary and secondary temperature sensors both recording large warm anomalies through the thermocline.

The spikes appear to be associated with a decrease in the decent rate of the CTD package (see figure 4.4) and are therefore likely associated with inefficient flushing of the CTD package. This is similar problem to that encountered on cruise CD173 (Charles Darwin 2005). As the veer rate on the winch slows 'old' water is pushed back passed the sensors out the base of the rosette. As the rate of decent increases again 'new' water is flushed back passed the sensors.

Given that these spikes disrupt at times up to 2 m of the profile averaging over 1db pressure bins will not always remove the signal (Figure 4.5). Interpretation of these features and those appearing in the salinity profile should therefore be treated with caution.

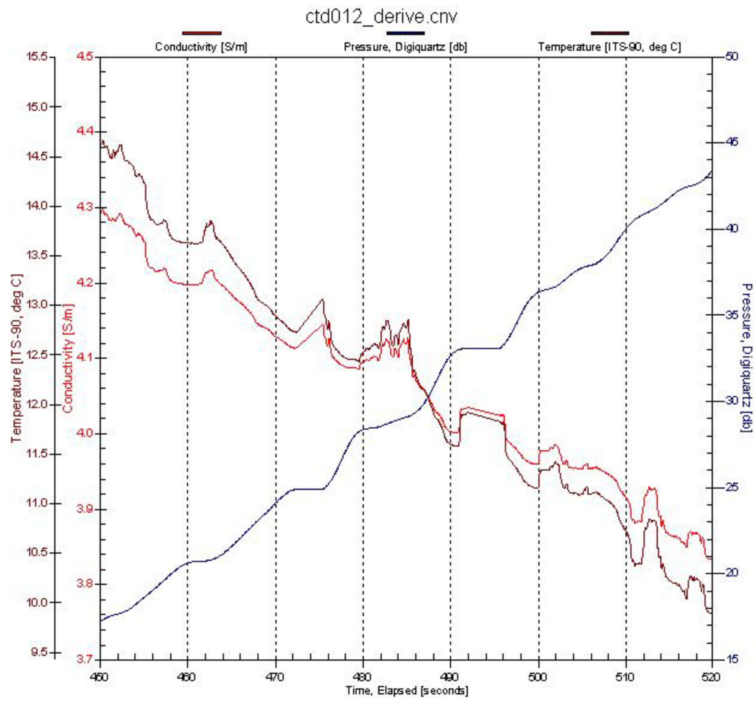


Figure 4.4. Time vs temperature, conductivity and pressure through the thermocline. Note the temperature and conductivity spiking at times when the CTD decent rate has slowed/stopped.

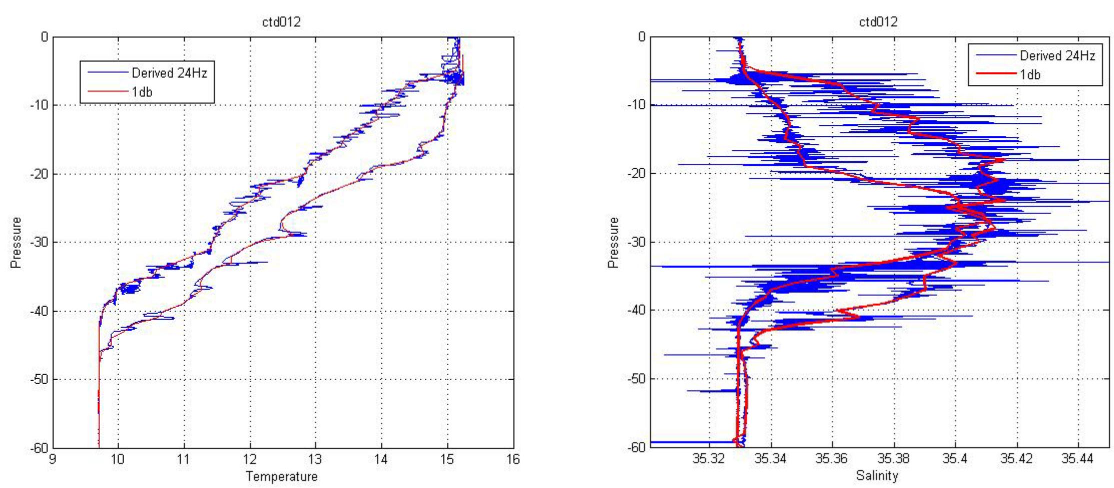


Figure 4.5. 24Hz temperature and salinity profiles (blue) and 1db averaged (red) data.

Further observations: The fluorescence channel on casts 58 and 59 is very noisy suggesting a problem with the sensor.

Calculation of derived variables

- Salinity and density were calculated using formulas from '*N.P Fofonoff and R.C. Millard. UNESCO technical papers in marine science #44, 1983'*.

- Oxygen (ml/l) and oxygen percent saturation were calculated as described in '*Application Note 64: SBE 43 Dissolved Oxygen Sensor'*.

- Oxygen (um/kg) was calculated as follows:

  Oxygen [um/kg] = (44660 / (sigma-theta + 1000)) * oxygen [ml/l]

- Beam attenuation (c) was calculated from the light transmission (%) as follows:

  c = -(1/z) * ln (light transmission [decimal]),

  where light transmission [decimal] is light transmission (%) divided by 100. See *'SBE Application Note 7: Calculation of Calibration Coefficients for Sea Tech, Chelsea (Alphatracka), and WET Labs Cstar Transmissometers'*.

Instrument Configuration- Calibration

Instrument calibration dates and serial numbers taken from the CTD configuration file (supplied to BODC).

Sensor	**Serial Number**	**Calibration date**
SeaBird 9 temperature sensor (1)	4151	27 February 2010
SeaBird 9 temperature sensor (2) – mounted on the vane	4872	31 March 2010
SeaBird 9 conductivity sensor (1)	3272	25 February 2010
SeaBird 9 conductivity sensor (2) – mounted on the vane	3258	31 March 2010

Digiquartz pressure sensor with TC	90573	20 October 2008
SeaBird 43 Oxygen sensor – mounted on the CTD	1624	9 April 2010
Fluorometer, Chelsea Aqua 3	88-2050-095	19 January 2009
PAR/Irradiance (1) upwelling	07	11 October 07
PAR/Irradiance (2) downwelling	06	26 October 07
Transmissometer, Chelsea	161050	7 November 2005

Salinity Calibration

Water samples for salinity calibration were collected by NMF at most sites. A total of 107 samples were analyzed using a Guildline Autosal salinometer (S/N 68958) against standard seawater. Using all 107 samples, the mean and standard deviation of residuals for the primary and secondary sensors are 0.0057 ± 0.016 and 0.020 ± 0.017 respectively.

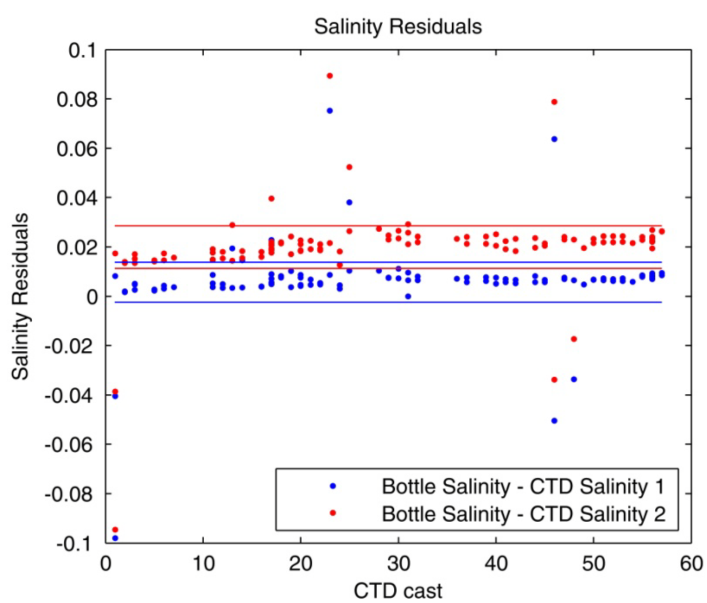


Figure 4.6 Residual salinity (Bottle - CTD) for primary (blue) and secondary (red) sensors. Lines mark ½ a standard deviation above and below the mean residual for each sensor.

Removing outliers ½ a standard deviation above or below the mean residuals leaves 97 data points. The new means and standard deviations are 0.0062 ± 0.0021 (primary) and 0.021 ± 0.0036 (secondary). The raw CTD salinities from the primary and secondary sensors therefore require offsets of 0.0062 and 0.021 respectively. These have been applied to the processed data provided to BODC.

Chlorophyll Calibration

Details of the calibration of the on-board fluorometer and drift correction applied to readings can be found in the report provided by Anna Hickman and Mark Moore.

Two different calibrations have been applied to the CTD chlorophyll readings; one for the shelf edge (casts 53-56) and one for the Celtic Sea shelf water. Samples at all depths from pre-dawn CTD casts were used in the calibration. If a cast was taken during daylight hours only samples from 50m or deeper were included.

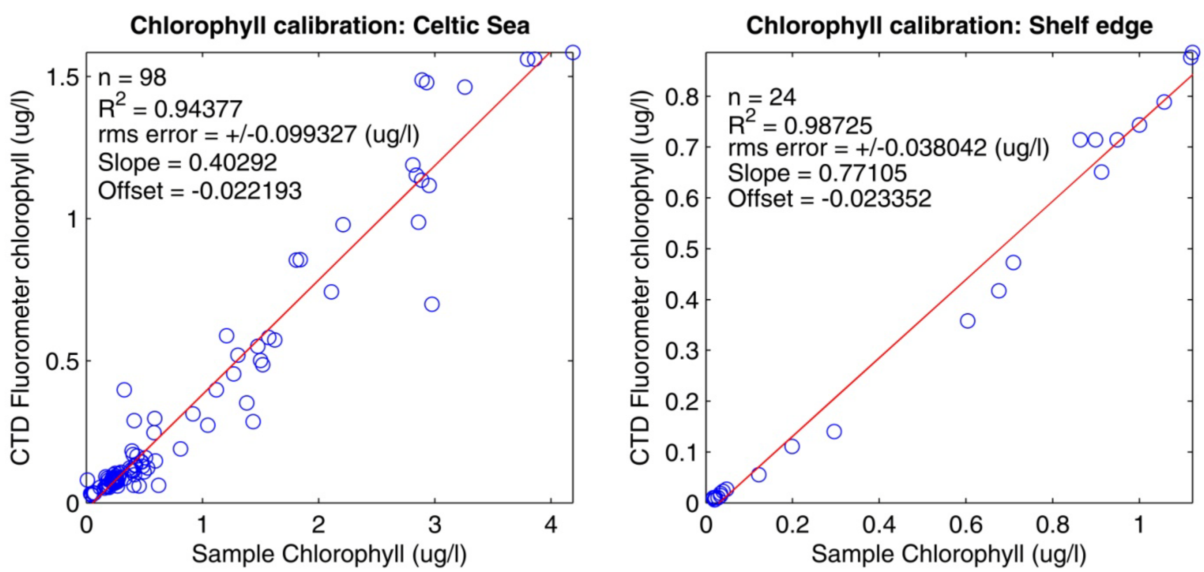


Figure 4.7. CTD raw chlorophyll vs. bottle samples for Celtic Sea water (left) and shelf edge water (right)

Based on the regressions shown above the following calibrations have been applied:

At the shelf-edge

$$CTD_{chl} = 0.77 \times BOT_{chl} - 0.023$$

therefore,

$$CHL_{calib} = 1.30 \times CTD_{chl} + 0.03 \quad \mu g/l$$

In the Celtic Sea

$$CTD_{chl} = 0.40 \times BOT_{chl} - 0.022$$

therefore,

$$CHL_{calib} = 2.5 \times CTD_{chl} + 0.06 \quad \mu g/l$$

Oxygen Calibration

Oxygen concentrations recorded by the SeaBird 43 Oxygen sensor at the times of bottle firings (in .btl file) were converted from ml/l to um/kg as follows:

$$CTD_{oxy}\,[um/kg] = (44660 / (sigma\text{-}theta + 1000)) * CTD_{oxy}\,[ml/l]$$

Oxygen concentrations from bottle measurements were converted from um/l to um/kg as follows:

oxygen[um/kg] = (1000 * botoxy [um/l]) / (sw_dens0(salinity , botoxytemp)) ,

The routine sw_dens0 calculates the density at atmospheric pressure (i.e. sigma-t + 1000) using the salinity recorded at the time of bottle firing (salinity) and the oxygen fixation temperature of the sample (botoxytemp).

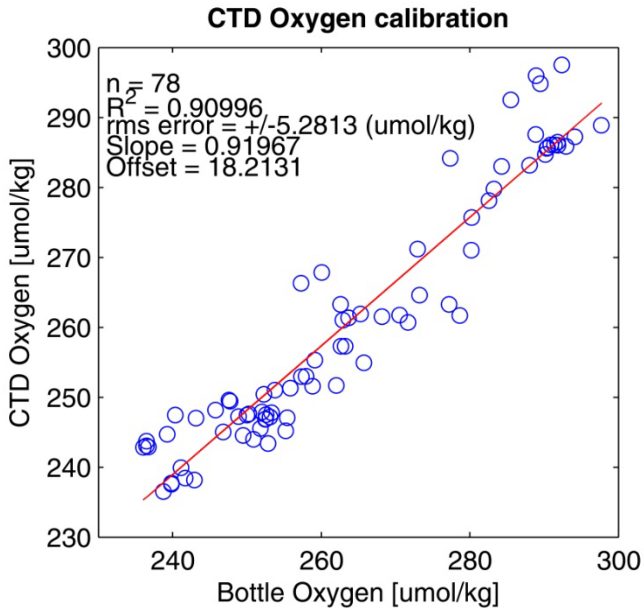


Figure 4.8. CTD oxygen vs bottle oxygen

Based on the CTD vs bottle regression [um/kg] the following calibration has been applied:

$OXY_{calib} = 1.0873 * CTD_{oxy} – 19.8039$ um/kg

5. D352 Scanfish (Jo Hopkins and Dave Teare)

The Scanfish towed undulator consists of the following systems:

The manufacturer's (G.M.I.) underwater vehicle, flight control software and hardware; an instrumentation package based around the Seabird SBE911+ CTD system. The manufacturer's equipment controls all aspects of the flight control of the vehicle including the logging of flight parameters. The Seabird system comprised of the following equipment: SBE911+ CTD and deck unit; a single temperature and conductivity pair, mounted externally on the port wing cheek; a SBE43 oxygen sensor and a Chelsea instruments Aquatracka fluorometer.

A total of seven surveys runs were completed with approximately five and a half days of time spent in the water. The following problems were encountered. On survey six a number of data drop outs occurred, this culminated in the eventual failure of the underwater termination, after some thirty six hours of the survey. The cable was re-terminated and the survey run was completed at the end of the cruise.

Scanfish tows

Tow	**Date** (start of tow)	**Start Lat/Lon**	**End Lat/Lon**	**Distance towed**	**Description**
1	Jun 05 2010 18:57	49.20 N, 8.67 W	49.62 N, 9.34 W	69 km	Short initial tow on shelf from the 150m isobath.
2	Jun 12 2010 08:55	49.42 N, 8.94 W	49.12 N, 9.46 W	245 km	A tow of 4 legs turning at: (49.72 N, 8.55 W) , (49.82, 8.73 W) , (48.96 N, 10.01 W) .
3	Jun 13 2010 13:37	49.11 N, 9.46 W	49.14 N, 9.52 W	127 km	Along shelf tow over approx. 150m of water. Turns at: (49.35 N, 9.80 W), (49.35 N, 10.22 W)
4	Jun 14 2010 18:04	49.17 N, 9.48 W	49.42 N, 9.03 W	467 km	Long tow of 6 legs crossing multiple rises. Water depths 100-170 m.
5	Jun 17 2010 17:59	49.42 N, 9.01 W	49.42 N, 9.03 W	186 km	Triangular tow turning at: (49.16 N, 8.02 W), (49.62 N, 8.72 W)
6	Jun 21 2010 11:15:00	48.31 N, 9.60 W	50.07 N, 8.99 W	479 km	Initial section of tow along the shelf-break followed by a transect across the shelf

					from 48.25 N, 10.74 W to 50.07 N, 8.00 W.
7	Jun 22 2010 18:09:49	50.07 N, 8.00 W	50.58 N, 7.19 W	83 km	Continuation of tow 6
8	Jun 24 2010 10:52:49	53.09 N, 5.20 W	50.63 N, 7.10 W	312 km	Final tow south → north joining up with the end of tow 7

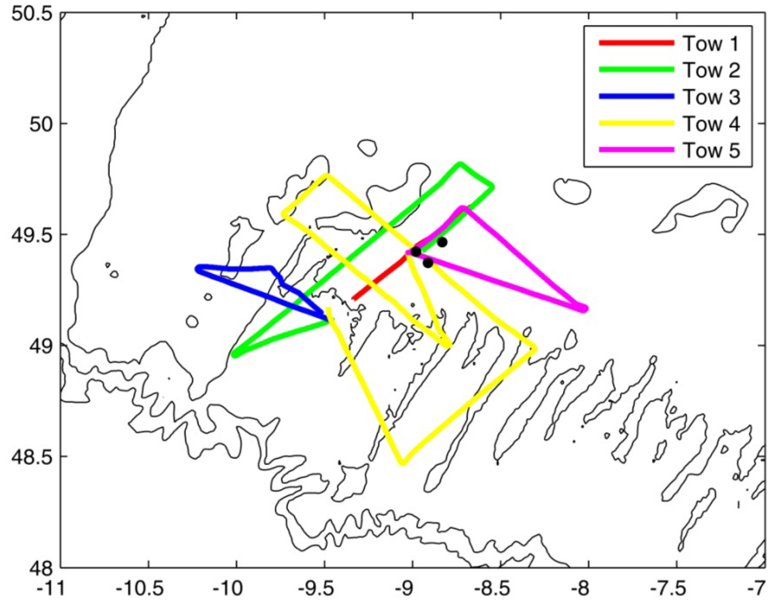


Figure 5.1 Map of Scanfish tows 1-5. Black contours mark the 150m, 500m and 1000m isobaths. Black dots are mooring locations.

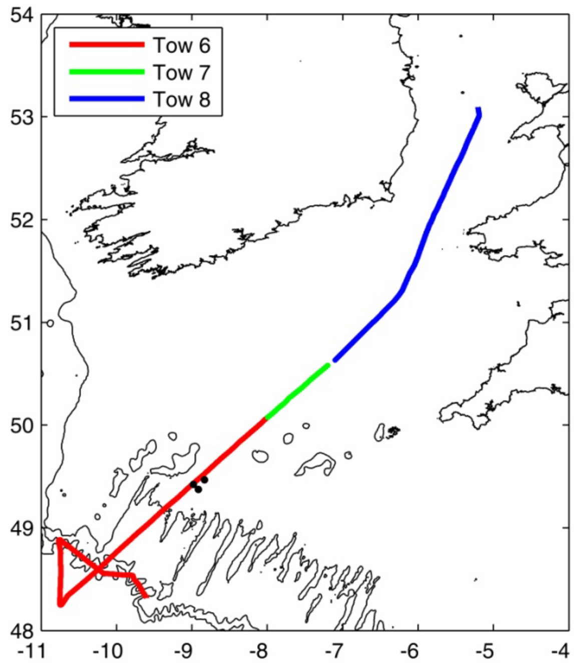


Figure 5.2 Map of Scanfish tows 6-8. Black contours mark the 150m, 500m and 1000m isobaths. Black dots are mooring locations.

Data Processing

Scanfish tows were recorded using the SeaBird data collection software SeaSave-Win32. The software output three files in the form Scanfish_run_*n* (*nnn*= tow number) with the following extension:

- .hex (raw data file)
- .CON (configuration file)
- .hdr (header file)

These were backed up onto the ships network.

The following SeaBird Software Processing, Version 7.18c (SBEDataProcessing-Win32) steps were performed (further routine details found under CTD processing).

DatCnv: Data Setup options were set to the following:

Process scans to end of file: yes

Scans to skip: 0

Output format: ascii

Convert data from: upcast and downcast

Create file types: create converted data file only (.cnv)

Selected output variables were:

- Scan count & Time elapsed (secs)
- Latitude and Longitude (deg)
- Pressure, digiquartz (db)
- Temperature (ITS-90 °C)
- Conductivity (S/m)
- Oxygen voltage, SBE 43 (V)
- Fluorescence (ug/l)
- Decent rate (m/s)
- Salinity (psu)

A hysteresis correction using a window size of 2 seconds was made to the Oxygen. One output file is generated: Scanfish_run_*n*.cnv.

Section: This module was run on Scanfish runs 4 and 6 following advise by SeaBird. The Filter module necessary to remove high frequency noise in the pressure channel was unable to cope with large file sizes. Therefore, runs 4 and 6 were split into 3 and 2 subsections respectively based on scan number. File names were appended with A, B or C (e.g. Scanfish_run_4C.cnv). The table below shows the scan numbers used to split the files.

	Scanfish_run_4	Scanfish_run_6
Scanfish_run_*n*A.cnv	0 → 970,000	0 → 1,084,700
Scanfish_run_*n*B.cnv	970,000 → 1,721,700	1,084,700 → 2,668,104
Scanfish_run_*n*C.cnv	1,721,700 → 2,750,393	

WildEdit: The following settings were used:

Scan range: 100 scans

Standard deviation, pass 1: 2

Standard deviation, pass 2: 20

Exclude scans marked as bad: yes

Select WildEdit variables: pressure only

Output written to scanfish_run_*n*_We.cnv.

Filter was run on the pressure channel to smooth out high frequency data (Low pass filter time constant set to 0.15 seconds).

Output written to scanfish_run_*n*_We_Ft.cnv.

AlignCTD was used to align the oxygen sensor. The Scanfish calibration cast (Scanfish_calib_1) was tested for corrections of +2-8 seconds. A +4 second was chosen as the optimal adjustment.

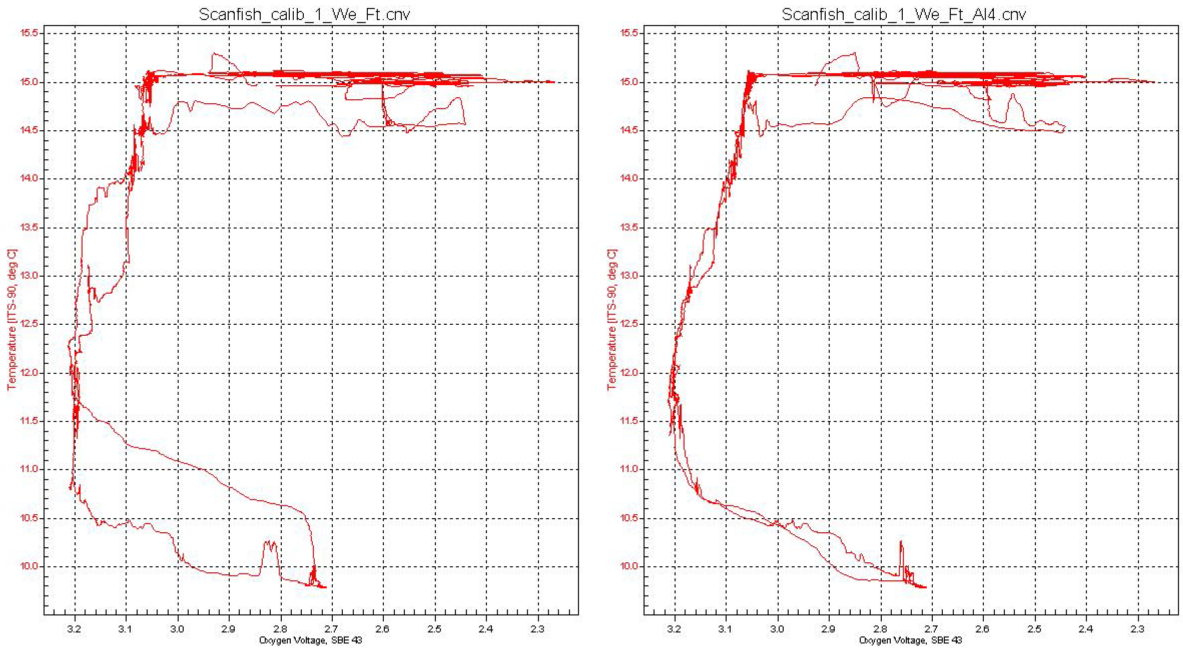


Figure 5.3 (Left) Temperature vs oxygen voltage for the Scanfish calibration cast before oxygen aligment. (Right) Temperature vs oxygen voltage after a 4 second adjustment.

Output written to scanfish_run_*n*_We_Ft_Al.cnv.

CellTM: The thermal anomaly amplitude α was set to 0.03 and the thermal anomaly time constant 1/β to 7.

Output written to scanfish_run_*n*_We_Ft_Ctm.cnv.

Loopedit is used for the calibration cast only (Scanfish_calib_1). Settings are the same as for the CTD processing.

Derive: Derived variables selected:

Oxygen concentration (ml/l), oxygen saturation (%), oxygen concentration (umol/kg)

Salinity (psu),

Density (kg/m^3),Density (sigma-theta, kg/m^3)

Output written to scanfish_run_*n*_We_Ft_Ctm_Dr.cnv.

BinAverage: This program was run on the 24Hz data file containing the final derived values to create a 2Hz file.

Bin Type: Time, seconds

Bin Size: 0.5

Include no. of scans per bin: no

Exclude scans marked as bad: yes

Scans to skip over: 0

Cast to process: Up and down cast

Output written to scanfish_run_*n*_We_Ft_Ctm_Dr_2Hz.cnv.

Instrument configuration

Instrument calibration dates and serial numbers taken from the Scanfish configuration file (supplied to BODC).

Sensor	**Serial Number**	**Calibration date**
SeaBird 9 temperature sensor - wing cheek mounted	4782	12 February 2010
SeaBird 9 conductivity sensor - wing cheek mounted	2450	10 February 2010
Digiquartz pressure sensor with TC – mounted internally	110557	26 April 2009
SeaBird 43 Oxygen sensor – mounted internally	0621	20 March 2010
Fluorometer, Chelsea Aqua 3	088126	2 January 2007

Scanfish calibration (*Stephanie Bates and Jo Hopkins)*

Calibration of the Scanfish temperature, salinity, oxygen and chlorophyll fluorescence was carried out by profiling the Scanfish vertically and comparing the data with CTD profiles carried out immediately before (ctd010) and after (ctd011 and ctd011a) the profile on 6th June 2010 (Scanfish_calib_1). Both CTD casts and the Scanfish profile were processed in the same way and averaged into 1db intervals. The salinity, oxygen and chlorophyll CTD values used here are the calibrated ones.

The following figure reveals that over the time taken to complete the four casts the position of the thermocline change by approx. 10 db, suggesting the passage of an internal wave.

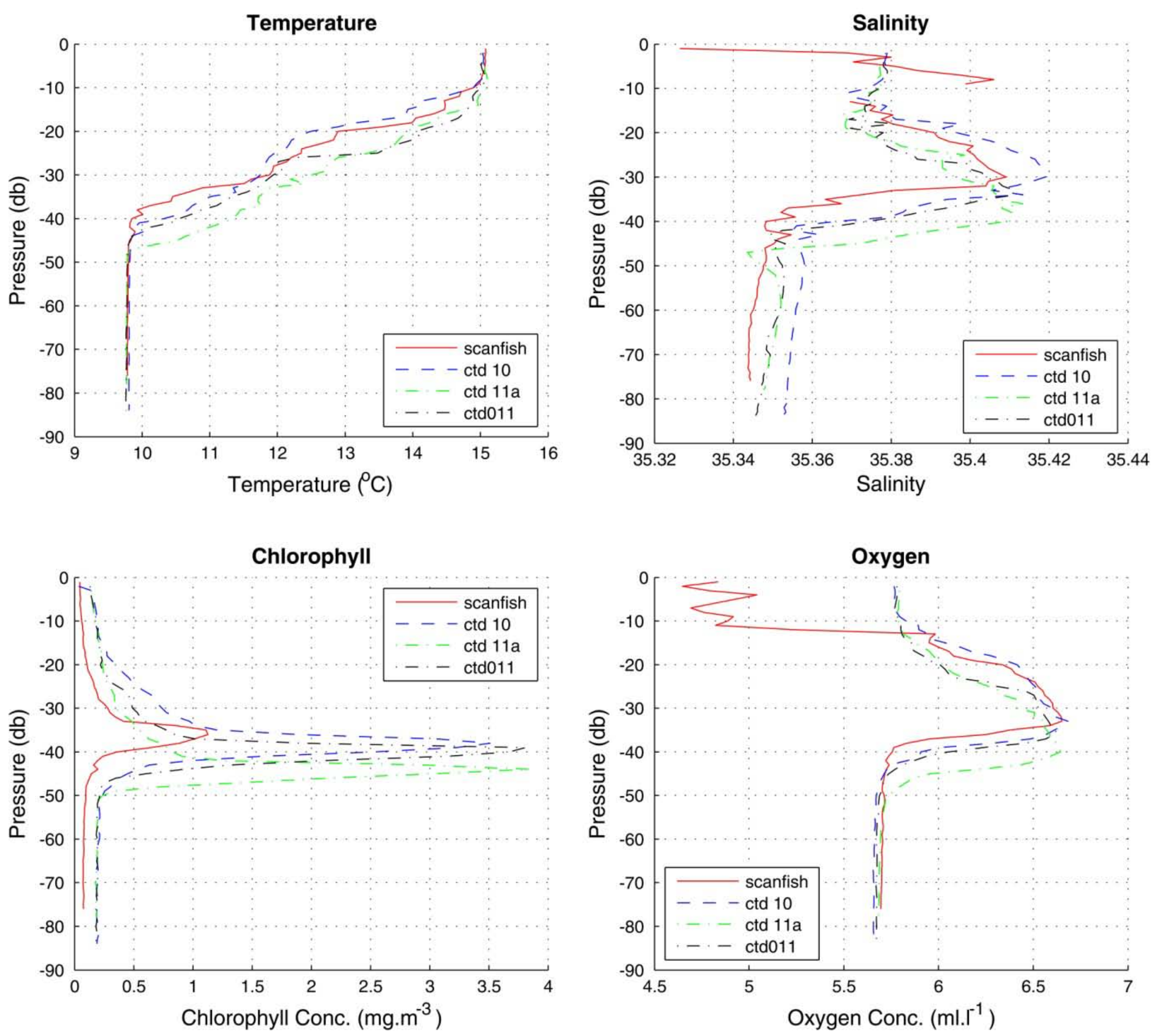


Figure 5.4 CTD casts 10 – 11a used for Scanfish calibration. Only the primary channels have been used.

The mean difference between Scanfish and the mean of the three CTD casts in regions of the water column where conditions were homogeneous was used to calibrate the temperature, salinity and oxygen. Only the primary sensor on the CTD cast, and measurements made on the downcast were used.

Using data over 50-76 db the mean offsets are:

For temperature: mean (Scanfish – CTD) = 0.0019 ± 0.00273°C

For salinity: mean (Scanfish – CTD) = -0.0072 ± 0.0009

For oxygen: mean (Scanfish - CTD) = 0.025 ± 0.0040 ml/l

n.b. calibrated CTD data was used for the above Scanfish calibrations.

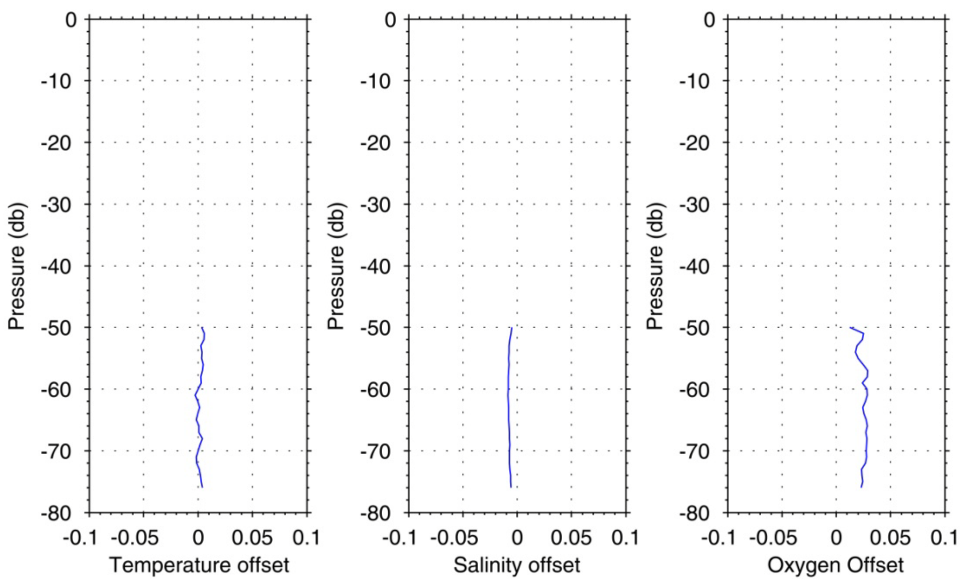


Figure 5.5 Temperature, salinity and oxygen offsets (Scanfish - CTD) in the bottom mixed region of the water column (50-76 db).

The Scanfish chlorophyll was calibrated by comparing the data collected through the subsurface maximum from CTD casts 10-11a with the vertical Scanfish cast. Pairs of chlorophyll values (Scanfish-CTD) were selected based on the water temperature (9.8-12°C, in increments of 0.1°C), rather than depth. This was necessary given the large vertical displacements of the thermocline. The mean measurement from the three CTD casts was used.

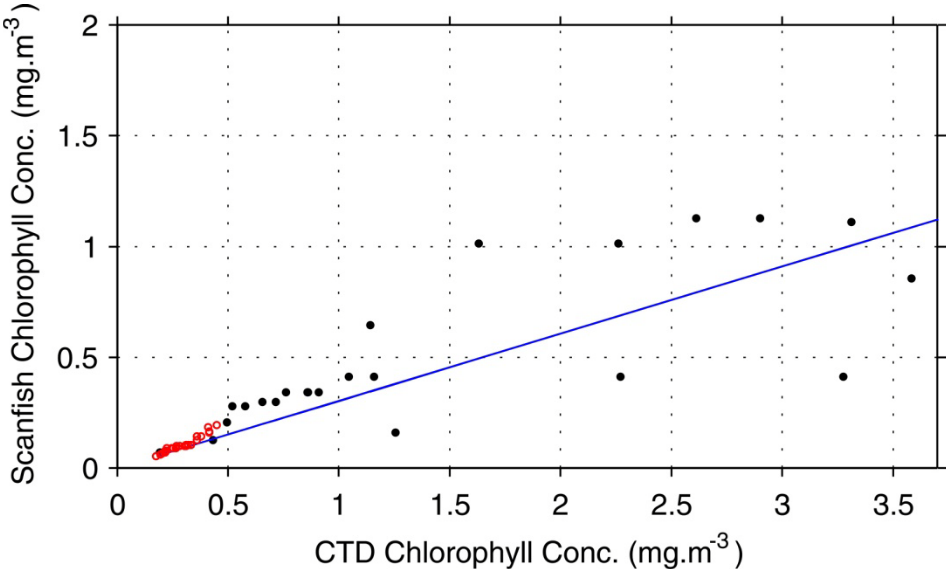


Figure 5.6 Regression of CTD chlorophyll concentration vs. Scanfish chlorophyll. Black dots are from the subsurface maximum and are used in the regression. Open red circles at lower concentrations are values outside the peak and NOT used in the regression.

$CHL_{SF} = 0.3029 \times CHL_{CTD}$

$r^2 = 0.48$, *rms error = 0.24*

The regression was forced through zero so as to avoid large numbers of negative values.

Using the regression above the Scanfish chlorophyll measurements are calibrated as follows:

$$CHL_{SFcal} = 3.3019 \times CHL_{SF} \text{ mg.m}^3,$$

where CHL_{SF} is the raw chlorophyll measured by Scanfish.

The rms error about this regression is 0.24 $mg.m^3$. As the calibration was performed using the calibrated CTD chlorophyll concentration, the total error in Scanfish chlorophyll estimates is $(0.10^2+0.24^2)^{1/2} = 0.26$ $mg.m^3$ (using the rms error from the Celtic Sea regression).

6. Microstructure turbulence observations (Yueng-Djern Lenn)

Turbulence Team

Bangor University personnel:

Yueng-Djern Lenn[8], Ben Lincoln[12], Chris Old[4], Ben Powell[4], Tom Millgate[12], Holly Pelling[8].

NOC personnel:

Jeff Polton[12]

[superscripts correspond to the start of the 4-hour watches. Watch leaders: YDL, BL and CO].

Instruments & set-up:

The principal instrument used during the cruise was the Bangor University VMP500. The NOC VMP750 and accessories were also brought along as a back-up. The VMP- 500, winch and line-puller was set up to be deployed from the back deck in order to tow the instrument during profiling. The block was hung from the starboard crane which was also used to help deploy and recover the instruments during repositioning exercises. Both the VMP500 and VMP750 winches were run off the dedicated pumps instead of ships hydraulics.

VMP profiling during each time series was confined to 4-mile diameter circle centered on the IM1 mooring. Tow speeds ranged from 0.4-1.5 knots depending on the winds and tides. Each time-series was interrupted by time taken to reposition the ship or conduct a CTD cast to resolve the nutrient structure and provide calibration for the VMP Seabird data. While profiling with the VMP500, the instrument was deployed in free fall mode until it reached the bottom before being recovered to the surface whereupon it was promptly redeployed. While profiling with the VMP2000, more care was taken to try and keep the instrument off the bottom as is preferred by Matt Palmer (NOC Liverpool).

Observations:

Initial cruise plan was to include several 60-hour long VMP time-series at the central Celtic Sea mooring location to resolve at least 4 inertial periods. Each time-series was to be timed to coincide with springs/neaps and the mid-tidal cycles and preferably a wind event. This was amended based on the incidence of weather fronts across the sampling region.

We completed one 50-hour VMP-500 time-series when the first front passed through the mooring locations, breaking for a day before commencing a second time-series in anticipation of a second weather front. A couple of bad profiles after 24 hours instigated a re-termination, following which we had to stop the time-series due bad data from the micro-temperature and shear probes. This was eventually traced to a small leak in the VMP-500 pressure case that damaged the PCB to which the shear and micro-temperature probes were connected.

A third 15-hour time-series was completed in the remaining time allotted to the second time-series in the central Celtic Sea using the VMP750, while repairs on the VMP500 were attempted. All together the central Celtic Sea turbulence data showed a lot of interesting features and were successful at resolving the dissipation due to shear-spiking.

Following the conclusion of the central Laptev Sea observations we proceeded to a midway point between the moorings and shelf-edge to make new observations relating to the progression of the internal tide from the shelf edge. Upon arrival at the mid-point location, we tested the now-dry VMP500. The poor data streams from T1,T2, S1 and S2 confirmed the permanent damage to the PCB and we switched over to using the VMP750.

After 40 minutes of profiling with the VMP750, the instrument was recovered for repositioning. During recovery, the VMP750 sustained a serious collision with the ship that resulted in obvious external damage to the Seabird conductivity cell, as well as the Seabird thermistor. Further investigation showed that the VMP750 had developed a leak due to a failure of the pressure case in a manner similar to the VMP500. Tests showed that the VMP750had sustained damage to the same PCB as the VMP500. Regrettably, this meant the conclusion of further turbulence profiling as repair was not possible at sea. An e-mail discussion between Ben Powell (Bangor technician extraordinaire) and the manufacturer about the source of the problem and necessary repairs is appended at the end of this document.

Minor operational issues:
The placement of the crane/block was critical to the ease of repeat profiling. First it was imperative to place the block in line between the winch and line-puller. The optimum set-up was with the block set quite high up with the crane at a 90-degree angle so the arm holding the block was parallel to the deck. If the crane arm was inclined towards the deck, the crane had a tendency to slip resulting in the block drifting out of alignment. This caused the occurrence of standing waves in the wire between the block and line-puller during the downcasts that tended to push the wire o_ the yellow line-puller pulley, and also compounded spooling onto the winch during upcasts.

Throughout the VMP500 profiling, we experienced loss of communications between the VMP500 and laptop on a semi-regular basis. The pop-up error message would say that the USB device had unmounted from the laptop and the data feed would cease. We suspected that this was due to problems at the utrans/laptop end of things, and appeared to be rectified by unplugging all the USB connections (VMP, serial nav stream, external hard drive) and restarting the ODAS software and plugging everything back in. As the profiling progressed we noticed more frequent Bad Buffer notices. Eventually when the VMP500 profiling was halted due to the leak, we found that the black Utrans box was also no longer functioning and concluded that this had been the source of the communications issues.

Preliminary results:

Drift during each time-series in the vicinity of the IM1 mooring is shown in Fig. 6.1. Comparison of the Seabird conductivity cells is not good, in particular the VMP750 appeared to values far fresher than is realistic for the Celtic Sea. The two Seabird thermistors also appear to have different calibrations (Fig. 6.2). Clearly the Seabird data from each instrument will have to be calibrated to the independent CTD observations before the data is finalised.

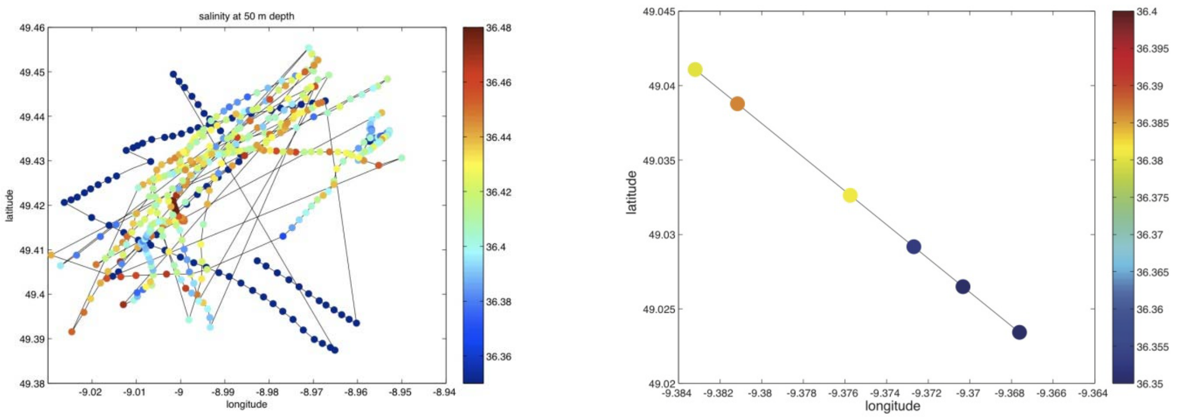


Figure 6.1: salinity at 50 m depth versus position in the vicinity of IM1 (left) and midway between IM1 and the shelf edge (right).

The microstructure shear profiles have been despiked and processed to produce dissipation (ε) estimates. Results from the two shear (orthogonally aligned) channels compared well with each other in terms of magnitude and temporal variability for each of the VMP500 and VMP2000 instruments..

Table 1: First VMP500 time-series, 50 hours, 249 good pro_les.

Date and time	Comments	Latitude & Longitude
06-Jun-2010 17:38:00	start VMP profiling	49° 26.43'N 8° 59.25'W
06-Jun-2010 22:47:00	break for repositioning	49° 23.63'N 8° 59.51'W
07-Jun-2010 00:00:00	recommence VMP profiling	49° 26.97'N 8° 57.97'W
07-Jun-2010 03:39:00	break for repositioning and CTD012	49° 24.25'N 9° 0.87'W
07-Jun-2010 05:40:00	recommence VMP profiling	49° 27.32'N 8° 58.26'W
07-Jun-2010 12:44:00	break for repositioning	49° 23.46'N 8° 59.26'W
07-Jun-2010 13:51:00	recommence VMP profiling	49° 26.91'N 8° 58.13'W
07-Jun-2010 15:04:00	break for repositioning and CTD013	49° 25.83'N 8° 59.58'W
07-Jun-2010 15:55:00	recommence VMP profiling	49° 25.27'N 9° 0.29'W
07-Jun-2010 17:00:00	break for repositioning	49° 24.13'N 9° 2.07'W
07-Jun-2010 18:17:00	recommence VMP profiling	49° 27.00'N 8° 58.19'W
07-Jun-2010 21:59:00	break for CTD014	49° 25.64'N 8° 59.97'W
07-Jun-2010 23:12:00	recommence VMP profiling	49° 26.58'N 8° 58.07'W
08-Jun-2010 01:17:00	break to sort out bad tangle and reboot laptop	49° 25.94'N 8° 58.99'W
08-Jun-2010 01:53:00	recommence VMP profiling	49° 25.69'N 8° 59.37'W
08-Jun-2010 02:41:00	break for retermination of VMP cable, CTD015	49° 25.28'N 9° 0.20'W
08-Jun-2010 05:01:00	recommence VMP profiling	49° 26.12'N 8° 59.23'W

08-Jun-2010 06:30:00	break for repositioning	49° 24.63'N 9° 2.68'W
08-Jun-2010 08:03:00	recommence VMP profiling	49° 26.46'N 8° 58.71'W
08-Jun-2010 15:57:00	break for repositioning	49° 23.66'N 9° 0.48'W
08-Jun-2010 17:07:00	recommence VMP profiling	49° 26.80'N 8° 58.18'W
08-Jun-2010 20:03:00	conclude VMP time-series and CTD016	49° 23.24'N 9° 1.54'W

Table 2: Second VMP500 time-series, 24 hours, 153 pro_les

Date and time	Comments	Latitude & Longitude
09-Jun-2010 17:06:00	start VMP profiling	49° 25.44'N 9° 0.57'W
09-Jun-2010 23:29:00	break for repositioning	49° 26.08'N 8° 57.23'W
10-Jun-2010 00:11:00	recommence VMP profiling	49° 24.20'N 9° 1.01'W
10-Jun-2010 01:09:00	break for repositioning	49° 24.42'N 8° 59.29'W
10-Jun-2010 01:53:00	recommence VMP profiling	49° 24.77'N 8° 58.62'W
10-Jun-2010 04:11:00	break for CTD017	49° 26.15'N 8° 57.33'W
10-Jun-2010 05:06:00	recommence VMP profiling	49° 25.82'N 8° 57.57'W
10-Jun-2010 09:24:00	break for repositioning	49° 26.27'N 8° 57.92'W
10-Jun-2010 10:11:00	recommence VMP profiling	49° 24.39'N 9° 1.14'W
10-Jun-2010 12:02:00	break for repositioning, retermination, CTD018	49° 25.68'N 8° 59.71'W
10-Jun-2010 13:44:00	recommence VMP profiling	49° 23.66'N 8° 59.88'W
10-Jun-2010 17:26:00	break for repositioning	49° 26.96'N 8° 57.08'W
10-Jun-2010 18:17:00	recommence VMP profiling	49° 24.52'N 9° 1.76'W
10-Jun-2010 19:19:00	halt VMP500 profiling due to instrument failure	49° 24.82'N 9° 1.35'W

Table 3: Third VMP time-series with VMP2000, 12 hours, 95 good profiles

Date and time	Comments	Latitude & Longitude
11-Jun-2010 11:10:00	start VMP profiling	49° 24.26'N 9° 0.87'W
11-Jun-2010 14:15:00	break for repositioning	49° 26.43'N 9° 0.38'W
11-Jun-2010 15:05:00	recommence VMP profiling	49° 23.29'N 8° 57.98'W
11-Jun-2010 18:27:00	break for new heading	49° 25.24'N 9° 1.58'W
11-Jun-2010 18:33:00	stop for CTD	49° 25.27'N 9° 1.50'W
11-Jun-2010 20:06:00	break for repositioning	49° 25.86'N 9° 0.06'W
11-Jun-2010 21:13:00	recommence VMP profiling	49° 25.96'N 9° 0.67'W
12-Jun-2010 00:08:00	break for repositioning	49° 26.37'N 8° 57.45'W
12-Jun-2010 00:48:00	recommence VMP profiling	49° 23.65'N 8° 57.70'W
12-Jun-2010 02:12:00	end of VMP time-series	49° 24.57'N 8° 59.23'W

Table 4: Fourth time-series with VMP500/VMP2000 midway to shelf edge.

Date and time	Comments	Latitude & Longitude
14-Jun-2010 00:31:00	begin test casts with VMP500	49° 2.33'N 9° 22.87'W
14-Jun-2010 03:51:00	stop test casts with VMP500, recover	49° 0.92'N 9° 21.63'W
14-Jun-2010 02:50:00	begin VMP2000 profiling	49° 2.33'N 9° 22.87'W
14-Jun-2010 03:51:00	break for repositioning	49° 0.92'N 9° 21.63'W

Comparisons of dissipation resolved by the different instruments was also good (Fig. 6.3). There is clear evidence of tidal modulation of the bottom boundary layer, as well as intermittent appearance of high dissipation events at different depths within diffuse thermocline of the water column (Fig. 6.3). Only some of these mid-water events were isolated events without strong relation to either surface mixed layer or bottom boundary layer processes.

A summary of the 6 good VMP2000 profiles at the mid-way point between IM1 and the shelf edge are shown in Fig. 6.4. This location is characterised by a warm surface mixed layer approximately 20m deep below which lies a salty intrusion itself about 20 m thick. The turbulent environment is characterised by high dissipation in the surface mixed-layer and below 80-m depth. The highest dissipation was observed at the base of the surface-mixed layer for at last 4 profiles from 0300 onwards.

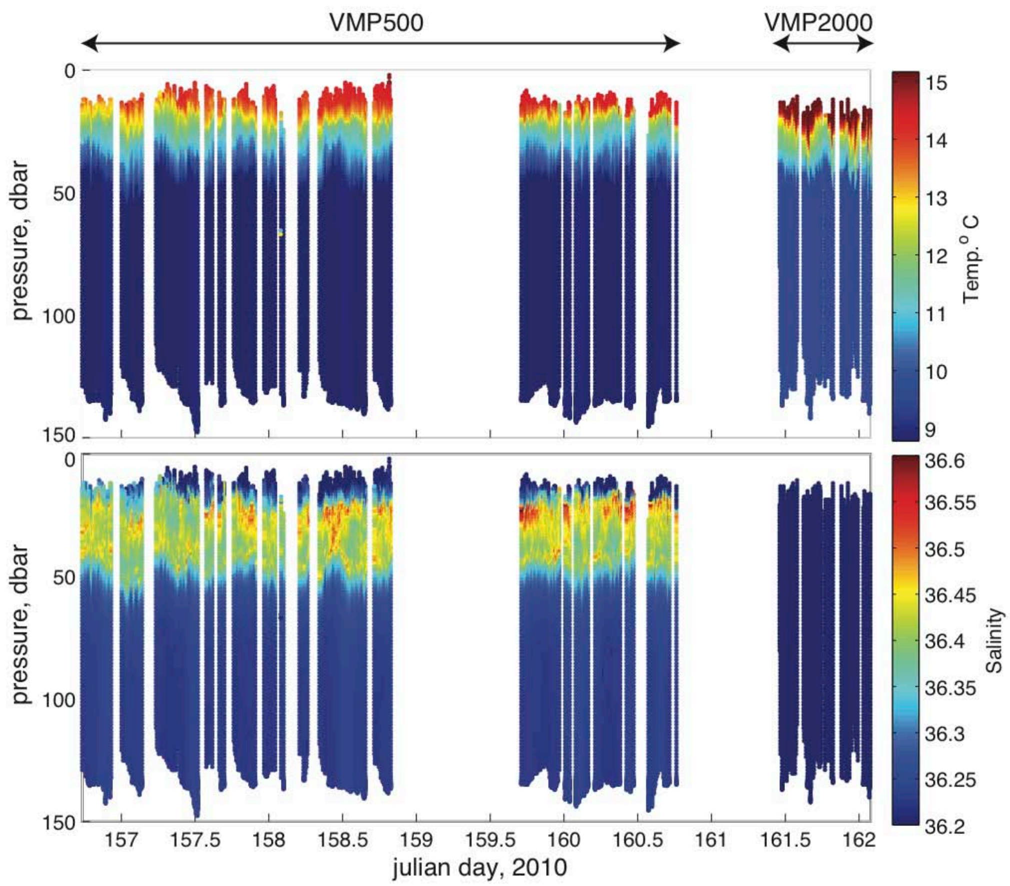


Figure 6.2: time-series of temperature (top) and salinity (bottom) from the seabirds on the 2 VMP profilers.

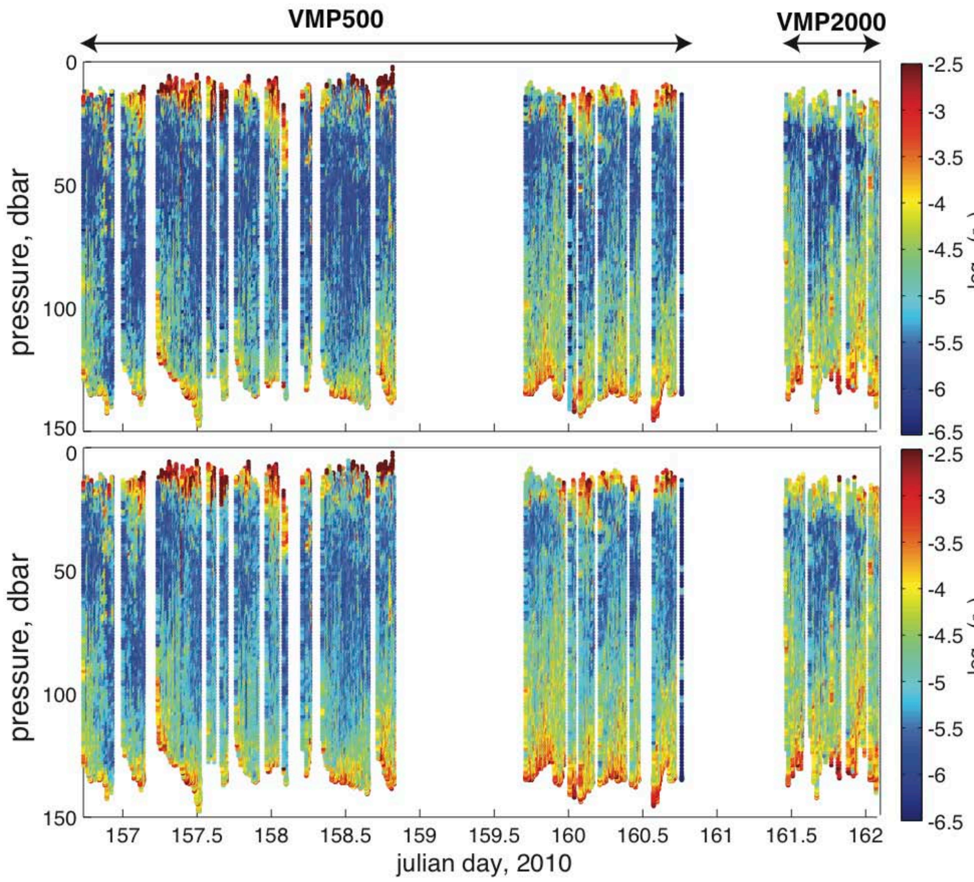


Figure 6.3: time-series of dissipation (ε , W m^{-3}) from the shear 1 (top) and shear 2 (bottom) channels.

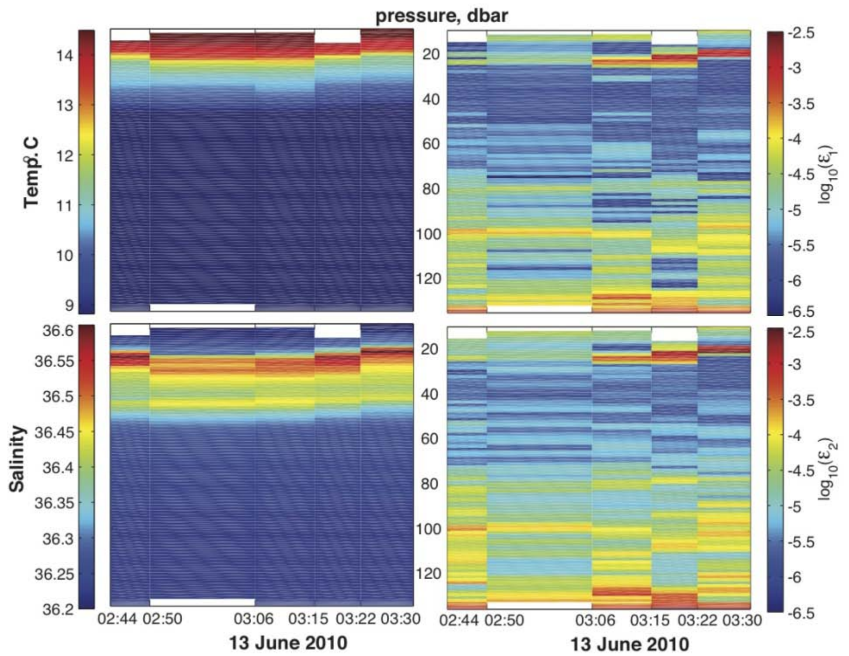


Figure 6.4: time-series of temperature (top left), salinity (bottom left), dissipation (ε , W m^{-3}) from the shear 1 (top right) and shear 2 (bottom right) channels.

Appendix

||{ Original Message ||{ Subject: Re: VMP500 sn21

Date: Sun, 20 Jun 2010 15:08:04 +0000

From: Ben Powell <b.powell@bangor.ac.uk>

To: Rolf Lueck <rolf@rocklandscienti_c.com>
CC: peter@rocklandscienti_c.com, 'Dave Cronkrite' <dave@rocklandscienti_c.com>, 'Fabian Wolk' <fabian@rocklandscienti_c.com>

Hi Rolf,

Thanks for your reply, I checked the inside of the nose cone and it was completely dry, however, I want to replace the cables on that side as the cables insulation is slightly frayed (caused by scraping when attaching probes) and this is what we think caused our previous noise problem. I would also like to replace the cables / hockey puck for the MC probe. I have connected to the instrument using a good UTRANS box via the winch tether (about 500m) and had no buffer errors I so hope that the RTRANS board is OK. The reason I suspected the ASTP board is because (as you guessed) there were splashes of water on the board.

I guess the next step is to remove all the known problems (the smc cables, the hockey pucks and the utrans box) and then conduct the tests you described.

I am still currently on a ship but will be back on land next week, as such I can't raise a purchase order at the moment. Would it be possible for you to invoice us a total once we know the full extent of the damage? Don't worry if this is a problem, we'll just wait till I get back, however we hoped to use the instrument again in July so it would be nice to get it fixed asap. If possible could you please send to Bangor the following :

1 x UTRANS box
5 x SMC Probe Cable with Straight Connector (18 in)
5 x SMC Probe Cable with Rt. Angle Connector (18 in)
2 x Hockey Puck

Thanks,

Ben

On 17/06/2010 20:12, Rolf Lueck wrote:

Ben,

You did a good job of describing the symptoms and this narrows the range of possible problems.

Bad signals on T1, T2, sh1 and sh2 but not on P, P dP and the accelerometers indicates that the ASTP board is very likely in good order. The shear probes and thermistors are on the front of the nose cone. A bulkhead separates the nose cone from the pressure case so that, in the unlikely event that water should enter the nose cone (possibly because of a leaky probe or an incorrectly installed o-ring), then this water cannot enter the main pressure case and ruin the electronics.

You found a back-door entrance for water into the pressure. When the instrument is oriented vertically and nose down, the lowest point inside of the pressure case is the dry side of the feed-through pins in the front bulkhead. Therefore the cables to the thermistors and shear probes got wet at the point of feed through. Even after you dry out everything, remnant salt crystals will remain in the coaxial cables and cause noise, particularly for the shear probe signals. The pressure transducer and accelerometers are elevated slightly above the bulkhead and it takes more water to cause trouble with these sensors. The fact

that you are getting sensible signals from these sensors indicates that they did not get wet and that (most probably) the ASTP board also remained dry. However, you should inspect everything carefully with a magnifying glass. Sometimes water will splash onto components when handling an instrument that is wet on its inside.
Before I describe what should be done, let me remind you to also check for evidence of water penetration into the nose cone. The symptoms you describe will also occur if water enters the nose cone. Also, a quick test of the system is obtained by disconnecting the shear probe cables at the ASTP board. Push some heat shrink tubing over the cables or insulate them by other means so that the cable ends do not touch anything electrical. Use the calibration option to look at the statistics of the channels. The shear probe mean should be within about 100 counts of zero and its standard deviation should be under 30, particularly if the board is shield by the pressure case or a sheet of aluminum foil that has been grounded to the analog ground of the ASTP board (usually, the black test points). To test the thermistors requires inserting a 3k-ohm resistor into the connector on the ASTP board. This may be difficult to do, so dont bother if you do not have a short SMC cable with a 3 k-ohm resistor soldered to its end. The mean would also be within 100 counts of zero and the standard deviation small.
You have to replace the coaxial cables. There is no way to clean them assuredly. Replacing the cables is a bit of fiddle but it can be done by a competent techno-person. To solder new cables to the dry side of the feed through pins (the units are usually called hockey pucks because of their shape), you must push the hockey pucks forward and out of their holes. There is not much free real estate between the pins. A 2 mm blunt rod will usually work. If the puck has been installed for a while, the o-ring grease is dry and the push may have to be strong. Once the puck is out, you can push new cables through the hole from the dry side and then solder them on to the old puck, if it looks OK, or on to a new puck. Follow the pin pattern that we used and be sure that shield on one side connects to the corresponding shield on the other side, dido for the inner conductors, etc. Also put heat shrink on as was done original (if it was done originally). Finally, be sure to remove residual ux and other contaminants from the soldering operation. Very lightly grease the o-ring(s) on the hockey puck and push it back into its hole. Your instrument probably has two hockey pucks and you have to service both of them.
You blew the UTRANS but it is also likely that you damaged the RSTRANS (or RTRANS), because this too connects to the signal lines in the tether and will have seen excessive voltage. The RSTRANS is repairable. The RSTRANS may work OK when using a short communication cable (such as your deck cable) but will fail to function properly on a real tether that is 1000 m or longer. You should conduct a few tests. One test is to look at the mean voltage with respect to digital ground (also the black test points) on the signal lines. This should be 2.500V +/- 0.005V. Take this measurement without the tether connected. If you get 2.500V, then that is a good sign. If not, the driver and or receiver chips got damaged and will have to be replaced. This is best done at RSI. The second test is to try communication using your tether. If you do not get bad buffers, the RTRANS is probably OK. The _nal test is to look at the signals at both ends of a (long) tether. If it comes to that, I can give you some guidance on the voltage levels that the signals should

have.

So, I think that you need at least:

1. 4 new SMC coaxial cables for the connection from the hockey pucks to the ASTP board.
2. A UTRANS
3. A new RSTRANS or a repaired one and or a spare one.

The other things on your list may not be needed but are useful spares. To repair the RSTRANS only requires the board and not the whole instrument.

Cheers, Rolf

From: Peter Stern [mailto:peter@rocklandscienti_c.com] Sent: 17 June, 2010 10:09

To: b.powell@bangor.ac.uk

Cc: Dave Cronkrite; 'Rolf Lueck'

Subject: VMP500 sn21

Hi Ben,

Rolf or Dave will comment on things electrical/electronic.

I am curious about the loosened rear sealing nut.

Do you have a sense of how loose it was?

Do you have any pictures of the instrument showing how it was rigged for those deployments, especially of the tail section showing how all the cables, etc.. were tied down.?

How many casts did you complete before the problem was noticed?

Was the tail _n securely bolted to the clamps & were the clamps securely bolted together and tight to the tube?

Having this nut back o_ has not happened before so I am very interested in this, obviously.

I have ordered some low strength Loctite 222 (purple) and will do a loctite test. There are two possible problems with using loctite (these are what spring to mind, there could be other problems/issues): 1. Residual grease, etc on the threads will stop the loctite from curing.

2. Loctite cures, but makes removing the nut so difficult that something is damaged or you wind up pulling the threaded rod out of its mount inside the instrument. This threaded rod is locked into place using Loctite 262 (Red) which should hold much more strongly than the 222 Purple. Usually you cant remove the threaded rod without the aid of a heat gun.

Cheers, Peter

Peter Stern Mechanical Engineer Rockland Scientific International 520 Dupplin Road Victoria, BC V8Z 1C1 t: 250.370.1688 f: 250.370.0234

7. Vessel Mounted ADCPs (Chris Old)

Overview

The RRS Discovery operates a pair of hull mounted ADCPs; a 75 kHz RDI Ocean Surveyor and a 150 kHz RDI Ocean Surveyor.

These were configured while steaming from Govan and through the Clyde Sea. There are a set of test files that were generated while sorting out navigation and time synchronizing issues. The last test files ends in St George's Channel (52° 14.03' N, 005° 44.72' W) at 2104 on the 3rd of June.

The main set of cruise deployment files were started at 2115 on 3rd June at the southern end of St George's Channel (52° 12.13' N , 005° 46.17' W). A new set of deployment files was started between major set of data collection. A summary of each deployment file for the ADCPs is presented in Tables 1 and 2 below.

ADCP Configurations

Two configurations were used with each of the ADCPs, these were with the bottom tracking turned on and the bottom tracking turned off. The column 'Bot. Track' in Tables 1 & 2 identify when the bottom tracking was turned ON or OFF for each instrument.

The 75 kHz ADCP was configured to measure

Number of depth bins	(WN)	100	
Bin size	(WS)	8 m	
Blanking distance	(WF)	8 m	
Pings per ensemble	(WP)	1	
Water mode	(WM)	10	
Max. error velocity	(WE)	1 m/s	
Time between pings	(TP)	00:00.00	(ping immediately after processing)
Coordinates	(EX)	beam	

With bottom tracking on

Pings per record	(BP)	1
Delay for reacquire	(BD)	0
Minimum correlation	(BC)	220
Minimum amplitude	(BA)	30
Bottom track mode	(BM)	1
Max. error velocity	(BE)	1000

This configuration gives approximately 6.1 s per record.

The 150 kHz ADCP was configured to measure

Number of depth bins	(WN)	96	
Bin size	(WS)	4 m	
Blanking distance	(WF)	4 m	
Pings per ensemble	(WP)	1	
Water mode	(WM)	10	
Max. error velocity	(WE)	1 m/s	
Time between pings	(TP)	00:00.00	(ping immediately after processing)
Coordinates	(EX)	00000	(uncorrected beam coordinates)

With bottom tracking on

Pings per record	(BP)	1
Delay for reacquire	(BD)	0
Minimum correlation	(BC)	220
Minimum amplitude	(BA)	30
Bottom track mode	(BM)	1
Max. error velocity	(BE)	1 m/s

This configuration gives approximately 4.67 s per record.

Single pings were used to facilitate the removal of the ships motion in the post-processing before time averaging to reduce the measurement variance (error).

PC Clock drift.

The ADCPs internal clocks are reset from the computers CPU clock. The CPU time is the time stamp tied to the output data stream, therefore any CPU clock drift will lead to a drift in the time difference between the navigation data (which uses the GPS clock) and the ADCP ensemble data.

	CPU Clock Reset			End of Data Collection		
ADCP	Date	Time	UTC-CPU	Date	Time	UTC-CPU
75 kHz	02/06/2010	19:18:00	0s	25/06/2010	07:04	1s
150 kHz	02/06/2010	19:16:30	0s	25/06/2010	07:04	38s

TABLE 1: 75 kHz ADCP

File Name	Day #	Date	Time	Latitude	Longitude	Bot. Track	Comments
D352_OS75001_*.*	154	03/06/2010	2115	52° 12.32’ N	005° 46.17’ W	ON	St Georges to mooring site
D352_OS75002_*.*	156	05/06/2010	0251	49° 25.06’ N	008° 59.62’ W	ON	VMP set 1
D352_OS75003_*.*	157	06/06/2010	1710	49° 26.64’ N	008° 58.90’ W	ON	VMP set 2
D352_OS75004_*.*	159	08/06/2010	2021	49° 29.41’ N	009° 00.49’ W	ON	Scanfish survey
D352_OS75005_*.*	164	13/06/2010	0820	49° 05.93’ N	009° 25.78’ W	ON	VMP set 3 / CTD + LADCP
D352_OS75006_*.*	167	16/06/2010	0133	49° 24.72’ N	008° 59.80’ W	ON	Scanfish
D352_OS75007_*.*	170	19/06/2010	1407	49° 24.53’ N	009° 00.36’ W	ON	CTD section
D352_OS75008_*.*	171	20/06/2010	1327	48° 36.35’ N	010° 14.19’ W	OFF	Off shelf edge CTD
D352_OS75a08_*.*	171	20/06/2010	1419	48° 29.44’ N	010° 23.99’ W	OFF	Incorrect config. file used
D352_OS75009_*.*	171	20/06/2010	1542	48° 29.95’ N	010° 27.93’ W	OFF	Correct config. file used
D352_OS75010_*.*	171	20/06/2010	2030	48° 34.87’ N	010° 16.17’ W	ON	Back on shelf
D352_OS75011_*.*	172	21/06/2010	0710	48° 42.03’ N	009° 39.39’ W	ON	Reset computers
D352_OS75012_*.*	172	21/06/2010	0820	48° 29.90’ N	009° 37.22’ W	ON	Along shelf scanfish
D352_OS75013_*.*	172	21/06/2010	2231	48° 16.80’ N	010° 45.24’ W	ON	Cross shelf scanfish (failed)
D352_OS75014_*.*	175	24/06/2010	0718	53° 03.88’ N	005° 12.18’ W	ON	Scanfish St Georges to fail pt.
	176	25/06/2010	0704	50° 45.28’ N	006° 30.53’ W		System turned off

TABLE 2: 150 kHz ADCP

File Name	Day #	Date	Time	Latitude	Longitude	Bot. Track	Comments
D352_OS150001_*.*	154	03/06/2010	2115	52° 12.32’ N	005° 46.17’ W	ON	St Georges to mooring site
D352_OS150002_*.*	156	05/06/2010	0251	49° 25.06’ N	008° 59.62’ W	ON	VMP set 1
D352_OS150003_*.*	157	06/06/2010	1710	49° 26.64’ N	008° 58.90’ W	ON	VMP set 2

D352_OS150004_*.*	159	08/06/2010	2021	49° 29.41’ N	009° 00.49’ W	ON	Scanfish survey
D352_OS150005_*.*	164	13/06/2010	0820	49° 05.93’ N	009° 25.78’ W	ON	CTD
D352_OS150006_*.*	167	16/06/2010	0133	49° 24.72’ N	008° 59.80’ W	ON	CTD
D352_OS150007_*.*	170	19/06/2010	1407	49° 24.53’ N	009° 00.36’ W	ON	CTD section
D352_OS150008_*.*	171	20/06/2010	1040	48° 49.57’ N	009° 59.99’ W	OFF	Off shelf edge
D352_OS150a08_*.*	171	20/06/2010	1419	48° 29.44’ N	010° 23.99’ W	OFF	Incorrect config. file used
D352_OS150009_*.*	171	20/06/2010	1544	48° 26.95’ N	010° 27.92’ W	OFF	Correct config. file used
D352_OS150010_*.*	171	20/06/2010	2229	48° 41.11’ N	010° 06.74’ W	ON	Back on shelf
D352_OS150011_*.*	172	21/06/2010	0710	48° 42.03’ N	009° 39.39’ W	ON	Reset computers
D352_OS150012_*.*	172	21/06/2010	0820	48° 29.90’ N	009° 37.22’ W	OFF	Along shelf scanfish
D352_OS150013_*.*	172	21/06/2010	2231	48° 16.80’ N	010° 45.24’ W	ON	Cross shelf scanfish
D352_OS150014_*.*	175	24/06/2010	0718	53° 03.88’ N	005° 12.18’ W	ON	Scanfish St Georges to fail pt.
	176	25/06/2010	0704	50° 45.28’ N	006° 30.53’ W		System turned off

8. Lowered ADCPs (Chris Old)

Overview

The aim of this deployment was to provide some independent validation of the method being developed to measure low-resolution profiles of TKE dissipation rates from a lowered downward-facing ADCP. The values estimated from the ADCP deployments will be compared with the profiles of TKE dissipation measured using the VMP.

We removed the LADCPs and mounted a high-frequency, high-resolution instrument on the CTD rosette using a custom built bracket. A number of different configurations were trialed to determine an optimal configuration. Both a 1200 kHz and 600 kHz RDI Workhorse Sentinel were trialed. The 600 kHz instrument used was the one recovered from the mid-water float high-frequency deployment.

Limiting factors on the success of the method are the amount of CTD rosette vertical movement while held at a fixed depth and the length of time the rosette is held at each fixed water depth (typically about 60s for a standard CTD cast). The longer the range the ADCP profiles the less the impact of vertical rosette motion and the longer the time series at each depth the better the turbulent statistics are sampled. A minimum of 90s at each depth is required as it takes 30s for the turbulence generated by the rosette during the up cast to dissipate, the remaining time series segment is used to estimate the TKE dissipation rate over the measurable range of the ADCP.

The data collected between CTD casts 004 and 031 were less controlled, only a few of the casts produced single depth time-series of more than 60s duration. The ADCP data were collected at the depths where the water samples were taken.

Casts 032 to 037 were specific to this experiment. For each cast the rosette was held for at least 2 minutes at each depth. Nominally 5 depths were chosen, these corresponded to the near-bottom, mid-water, bottom of thermocline, chlorophyll maximum, and the surface mixed-layer. The actual depths varied depending on water depth and water structure profile taken from CTD down cast.

It should be noted that the pressure sensor on the 600 kHz ADCP was limited to 100m, therefore the maximum depth for these casts was less than 100m.

LADCP Uncontrolled Casts

Cast #	Cfg File #	Date	Time	Latitude	Longitude	Depth	Comments
004	001	04/06	15:22:43	49° 29.30' N	008° 53.45' W	126	MODE 5 configuration , 1.8 mins per depth ***
005	001	04/06	16:25:00	49° 25.52' N	008° 53.45' W	137	< 1 min per depth
006	001	05/06	02:36:33	49° 25.12' N	008° 59.46' W	136	< 1 min per depth
007	002	06/06	02:27:12	49° 25.13' N	008° 58.12' W	142	MODE 12 configuration , < 1 min per depth
008	002	06/06	04:34:35	49° 24.30' N	008° 59.11' W	145	2 min bottom & top, < 1 min mid-water
009	002	06/06	06:13:13	49° 24.00' N	009° 00.32' W	137	< 1 min per depth
012	002	07/06	04:36:54	49° 27.32' N	008° 58.26' W	122	Cap left on ADCP , 1.25 mins per depth
013	003	07/06	15:03:14	49° 25.86' N	008° 59.59' W	133	MODE 12, increased WV and WO , < 1 min
014	003	07/06	21:44:05	49° 25.68' N	008° 59.94' W	135	< 1 min per depth
015	003	08/06	04:07:10	49° 26.98' N	008° 58.04' W	128	< 1 min per depth
016	003	08/06	20:28:07	49° 24.49' N	009° 00.27' W	137	< 1 min per depth
017	003	09/06	02:33:31	49° 25.55' N	008° 59.75' W	135	> 2 mins per depth ***
018	003	09/06	10:48:02	49° 25.10' N	008° 59.72' W	133	~ 1 min per depth
019	003	09/06	15:39:28	49° 25.40' N	009° 00.36' W	137	< 1 min per depth
020	003	10/06	00:52:38	49° 24.44' N	008° 59.23' W	146	< 1 min per depth
021	003	10/06	04:16:34	49° 26.11' N	008° 57.33' W	137	< 1 min per depth
022	003	10/06	12:10:43	49° 25.80' N	008° 59.68' W	161	< 1 min per depth
023	003	10/06	22:00:34	49° 25.58' N	009° 00.72' W	134	< 1 min per depth
024	003	11/06	09:54:30	49° 24.60' N	008° 58.25' W	142	< 1 min per depth
025	003	11/06	19:48:30	49° 25.80' N	009° 00.30' W	134	2 mins per depth ***
026	003	12/06	02:18:21	49° 24.80' N	008° 58.32' W	143	< 1 min per depth
027	003	12/06	04:24:31	49° 24.07' N	008° 58.32' W	143	2 mins per depth

							***
028	003	12/06	05:49:36	49° 24.34' N	008° 57.58' W	132.5	> 2 mins per depth ***
029	003	13/06	02:24:51	49° 06.96' N	009° 27.39' W	159	< 1 min per depth
030	004	13/06	11:30:34	49° 03.48' N	009° 28.92' W	159.5	MODE 5, increased WN to 80 , 2 mins ***
031	004	13/06	22:03:40	49° 07.07' N	009° 29.07' W	159.5	< 1 min per depth

LADCP Uncontrolled Casts Depths

Cast #	z(1)	z(2)	z(3)	z(4)	z(5)	z(6)	z(7)	z(8)	z(9)	z(10)	z(11)	z(12)	z(13)	z(14)
004	7.2	117.3												
005	127.4	102.3	82.4	62.2	52.2	41.9	37.8	32.76	26.8	21.6	16.5	11.4	4.3	
006	128.2	68.2	63.1	57.8	53.2	50.8	48.8	46.78	44.8	42.8	40.7	35.2	22.2	3.7
007	127.7	52.5	50.2	48.3	46.3	44.2	42.2	40.35	39.3	36.9	21.6	16.7	3.5	
008	132.3	72.3	42.0	38.8										
009	61.1	51.4	48.2	45.2	42.1	5.7								
012	111.8	36.7	6.3											
013	122.1	92.2	71.8	51.9	45.1	42.4	40.9	37.67	31.4	21.3	6.4			
014	122.8	93.0	73.1	53.3	37.9	23.0	7.7							
015	121.8	92.3	72.8	47.3	7.2									
016	122.6	93.0	73.4	53.1	39.9	22.7	7.5							
017	122.4	57.2	49.2	45.1	43.2	42.2	31.7	16.11	3.3					
018	62.7	39.9	3.1											
019	122.0	91.8	72.0	41.3	21.1									
020	133.2	123.0	7.6											
021	124.1	93.7	73.8	53.6	38.1	23.1	8.2							
022	122.8	93.2	72.9	53.1	45.9	40.6	35.9	7.5						

023	123.9	94.4	74.2	54.1	49.0	39.0	33.6	23.7	8.9					
024	122.8	93.6	73.4	53.0	43.1	37.8	32.8	22.5	7.6					
025	122.4	92.7	72.4	52.2	47.2	42.2	36.9	22.0	6.9					
026	122.9	92.8	72.6	52.5	47.4	44.7	42.6	37.0	22.1	7.0				
027	45.5	38.5												
028	37.1													
029	153.3	67.8	52.7	47.7	44.8	42.9	40.9	38.5	27.4	17.3	4.3			
030	73.2	43.2	35.9	4.4										
031	142.6	93.9	74.1	53.6	48.4	38.2	23.1	8.3						

LADCP Dedicated Casts 14 June 2010

Cast #	Cfg File #	Date	Time	Latitude	Longitude	Depth	Comments
1200 kHz ADCP							
032	004	14/06	08:07:15	49° 06.25' N	009° 29.63' W	161	Mode 5, 80 × 5cm bins
033	005	14/06	10:04:41	49° 06.22' N	009° 25.73' W	157	Mode 5, 45 × 10cm bins
034	006	14/06	11:24:28	49° 06.52' N	009° 27.21' W	157	Mode 11, 40 × 10cm bins
600khz ADCP							
035	001	14/06	12:58:51	49° 06.93 N	009° 28.46' W	158.5	Mode 5, 80 × 10cm bins
036	002	14/06	14:33:07	49° 07.57' N	009° 28.10' W	158.5	Mode 12, 80 × 10cm bins, 6 subpings
037	003	14/06	15:59:43	49° 07.89' N	009° 27.68' W	161	Mode 11, 80 × 10cm bins

LADCP Dedicated Cast Depths

Cast #	z(1)	z(2)	z(3)	z(4)	z(5)	z(6)
1200 kHz ADCP						

032	141.4	101.4	51.5	42.2	22.3	
033	141.6	103.3	52.9	43.0	22.8	
034	140.9	102.8	52.6	42.6	22.3	
600 kHz ADCP						
035	98.9	73.8	51.3	41.8	24.0	
036	97.6	74.5	51.9	35.3	24.5	14.8
037	97.3	74.1	51.6	37.7	24.3	

ADCP Configuration Files

1200 kHz RDI Workhorse Sentinel

```
File:   ctd_adcp1200_cfg_001.txt
CR1
CF11101
EA0
EB0
ED0
ES35
EX00000
EZ1111101
TE00:00:00.00
TP00:00.00
WA50
WB0
WC64
WD111100000
WF46
WM5
WN70
WP2
WS5
WZ5
RNCTDCS
RI1
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 1228800
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = YES
;High Rate Pinging  = NO
;Shallow Bottom Mode= NO
;Wave Gauge        = NO
;Lowered ADCP      = NO
;Beam angle        = 20
;Temperature       = 8.00
;Deployment hours   = 24.00
;Battery packs     = 1
;Automatic TP      = YES
;Memory size [MB]   = 1024
;Saved Screen      = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range   = 0.50 m
;Last cell range    = 3.95 m
;Max range          = 3.50 m
;Standard deviation = 0.43 cm/s
;Ensemble size      = 1548 bytes
;Storage required   = 201.82 MB (211625532 bytes)
;Power usage        = 78.61 Wh
;Battery usage      = 0.2
;
; WARNINGS AND CAUTIONS:
; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:00.64 is used for calculations.
; Advanced settings has been changed.
; Expert settings has been changed.
```

```
File:   ctd_adcp1200_cfg_002.txt
CR1
CF11101
EA0
EB0
```

ED0
ES35
EX00000
EZ1111101
TE00:00:00.00
TP00:00.00
WA50
WB0
WC64
WD111100000
WF170
WM12
WN45
WP1
WS10
WO6,5
WV80
WZ5
RNCTDCS
RI1
CK
CS
;
;Instrument = Workhorse Sentinel
;Frequency = 1228800
;Water Profile = YES
;Bottom Track = NO
;High Res. Modes = YES
;High Rate Pinging = YES
;Shallow Bottom Mode= NO
;Wave Gauge = NO
;Lowered ADCP = NO
;Beam angle = 20
;Temperature = 11.00
;Deployment hours = 24.00
;Battery packs = 1
;Automatic TP = YES
;Memory size [MB] = 1024
;Saved Screen = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range = 2.06 m
;Last cell range = 6.46 m
;Max range = 12.93 m
;Standard deviation = 5.88 cm/s
;Ensemble size = 1048 bytes
;Storage required = 173.75 MB (182187464 bytes)
;Power usage = 71.65 Wh
;Battery usage = 0.2
;
; WARNINGS AND CAUTIONS:
; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:00.50 is used for calculations.
; Advanced settings has been changed.
; Expert settings has been changed.

File: ctd_adcp1200_cfg_003.txt
CR1
CF11101
EA0
EB0
ED0
ES35
EX00000
EZ1111101
TE00:00:00.00
TP00:00.00
WA50
WB0
WC64

```
WD111100000
WF170
WM12
WN45
WP1
WS10
WO20,5
WV150
WZ5
RNCTDCS
RI1
CK
CS
;
;Instrument         = Workhorse Sentinel
;Frequency          = 1228800
;Water Profile      = YES
;Bottom Track       = NO
;High Res. Modes    = YES
;High Rate Pinging  = YES
;Shallow Bottom Mode= NO
;Wave Gauge         = NO
;Lowered ADCP       = NO
;Beam angle         = 20
;Temperature        = 11.00
;Deployment hours   = 24.00
;Battery packs      = 1
;Automatic TP       = YES
;Memory size [MB]   = 1024
;Saved Screen       = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range   = 1.93 m
;Last cell range    = 6.33 m
;Max range          = 11.90 m
;Standard deviation = 6.04 cm/s
;Ensemble size      = 1048 bytes
;Storage required   = 67.04 MB (70300888 bytes)
;Power usage        = 61.02 Wh
;Battery usage      = 0.1
;
; WARNINGS AND CAUTIONS:
; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:01.29 is used for calculations.
; Advanced settings has been changed.
; Expert settings has been changed.
```

File: ctd_adcp1200_cfg_004.txt

```
CR1
CF11101
EA0
EB0
ED0
ES35
EX00000
EZ1111101
TE00:00:00.00
TP00:00.00
WA50
WB0
WC64
WD111100000
WF46
WM5
WN80
WP2
WS5
WZ5
RNCTDCS
RI1
```

```
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 1228800
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = YES
;High Rate Pinging = NO
;Shallow Bottom Mode= NO
;Wave Gauge        = NO
;Lowered ADCP      = NO
;Beam angle        = 20
;Temperature       = 8.00
;Deployment hours  = 24.00
;Battery packs     = 1
;Automatic TP      = YES
;Memory size [MB]  = 1024
;Saved Screen      = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range  = 0.50 m
;Last cell range   = 4.45 m
;Max range         = 3.50 m
;Standard deviation = 0.43 cm/s
;Ensemble size     = 1748 bytes
;Storage required  = 209.04 MB (219197452 bytes)
;Power usage       = 76.46 Wh
;Battery usage     = 0.2
;
; WARNINGS AND CAUTIONS:
; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:00.69 is used for calculations.
; Advanced settings has been changed.
; Expert settings has been changed.
```

File: ctd_adcp1200_cfg_005.txt

```
CR1
CF11101
EA0
EB0
ED0
ES35
EX00000
EZ1111101
TE00:00:00.00
TP00:00.00
WA50
WB0
WC64
WD111100000
WF46
WM5
WN45
WP1
WS10
WZ5
RNCTDCS
RI1
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 1228800
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = YES
;High Rate Pinging = NO
;Shallow Bottom Mode= NO
;Wave Gauge        = NO
```

;Lowered ADCP = NO
;Beam angle = 20
;Temperature = 8.00
;Deployment hours = 24.00
;Battery packs = 1
;Automatic TP = YES
;Memory size [MB] = 1024
;Saved Screen = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range = 0.55 m
;Last cell range = 4.95 m
;Max range = 3.50 m
;Standard deviation = 0.44 cm/s
;Ensemble size = 1048 bytes
;Storage required = 349.61 MB (366588304 bytes)
;Power usage = 86.69 Wh
;Battery usage = 0.2
;
; WARNINGS AND CAUTIONS:
; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:00.25 is used for calculations.
; Advanced settings has been changed.
; Expert settings has been changed.

File: ctd_adcp1200_cfg_006.txt
CR1
CF11101
EA0
EB0
ED0
ES35
EX00000
EZ1111101
TE00:00:00.00
TP00:00.00
WA50
WB0
WC64
WD111100000
WF46
WM11
WN40
WP3
WS10
WZ5
RNCTDCS
RI1
CK
CS
;
;Instrument = Workhorse Sentinel
;Frequency = 1228800
;Water Profile = YES
;Bottom Track = NO
;High Res. Modes = YES
;High Rate Pinging = NO
;Shallow Bottom Mode= NO
;Wave Gauge = NO
;Lowered ADCP = NO
;Beam angle = 20
;Temperature = 8.00
;Deployment hours = 24.00
;Battery packs = 1
;Automatic TP = YES
;Memory size [MB] = 1024
;Saved Screen = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range = 0.55 m

;Last cell range   = 4.45 m
;Max range   = 3.50 m
;Standard deviation = 0.57 cm/s
;Ensemble size   = 948 bytes
;Storage required   = 154.99 MB (162514692 bytes)
;Power usage   = 100.96 Wh
;Battery usage   = 0.2
;
; WARNINGS AND CAUTIONS:
; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:00.51 is used for calculations.
; Advanced settings has been changed.
; Expert settings has been changed.

600 kHz RDI Workhorse Sentinel

File: ctd_adcp600_cfg_001.txt

```
CR1
CF11101
EA0
EB0
ED0
ES35
EX11111
EZ1111111
WA50
WB0
WD111100000
WF88
WM5
WN80
WP2
WS10
WV175
WZ5
TE00:00:00.00
TP00:00.00
CK
CS
;
;Instrument         = Workhorse Sentinel
;Frequency          = 614400
;Water Profile      = YES
;Bottom Track       = NO
;High Res. Modes    = YES
;High Rate Pinging  = YES
;Shallow Bottom Mode= NO
;Wave Gauge         = NO
;Lowered ADCP       = NO
;Beam angle         = 20
;Temperature        = 5.00
;Deployment hours   = 24.00
;Battery packs      = 1
;Automatic TP       = YES
;Memory size [MB]   = 16
;Saved Screen       = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range   = 0.97 m
;Last cell range    = 8.87 m
;Max range          = 7.50 m
;Standard deviation = 0.43 cm/s
;Ensemble size      = 1748 bytes
;Storage required   = 180.04 MB (188784000 bytes)
;Power usage        = 73.40 Wh
;Battery usage      = 0.2
;
; WARNINGS AND CAUTIONS:
; There is not enough memory for the deployment. (Memory of 16 MB will last < 1 days).
```

; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:00.80 is used for calculations.
; Advanced settings has been changed.

File: ctd_adcp600_cfg_002.txt
CR1
CF11101
EA0
EB0
ED0
ES35
EX11111
EZ1111111
WA50
WB0
WD111100000
WF88
WM12
WN80
WP1
WS10
WO6,6
WV175
WZ5
TE00:00:00.00
TP00:00.00
CK
CS
;
;Instrument = Workhorse Sentinel
;Frequency = 614400
;Water Profile = YES
;Bottom Track = NO
;High Res. Modes = YES
;High Rate Pinging = YES
;Shallow Bottom Mode= NO
;Wave Gauge = NO
;Lowered ADCP = NO
;Beam angle = 20
;Temperature = 5.00
;Deployment hours = 24.00
;Battery packs = 1
;Automatic TP = YES
;Memory size [MB] = 16
;Saved Screen = 3
;
;Consequences generated by PlanADCP version 2.02:
;First cell range = 1.20 m
;Last cell range = 9.10 m
;Max range = 33.15 m
;Standard deviation = 18.21 cm/s
;Ensemble size = 1748 bytes
;Storage required = 197.84 MB (207454388 bytes)
;Power usage = 67.62 Wh
;Battery usage = 0.2
;
; WARNINGS AND CAUTIONS:
; There is not enough memory for the deployment. (Memory of 16 MB will last < 1 days).
; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:00.73 is used for calculations.
; Advanced settings has been changed.

File: ctd_adcp600_cfg_003.txt
CR1
CF11101
EA0
EB0
ED0
ES35
EX11111

```
EZ1111111
WA50
WB0
WD111100000
WF88
WM11
WN80
WP2
WS10
WO6,6
WV80
WZ5
TE00:00:00.00
TP00:00.00
CK
CS
;
;Instrument         = Workhorse Sentinel
;Frequency          = 614400
;Water Profile      = YES
;Bottom Track       = NO
;High Res. Modes    = YES
;High Rate Pinging  = YES
;Shallow Bottom Mode= NO
;Wave Gauge         = NO
;Lowered ADCP       = NO
;Beam angle         = 20
;Temperature        = 10.00
;Deployment hours   = 24.00
;Battery packs      = 1
;Automatic TP       = YES
;Memory size [MB]   = 16
;Saved Screen       = 2
;
;Consequences generated by PlanADCP version 2.02:
;First cell range   = 0.97 m
;Last cell range    = 8.87 m
;Max range          = 7.50 m
;Standard deviation = 0.93 cm/s
;Ensemble size      = 1748 bytes
;Storage required   = 265.74 MB (278648680 bytes)
;Power usage        = 83.17 Wh
;Battery usage      = 0.2
;
; WARNINGS AND CAUTIONS:
; There is not enough memory for the deployment. (Memory of 16 MB will last < 1 days).
; The number of pings is too low for reasonable sampling of the currents.
; The ensemble interval 00:00:00.55 is used for calculations.
; Advanced settings has been changed.
```

9. Temperature-Chlorophyll Chain (Mike Smithson)

Introduction

The temperature-chlorophyll (T-Chl) chain consists of a series of self-contained internally-recording fluorometers and temperature loggers attached to a 10mm diameter galvanised steel wire. The chain is designed to be towed through the water at speeds up to 4kt. A 380kg lead sphere shackled to the bottom end of the wire acts as a depressor to prevent the line of instruments from streaming out behind the ship. Copper ferrules crimped onto the wire at 1m intervals are used as mounting points to attach the instruments. Specially designed clamps allow for quick attachment and release of instruments at these mounting points.

The fluorometers used were Wetlabs FLB self-logging, internally-powered fluorometers. Two types of temperature logger were used, both manufactured by Star-Oddi. Mounted at the same position on the wire as the fluorometers were Star-Oddi Centi-TD temperature and depth loggers. At the other positions were Star-Oddi Starmon-mini temperature loggers. Tables 1, 2 and 3 give the details and specifications of each instrument type.

Deployment details

Three deployments were carried out during the cruise using the port-side Schatt davit and winch, both towed at ~4kts and simultaneously with the VMP profiles and CTD casts. Details of each deployment are given in Tables 4, 5 and 6. Instrument positions are counted from the deepest ferrule (i.e. the first instrument attached to the wire during deployment). Depths are nominal values and true depths should be determined after careful analysis of the pressure sensor data.

Data were downloaded from all instruments after each deployment using the proprietary software supplied by the instrument manufacturers. Star-Oddi temperature calibrations are stored in each instrument and are applied automatically when the data is downloaded. No further processing is required. Calibrations for the fluorometers are applied individually to the raw data after downloading. The calibrations are linear across the range of the instrument and the coefficients are just a simple “dark-count” offset and scale factor. These are given in Table 1. Data return for the three deployments was 100%.

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

For the third deployment fluorometers 1512 and 1513 show periods where the sample interval has jumped from 60 to 61 seconds. Given that there is zero clock drift for these instruments for the duration of the deployment it is likely that this is a real increase in sampling interval rather than a “jump” in the internal clock.

A note on clock settings and timings is important here. All instruments have their internal clocks set with respect to the ship’s GPS clock. The timings of these are given in Tables 5, 6 and 7. The temperature loggers are programmed to start at a later time and will do so according to their internal clocks. For example, a programmed and internally recorded start time of 09:00:00 may in fact be a few seconds earlier or later depending how much drift has occurred up to that time. The difference between the internally recorded time and GPS time for the last sample is likely to be larger because of continuing clock drift for the duration of the deployment. The fluorometers, however, need to be treated differently. They cannot be programmed for a later start time and are started manually (this in itself can lead to some inaccuracy in the start time). If the instrument is started manually at 09:00:00 (GPS time) the internally recorded start time may be earlier or later than this because of internal clock drift up to that time. These differences between “real” time and recorded times may or may not be important depending on the magnitude of the clock drift and the frequency of events being studied.

Serial number	Calibration date	Calibration coefficients		
		Offset	Scale factor	
775	28-Jun-2007	91	0.0073	Excitation: λ=470nm Emission: λ=695nm Sensitivity: 0.01$\mu g\ l^{-1}$ Range: 0.01 to 125$\mu g\ l^{-1}$
776	28-Jun-2007	69	0.0077	
777	28-Jun-2007	67	0.0078	
778	28-Jun-2007	78	0.0076	
779	28-Jun-2007	78	0.0076	
780	09-Jul-2007	73	0.0077	
907	14-Feb-2008	83	0.0076	
937	14-Feb-2008	80	0.0078	
939	14-Feb-2008	78	0.0077	
*1512	5-Aug-2009	50	0.0077	
*1513	5-Aug-2009	49	0.0077	
*1514	5-Aug-2009	50	0.0077	
1712	21-Jan-2010	53	0.0077	

Table 1. Details and specifications of Wetlabs FLB chlorophyll fluorometers. *Fitted with biowiper.

Serial number	Calibration date	Depth range (m)	
3268	29-Jun-2007	100	Temperature: Accuracy: ±0.1ºC; Resolution: 0.032ºC Range: –1ºC to +40ºC Time constant: 20s Depth: Accuracy: ±0.4m Resolution: 0.03m
3269	29-Jun-2007	100	
3270	29-Jun-2007	100	
3271	29-Jun-2007	100	
3272	29-Jun-2007	100	
3273	29-Jun-2007	100	
3275	29-Jun-2007	100	
3276	29-Jun-2007	100	
3278	29-Jun-2007	100	
3653	17-Mar-2008	240	
3655	17-Mar-2008	240	
3661	18-Mar-2008	240	
683*	06-Nov-2007	100	

Table 2. Details and specifications of Star-Oddi Centi-TD temperature loggers.

*Centi-PR – has pitch and roll sensors in addition to temperature and pressure.

Serial number	Calibration date	Serial number	Calibration date	
2604	30-May-2007	3579	28-Dec-2009	Accuracy: ±0.05ºC Resolution: 0.013ºC Range: –2ºC to +40ºC Time constant: s/n 2604 – 2850: 18s s/n 3576 – 3585: 6s
2607	30-May-2007	3580	28-Dec-2009	
2622	29-Jun-2007	3581	28-Dec-2009	
2846	20-Mar-2008	3582	28-Dec-2009	
2850	20-Mar-2008	3583	28-Dec-2009	
3576	28-Dec-2009	3584	28-Dec-2009	
3577	28-Dec-2009	3585	28-Dec-2009	
3578	28-Dec-2009			

Table 3. Details and specifications of Star-Oddi Starmon-mini temperature loggers. Loggers with serial numbers from 3576 to 3585 are titanium-cased with a depth rating of 11,000m and faster response. The others have plastic cases and are rated to 400m.

Nominal depth (m)	Position on wire	Instrument type	Serial Number	Clock set		First sample		Last sample		†Clock drift (s)
				Date	Time	Date	Time	Date	Time	
5	60	T_S	3579	5-Jun	17:48:36	6-Jun	09:00:00	9-Jun	12:08:15	–6
7	58	T_S	3580	5-Jun	17:46:44	6-Jun	09:00:00	9-Jun	13:06:45	+1
9	56	T_S	3583	5-	17:43:55	6-	09:00:00	9-	12:56:30	+2

				Jun		Jun		Jun		
11	54	T_S	3581	5-Jun	17:42:44	6-Jun	09:00:00	9-Jun	13:01:30	–5
13	52	T_S	3585	5-Jun	17:41:42	6-Jun	09:00:00	9-Jun	13:17:45	+1
15	50	T_S	3576	5-Jun	17:38:07	6-Jun	09:00:00	9-Jun	12:40:30	–1
17	48	T_S	3577	5-Jun	17:37:08	6-Jun	09:00:00	9-Jun	12:13:30	–4
19	46	T_S	3584	5-Jun	17:36:03	6-Jun	09:00:00	9-Jun	13:13:30	–3
21	44	T_S	3582	5-Jun	17:34:24	6-Jun	09:00:00	9-Jun	12:00:00	–2
23	42	F T_{100}	780 *683	6-Jun 5-Jun	07:27:48 18:09:15	6-Jun 6-Jun	09:50:02 09:00:00	9-Jun 9-Jun	10:02:17 11:10:30	+17 –7
25	40	T_S	3578	5-Jun	17:32:27	6-Jun	09:00:00	9-Jun	11:52:00	–1
30	35	T_S	2619	5-Jun	17:54:41	6-Jun	09:00:00	9-Jun	08:56:15	+2
35	30	F T_{100}	775 3270	6-Jun 5-Jun	07:23:54 18:03:48	6-Jun 6-Jun	09:47:02 09:00:00	9-Jun 9-Jun	09:19:47 08:22:15	+18 –5
40	25	T_S	2607	5-Jun	17:51:35	6-Jun	09:00:00	9-Jun	08:44:15	0
45	20	T_S	2622	5-Jun	17:50:26	6-Jun	09:00:00	9-Jun	11:56:00	–4
50	15	T_S	2604	5-Jun	17:52:45	6-Jun	09:00:00	9-Jun	11:46:45	–3
55	10	T_S	2608	5-Jun	17:53:36	6-Jun	09:00:00	9-Jun	12:04:45	+1
60	5	F T_{100}	776 3268	6-Jun 5-Jun	07:26:13 18:04:40	6-Jun 6-Jun	09:49:02 09:00:00	9-Jun 9-Jun	09:47:17 11:31:45	+16 –3

Table 4: T-Chl chain deployment 1. All data were logged at 15s intervals. All times are GMT. Instrument types are indicated by: F – Wetlabs FLB fluorometer; T_S – Star-Oddi Starmon-mini temperature logger; T_{100} – Star-Oddi Centi-TD temperature logger with 100m pressure sensor. †See note on timings in Deployment Details section. *Centi-PR – has pitch and roll sensors in addition to temperature and pressure.

Nominal depth (m)	Position on wire	Instrument type	Serial Number	Clock set		First sample		Last sample		†Clock drift (s)
				Date	Time	Date	Time	Date	Time	
5	60	T_S	3579	13-Jun	17:37:39	13-Jun	22:00:00	15-Jun	12:41:00	–1
10	55	T_S	3580	13-Jun	17:38:47	13-Jun	22:00:00	15-Jun	12:28:00	+2
14	51	T_S	3583	13-Jun	17:40:22	13-Jun	22:00:00	15-Jun	12:19:00	+3
17	48	T_S	3581	13-Jun	17:42:03	13-Jun	22:00:00	15-Jun	12:23:30	–1

20	45	T_S	3585	13-Jun	17:44:06	13-Jun	22:00:00	15-Jun	12:04:30	+1
23	42	T_S	3576	13-Jun	17:45:39	13-Jun	22:00:00	15-Jun	12:15:45	0
26	39	F	780	13-Jun	21:18:34	13-Jun	21:21:01	14-Jun	17:30:16	+4
		T_{100}	*683	13-Jun	18:03:27	13-Jun	22:00:00	15-Jun	11:36:45	–5
29	36	T_S	3577	13-Jun	17:47:14	13-Jun	22:00:00	15-Jun	12:46:30	–2
32	33	T_S	3584	13-Jun	17:49:03	13-Jun	22:00:00	15-Jun	12:11:15	+1
35	30	T_S	3582	13-Jun	17:50:39	13-Jun	22:00:00	15-Jun	12:00:15	–1
38	27	T_S	3578	13-Jun	17:52:24	13-Jun	22:00:00	15-Jun	12:31:30	+1
41	24	F	775	13-Jun	21:23:01	13-Jun	21:25:01	14-Jun	17:46:31	+4
		T_{100}	3270	13-Jun	18:05:55	13-Jun	22:00:00	15-Jun	11:12:00	–2
44	21	T_S	2619	13-Jun	17:53:48	13-Jun	22:00:00	15-Jun	12:58:45	+4
47	18	T_S	2607	13-Jun	17:55:01	13-Jun	22:00:00	15-Jun	13:06:30	0
50	15	T_S	2622	13-Jun	17:56:10	13-Jun	22:00:00	15-Jun	13:03:00	–3
53	12	T_S	2604	13-Jun	17:57:28	13-Jun	22:00:00	15-Jun	12:54:30	–1
56	9	T_S	2608	13-Jun	17:58:39	13-Jun	22:00:00	15-Jun	12:50:30	+1
60	5	F	776	13-Jun	21:26:43	13-Jun	21:29:01	14-Jun	18:06:01	+4
		T_{100}	3268	13-Jun	18:07:21	13-Jun	22:00:00	15-Jun	11:25:45	–2

Table 5: T-Chl chain deployment 2. All data were logged at 15s intervals. All times are GMT. Instrument types are indicated by: F – Wetlabs FLB fluorometer; T_S – Star-Oddi Starmon-mini temperature logger; T_{100} – Star-Oddi Centi-TD temperature logger with 100m pressure sensor. †See not on timings in Deployment Details section. *Centi-PR – has pitch and roll sensors in addition to temperature and pressure.

Nominal depth (m)	Position on wire	Instrument type	Serial Number	Clock set		First sample		Last sample		†Clock drift (s)
				Date	Time	Date	Time	Date	Time	
2	–	T_S	2846	20-Jun	14:27:36	20-Jun	16:00:00	21-Jun	12:07:15	+1
	–	T_{240}	3653	20-Jun	14:12:06	20-Jun	16:00:00	21-Jun	10:05:00	–2
7	–	T_S	2850	20-Jun	14:24:57	20-Jun	16:00:00	21-Jun	12:16:30	+2
		T_{240}	3655	20-Jun	14:18:27	20-Jun	16:00:00	21-Jun	10:12:15	–1
12	59	F	1712	20-Jun	15:12:37	20-Jun	15:16:02	21-Jun	07:15:02	0
		T_{240}	3268	20-Jun	13:50:01	20-Jun	16:00:00	21-Jun	10:19:45	–1
15	56	T_S	2607	20-Jun	15:02:08	20-Jun	16:00:00	21-Jun	12:21:00	0
18	53	F	780	20-Jun	15:58:38	20-Jun	16:00:01	21-Jun	07:39:46	+3
		T_{100}	3270	20-Jun	13:54:43	20-Jun	16:00:00	21-Jun	10:48:45	–1
21	50	T_S	3580	20-Jun	14:59:44	20-Jun	16:00:00	21-Jun	12:28:15	+1
24	47	F	778	20-Jun	15:23:05	20-Jun	15:25:02	21-Jun	07:58:47	+3
		T_{100}	3273	20-Jun	13:56:15	20-Jun	16:00:00	21-Jun	10:57:15	–5
26	45	T_S	3581	20-Jun	14:56:28	20-Jun	16:00:00	21-Jun	12:32:30	+1
28	43	F	937	20-Jun	15:28:19	20-Jun	15:30:01	21-Jun	08:14:01	0
		T_{100}	3276	20-Jun	13:58:09	20-Jun	16:00:00	21-Jun	11:04:00	–2
30	41	T_S	3583	20-Jun	14:54:30	20-Jun	16:00:00	21-Jun	12:36:45	+1
32	39	F	779	20-Jun	15:32:03	20-Jun	15:33:02	21-Jun	08:30:32	+3
		T_{100}	3278	20-Jun	13:59:55	20-Jun	16:00:00	21-Jun	11:10:00	–4
34	37	T_S	3576	20-Jun	14:52:28	20-Jun	16:00:00	21-Jun	12:42:45	0
36	35	F	907	20-Jun	15:35:44	20-Jun	15:37:01	21-Jun	08:40:46	+1
		T_{100}	3275	20-Jun	14:01:16	20-Jun	16:00:00	21-Jun	11:17:30	–3
38	33	T_S	3584	20-Jun	14:50:08	20-Jun	16:00:00	21-Jun	12:47:30	+1
40	31	F	1512	20-Jun	15:40:03	20-Jun	15:43:02	21-Jun	08:54:21	0

		T_{100}	3269	20-Jun	14:04:22	20-Jun	16:00:00	21-Jun	11:24:00	–3
42	29	T_S	3578	20-Jun	14:48:25	20-Jun	16:00:00	21-Jun	12:51:30	–1
44	27	F	1513	20-Jun	15:45:54	20-Jun	15:48:02	21-Jun	09:08:50	0
		T_{100}	3271	20-Jun	14:05:55	20-Jun	16:00:00	21-Jun	11:31:00	–3
46	25	T_S	3585	20-Jun	14:45:12	20-Jun	16:00:00	21-Jun	12:55:15	+2
48	23	F	1514	20-Jun	15:49:40	20-Jun	15:51:02	21-Jun	09:18:47	–1
		T_{100}	3272	20-Jun	14:08:00	20-Jun	16:00:00	21-Jun	11:37:15	–5
50	21	T_S	3579	20-Jun	14:42:40	20-Jun	16:00:00	21-Jun	12:59:15	0
53	18	T_S	3582	20-Jun	14:40:22	20-Jun	16:00:00	21-Jun	13:03:00	+1
56	15	T_S	2622	20-Jun	14:38:11	20-Jun	16:00:00	21-Jun	13:06:45	–2
59	12	F	777	20-Jun	15:54:33	20-Jun	15:56:00	21-Jun	09:34:00	+3
		T_{100}	683	20-Jun	14:21:57	20-Jun	16:00:00	21-Jun	11:43:30	–5
62	9	T_S	3577	20-Jun	14:36:19	20-Jun	16:00:00	21-Jun	13:10:30	0
65	6	T_S	2604	20-Jun	14:33:48	20-Jun	16:00:00	21-Jun	13:14:30	0
70	1	F	938	20-Jun	16:03:45	20-Jun	16:05:00	21-Jun	09:43:30	–1
		T_{240}	3661	20-Jun	14:09:46	20-Jun	16:00:00	21-Jun	11:52:00	0

Table 6: T-Chl chain deployment 3. All data were logged at 15s intervals. All times are GMT. Instrument types are indicated by: F – Wetlabs FLB fluorometer; T_S – Star-Oddi Starmon-mini temperature logger; T_{PPP} – Star-Oddi Centi-TD temperature and depth logger, suffix indicates the depth rating of the pressure sensor. †See note on timings in Deployment Details section. *Centi-PR – has pitch and roll sensors in addition to temperature and pressure.

10. Moorings (Mike Smithson, NOC)

Introduction

Instruments were deployed at four mooring sites, one in the western Irish Sea (WIS), and three in the Celtic Sea (IM1, IM2, IM3). WIS had two components: a line of temperature loggers up to a surface toroid fitted with two independent meteorological packages; a seabed lander fitted with a 300kHz RDI Workhorse ADCP and a 150kHz RDI narrowband ADCP. IM1 had three components: a line of temperature loggers, fluorometers, CTDs and two McLane RAS water samplers up to a surface toroid fitted with a meteorological package; a seabed lander fitted with a 150kHz FlowQuest ADCP; a subsurface 600kHz RDI Workhorse ADCP. IM2 had two components: a line of temperature loggers and CTDs up to a surface toroid fitted with a meteorological package; a seabed lander fitted with a 300kHz RDI Workhorse ADCP. IM3 had two components: a line of temperature loggers and CTDs up to a surface toroid fitted with a meteorological package; a seabed lander fitted with a 150kHz RDI narrowband ADCP. In addition, guard buoys were deployed at two of the mooring sites, two at IM1 and one at IM3.

Toroid moorings

Irish Sea mooring

This mooring will be recovered on a subsequent cruise and will be described elsewhere.

Celtic Sea moorings

The three Celtic Sea moorings were of the same basic design. Each was a single-point mooring with a 1 tonne anchor, acoustic release and surface toroid with navigation light and radar reflector. The mooring line was divided into two sections, an upper section 55m in length held vertical by a 150kg weight and a lower section whose length was determined by the water depth at the mooring position and held vertical by a 1m diameter steel buoyancy sphere. Short sections of wire could be removed or added to the lower section to suit the depth at each site. The upper and lower sections were decoupled by two 25m sections of rope, one polyester attached to the bottom of the upper section, the other polypropylene attached to the top of the lower section. In terms of instrumentation IM1 was the most complex mooring. The upper section consisted of a Seabird MicroCAT top and bottom, a series of Wetlabs FLB fluorometers and Star-Oddi temperature loggers at intermediate depths, a McLane RAS100 water sampler in the surface mixed layer at ~20m depth and a McLane RAS500 water sampler in the chlorophyll maximum at the bottom of the thermocline (depth determined by CTD immediately prior to mooring deployment). The lower section consisted of a series of Star-Oddi temperature loggers with a Seabird CTD at the bottom, immediately above the acoustic release. IM2 and IM3 had Seabird MicroCATs immediately below the surface toroid and above the acoustic release with a series of Star-Oddi temperature loggers between. The toroid at each site was fitted with a package of meteorological sensors and a data logger. The moorings were deployed toroid first, with instruments, buoyancy etc being attached as the mooring line was payed out, stopping off as necessary to wind subsequent sections of mooring line onto the winch. The slow speed of the winch was frustrating at times but did not hinder the proper execution of the mooring operations. One issue was the necessity for the RAS water samplers to be upside down for part of the time during deployment. This needs some thought for future deployments. Mooring diagrams are given in Figs 1, 2 and 3. Details of instrumentation are given in Tables 1, 2, 3 and 4. Three Star-Oddi temperature loggers were lost during the recovery operations, these are indicated in the relevant table.

Data were downloaded from all instruments after recovery. Star-Oddi temperature calibrations are stored in each instrument and are applied automatically when the data is downloaded, no further processing is required. Calibrations for the fluorometers are applied individually to the raw data after downloading. The calibrations are linear across the range of the instrument and the coefficients are just a simple “dark-count” offset and scale factor. These are given in Table 1. Start and stop times, instrument clock drift etc. are given in Tables 5, 6 and 7 (see below on clock settings and timings).

Depth data from the Star-Oddi depth sensors show an offset prior to and post deployment and this needs to be taken into account when processing the data. For IM1, fluorometers 1512 and 1513 show periods where the sample interval has jumped from 60 to 61 seconds. Given that the clock drifts for these instruments for the duration of the deployment are –3 and +12 seconds respectively it is likely that this is a real increase in sampling interval rather than a “jump” in the internal clock.

A note on clock settings and timings is important here. All instruments have their internal clocks set with respect to the ship’s GPS clock. The timings of these are given in Tables 5, 6 and 7. The temperature loggers are programmed to start at a later time and will do so according to their internal clocks. For example, a programmed and internally recorded start time of 09:00:00 may in fact be a few seconds earlier or later depending how much drift has occurred up to that time. The difference between the internally recorded time and GPS time for the last sample is likely to be even larger because of continuing clock drift for the duration of the deployment. The fluorometers, however, need to be treated differently. They cannot be programmed for a later start time and are started manually (this in itself can lead to some inaccuracy in the start time). If the instrument is started manually at 09:00:00 (GPS time) the internally recorded start time may be earlier or later than this because of internal clock drift up to that time. These differences between “real” time and recorded times may or may not be important depending on the magnitude of the clock drift and the frequency of events being studied.

Serial number	Calibration date	Calibration coefficients		Excitation: λ=470nm
		Offset	Scale factor	Emission: λ=695nm
777	28-Jun-07	67	0.0078	Sensitivity: 0.01μg l^{-1}
778	28-Jun-07	78	0.0076	Range: 0.01 to 125μg l^{-1}

779	28-Jun-07	78	0.0076	
907	14-Feb-08	83	0.0076	
937	14-Feb-08	80	0.0078	
939	14-Feb-08	78	0.0077	
*1512	5-Aug-09	50	0.0077	
*1513	5-Aug-09	49	0.0077	
*1514	5-Aug-09	50	0.0077	
1712	21-Jan-10	53	0.0077	

Table 1. Details and specifications of Wetlabs FLB chlorophyll fluorometers. *Fitted with biowiper.

<table>
<tr><th>Serial number</th><th>Calibration date</th><th>Depth range (m)</th><td rowspan="13">Temperature:
Accuracy: ±0.1ºC;
Resolution: 0.032ºC
Range: –1ºC to +40ºC
Time constant: 20s
Depth:
(100m sensor) Accuracy: ±0.4m
Resolution: 0.04m
(240m sensor) Accuracy: ±1.0m
Resolution: 0.08m</td></tr>
<tr><td>3269</td><td>29-Jun-07</td><td>100</td></tr>
<tr><td>3271</td><td>29-Jun-07</td><td>100</td></tr>
<tr><td>3272</td><td>29-Jun-07</td><td>100</td></tr>
<tr><td>3273</td><td>29-Jun-07</td><td>100</td></tr>
<tr><td>3275</td><td>29-Jun-07</td><td>100</td></tr>
<tr><td>3276</td><td>29-Jun-07</td><td>100</td></tr>
<tr><td>3278</td><td>29-Jun-07</td><td>100</td></tr>
<tr><td>3598</td><td>12-Feb-08</td><td>n/a</td></tr>
<tr><td>3599</td><td>12-Feb-08</td><td>n/a</td></tr>
<tr><td>3601</td><td>12-Feb-08</td><td>n/a</td></tr>
<tr><td>3602</td><td>12-Feb-08</td><td>n/a</td></tr>
<tr><td>3604</td><td>12-Feb-08</td><td>n/a</td></tr>
</table>

3605	12-Feb-08	n/a	
3606	12-Feb-08	n/a	
3608	12-Feb-08	n/a	
3610	12-Feb-08	n/a	
3613	12-Feb-08	n/a	
3614	12-Feb-08	n/a	
3616	12-Feb-08	n/a	
3619	12-Feb-08	n/a	
3653	17-Mar-08	240	
3655	17-Mar-08	240	
3661	18-Mar-08	240	
3662	18-Mar-08	240	

Table 2. Details and specifications of Star-Oddi Centi-T(D) temperature loggers.

Serial number	Calibration date	Serial number	Calibration date	
2605	30-May-07	2621	29-Jun-07	
2606	30-May-07	2623	29-Jun-07	
2609	30-May-07	2624	29-Jun-07	Accuracy: ±0.05ºC
2610	30-May-07	2625	29-Jun-07	Resolution: 0.013ºC
2611	30-May-07	2833	20-Mar-08	Range: –2ºC to +40ºC
2612	30-May-07	2834	20-Mar-08	Time constant: 18s
2613	30-May-07	2835	20-Mar-08	
2614	30-May-07	2839	20-Mar-08	

2617	29-Jun-07	2845	20-Mar-08	
2618	29-Jun-07	2846	20-Mar-08	
2620	29-Jun-07	2850	20-Mar-08	

Table 3. Details and specifications of Star-Oddi Starmon-mini temperature loggers.

Serial number	Calibration date	Depth range (m)	
3795		3500	
4463		7000	
5595		1000	
5596		1000	
7458	2-Nov-09	250	
7459	2-Nov-09	250	
7460	2-Nov-09	250	

Table 4. Details and specifications of Seabird MicroCATs.

Nominal depth (m)	Instrument type	Serial Number	Clock set		First sample		Last sample		†Clock drift (s)
			Date	Time	Date	Time	Date	Time	
Surface	M_{1000}	5596	4-Jun	11:25:15	4-Jun	21:00:01	19-Jun	20:57:01	+4
5	T_S	2834	2-Jun	08:35:57	4-Jun	12:00:00	Lost during recovery		
10	F	1712	2-Jun	12:08:46	4-Jun	12:04:03	19-Jun	18:09:03	+7
	T_S	2846	2-Jun	08:38:13	4-Jun	12:00:00	20-Jun	10:55:00	+1
15	F	907	2-Jun	12:17:21	4-Jun	12:02:03	19-Jun	19:54:03	+16
	T_S	2845	2-Jun	08:39:25	4-Jun	12:00:00	20-Jun	11:02:00	–6
20	RAS100		2-Jun		4-Jun				

	F	*1514	2-Jun	11:22:50	4-Jun	11:37:01	19-Jun	17:22:01	–13
	T_{100}	3276	2-Jun	09:25:39	4-Jun	12:00:00	20-Jun	08:46:00	–5
25	F	778	2-Jun	12:24:45	4-Jun	12:00:11	19-Jun	19:12:11	+85
	T_S	2850	2-Jun	08:40:11	4-Jun	12:00:00	20-Jun	11:07:00	–1
30	F	937	2-Jun	12:56:28	4-Jun	11:58:02	19-Jun	18:24:02	+7
	T_{100}	3278	2-Jun	09:26:19	4-Jun	12:00:00	20-Jun	08:58:00	–22
35	F	*1512	2-Jun	11:53:21	4-Jun	11:54:03	19-Jun	19:24:18	–3
	T_S	2833	2-Jun	08:41:44	4-Jun	12:00:00	20-Jun	11:10:00	–9
40	RAS500		2-Jun		4-Jun				
	F	*1513	2-Jun	11:39:54	4-Jun	11:40:05	19-Jun	17:41:34	+12
	T_{100}	3275	2-Jun	09:27:25	4-Jun	12:00:00	20-Jun	09:09:00	–12
45	F	938	2-Jun	13:04:33	4-Jun	11:56:02	19-Jun	20:11:02	+7
	T_S	2839	2-Jun	08:41:00	4-Jun	12:00:00	20-Jun	11:14:00	–2
50	F	777	2-Jun	13:15:44	4-Jun	11:52:11	19-Jun	20:27:11	+95
	T_S	2835	2-Jun	08:42:28	4-Jun	12:00:00	20-Jun	11:18:00	–5
55	F	779	2-Jun	13:23:47	4-Jun	11:50:11	19-Jun	19:42:11	+90
	M_{250}	7460	3-Jun	09:56:00	4-Jun	21:00:01	19-Jun	23:10:01	–1
60	T_{100}	3269	2-Jun	09:28:52	4-Jun	12:00:00	20-Jun	09:21:00	–10
70	T_S	2618	2-Jun	08:43:45	4-Jun	12:00:00	20-Jun	11:21:00	–17
85	T_{100}	3271	2-Jun	09:28:07	4-Jun	12:00:00	20-Jun	09:32:00	–11
100	T_S	2624	2-Jun	08:44:29	4-Jun	12:00:00	20-Jun	11:24:00	–18
Bottom	M_{250}	7459	3-Jun	10:12:00	4-Jun	21:00:01	19-Jun	22:10:01	0

Table 5: IM1, location: 49º 25.31’N, 08º 58.88’W, depth 140m. All data were logged at 1 minute intervals. All times are GMT. Instrument types are indicated by: F – Wetlabs FLB fluorometer; T_S – Star-Oddi Starmon-mini temperature logger; T_{PPP} – Star-Oddi Centi-TD temperature and depth logger, suffix denotes the pressure sensor limit in metres; M_{PPP} – Seabird MicroCAT with 250m pressure sensor, suffix denotes the pressure sensor limit in metres. †See Deployment Details section for notes on timings.

Nominal depth (m)	Instrument type	Serial Number	Clock set Date	Clock set Time	†First sample Date	†First sample Time	†Last sample Date	†Last sample Time	†Clock drift (s)
Surface	M_{7000}	4463			3-Jun	10:00:01	18-Jun	12:34:01	
5	T_S	2620	2-Jun	14:22:48	4-Jun	12:00:00	20-Jun	18:05:00	+6
10	T_S	2625	2-Jun	14:24:38	4-Jun	12:00:00	20-Jun	18:11:00	+25
15	T_S	2611	2-Jun	14:25:28	4-Jun	12:00:00	20-Jun	18:18:00	+11
20	T_S	2609	2-Jun	14:26:27	4-Jun	12:00:00	20-Jun	18:22:00	+13
25	T_S	2606	2-Jun	14:27:20	4-Jun	12:00:00	20-Jun	18:25:00	–15
30	T_{100}	3272	2-Jun	15:04:58	4-Jun	12:00:00	20-Jun	09:50:00	–32
35	T_S	2605	2-Jun	14:28:15	4-Jun	12:00:00	20-Jun	18:29:00	–24
40	T_S	2621	2-Jun	14:30:13	4-Jun	12:00:00	20-Jun	18:33:00	+10
45	T_S	2623	2-Jun	14:30:59	4-Jun	12:00:00	20-Jun	18:37:00	–15
50	T_S	2614	2-Jun	14:31:53	4-Jun	12:00:00	20-Jun	18:40:00	–15
55	T_{240}	3655	2-Jun	15:05:49	4-Jun	12:00:00	20-Jun	10:02:00	–14
60	T_{240}	3653	2-Jun	15:06:38	4-Jun	12:00:00	20-Jun	10:12:00	–18
70	T_S	2610	2-Jun	14:32:42	4-Jun	12:00:00	20-Jun	18:45:00	–23
85	T_S	2617	2-Jun	14:33:33	4-Jun	12:00:00	20-Jun	18:49:00	–28
100	T_S	2612	2-Jun	14:34:31	4-Jun	12:00:00	20-Jun	18:52:00	+8
120	T_S	2613	2-Jun	14:35:17	4-Jun	12:00:00	20-Jun	18:55:00	+7
Bottom	M_{250}	7458	3-Jun	10:32:00	5-Jun	09:00:01	18-Jun	12:15:01	0

Table 6: IM2, location: 49º 27.92’N, 08º 49.96’W, depth 149m. All data were logged at 1 minute intervals. All times are GMT. Instrument types are indicated by: T_S – Star-Oddi Starmon-mini temperature logger; T_{PPP} – Star-Oddi Centi-TD temperature and depth logger, suffix denotes the pressure sensor limit in metres; M_{PPP} – Seabird MicroCAT with 250m pressure sensor, suffix denotes the pressure sensor limit in metres. †See Deployment Details section for notes on timings.

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Nominal depth (m)	Instrument type	Serial Number	Clock set Date	Clock set Time	First sample Date	First sample Time	Last sample Date	Last sample Time	†Clock drift (s)
Surface	M_{3500}	3795			3-Jun	10:00:01	19-Jun	10:07:01	
5	T_C	3616	2-Jun	15:43:54	4-Jun	12:00:00	Lost during recovery		
10	T_C	3610	2-Jun	15:45:30	4-Jun	12:00:00	20-Jun	19:20:00	–8
15	T_C	3605	2-Jun	15:46:07	4-Jun	12:00:00	20-Jun	19:29:00	–7
20	T_C	3606	2-Jun	15:46:41	4-Jun	12:00:00	20-Jun	19:35:00	–9
25	T_C	3598	2-Jun	15:47:22	4-Jun	12:00:00	20-Jun	19:41:00	–8
30	T_{100}	3273	2-Jun	15:54:08	4-Jun	12:00:00	20-Jun	10:24:00	–32
35	T_C	3602	2-Jun	15:48:16	4-Jun	12:00:00	20-Jun	19:46:00	–11
40	T_C	3601	2-Jun	15:48:48	4-Jun	12:00:00	20-Jun	19:52:00	–11
45	T_C	3604	2-Jun	15:49:21	4-Jun	12:00:00	20-Jun	19:58:00	–10
50	T_C	3619	2-Jun	15:49:58	4-Jun	12:00:00	20-Jun	20:04:00	–8
55	T_{240}	3661	2-Jun	15:55:12	4-Jun	12:00:00	20-Jun	10:34:00	–24
60	T_{240}	3662	2-Jun	15:55:47	4-Jun	12:00:00	Lost during recovery		
70	T_C	3614	2-Jun	15:50:34	4-Jun	12:00:00	20-Jun	20:10:00	–12
85	T_C	3599	2-Jun	15:51:09	4-Jun	12:00:00	20-Jun	20:15:00	–21
100	T_C	3613	2-Jun	15:51:53	4-Jun	12:00:00	20-Jun	20:21:00	–21
120	T_C	3608	2-Jun	15:52:24	4-Jun	12:00:00	20-Jun	20:26:00	–13
Bottom	M_{1000}	5595	5-Jun	13:30:00	5-Jun	17:00:01	19-Jun	10:31:01	

Table 7: IM3, location: 49º 22.34'N, 08º 54.77'W, depth 136m.. All data were logged at 1 minute intervals. All times are GMT. Instrument types are indicated by: T_S – Star-Oddi Starmon-mini temperature logger; T_{PPP} – Star-Oddi Centi-TD temperature and depth logger, suffix denotes the pressure sensor limit in metres; M_{PPP} – Seabird MicroCAT with 250m pressure sensor, suffix denotes the pressure sensor limit in metres.
†See Deployment Details section for notes on timings.

Seabed landers (John Kenny)

RDI 150kHz narrowband ADCPs were deployed at WIS and IM3 on modified NOCL pop-up ADCP frames. A 300kHz RDI Workhorse ADCP was also fitted to WIS. Each frame was attached to a releasable aluminium bed frame fitted with lead ballast weights. A 12 m stray-line with pellet floats was attached to the top of each frame to facilitate recovery. A 300m spooling line was attached to the ballast and to the instrument frame via an acoustic release mechanism located on the instrument frame (only one benthos release was attached to the release mechanism along with a blank). This was to allow the ballast frame to be discarded should the spooling line become tangled and hinder the instrument frame from reaching the surface. The release mechanisms were standard titanium releases fitted with two "fizz link" burn wires on each. Each of the burn wires can be fired independently, only one being needed to release the mechanism and thus release the frame or the spooler line. Each frame was fitted with one RD Instruments 150 kHz broadband ADCP. Both ADCPs were set up independently. The Flowquest ADCP at IM1 was deployed on a pop-up frame. The frame was attached to a releasable ballast weight. A 12 m stray-line with pellet floats was attached to the top of each frame to facilitate recovery. The release mechanisms were the same as described earlier. The configuration of the ADCPs is given in Tables 8, 9 and 10. Figure 10.1 shows the 150kHz lander ready for deployment at WIS.

Figure 10.1: 150kHz ADCP lander ready for deployment at WIS.

An NMF supplied low-profile lander fitted with a 300kHz RDI Workhorse was deployed at IM2 and is shown in Figure 10.2. The setup script is listed below

```
;SHARPLES_13872_D352
CR1
CF11101
EA00000
EB00000
ED01120
ES35
EX11111
EZ1111111
TE00:05:00.00
TF10/06/01,16:00:00
```

```
TP00:06.66
WB0
WD111100000
WF0176
WN112
WP00045
WS0100
WV170
CK
CS
;Temperature      = 5.00
;Frequency        = 307200
;Deployment hours = 1440.00
```

Figure 10.2: NMF low-profile ADCP lander being recovered at IM2

<u>WIS</u>

Table 8: NOCL RDI ADCP setup (WIS) and details of the instruments

Number of depth cells	28
Depth cell size	4 m
Time per ensemble	2 minutes
Time per ping	4 s
Number of pings per ensemble	30
Data recorded	Velocity, correlation, echo intensity, percent good, heading, temperature, pitch, roll
Coordinates	Radial beam coordinates
Pitch and roll correction	No correction applied

Frame IS – RDI ADCP deployment						
Instrument	*Serial number*	*Deployment details*		*Recovery details*		*Data*
		Clock set	*First data*	*Last data*	*Drift (s)*	
RD Instruments 150 kHz ADCP, broadband	1149	15:20:00 31/05/2010	09:00:00 01/06/2010			
Benthos acoustic transponder	67679	Receive frequency 11.5 kHz, Transmit 12.0 kHz Release code B				
Benthos acoustic transponder	71904	Receive frequency 10.0 kHz, Transmit 12.0 kHz Release code C				
Benthos acoustic transponder (Spooler)	72378	Receive frequency 10.5 kHz, Transmit 12.0 kHz Release code A				

IM1

Table 9: NOCL FLOWQUEST ADCP setup (IM1) and details of the instruments

Number of depth cells	31
Depth cell size	4 m
Time per ensemble	2 minutes
Time per ping	1 s
Number of pings per ensemble	120
Data recorded	Velocity, correlation, echo intensity, percent good, heading, temperature, pitch, roll, SNR, signal strength, pressure
Coordinates	Radial beam, Instrument and earth coordinates
Pitch and roll correction	No correction applied

Frame IM2 – FLOWQUEST ADCP deployment						
Instrument	*Serial number*	*Deployment details*		*Recovery details*		*Data*
		Clock set	*First data*	*Last data*	*Drift (s)*	
Flowquest ADCP	011048	08:51:00 01/06/2010	15:00:00 01/06/2010	10:48:55 20/06/2010	In sync	27782 kbytes
Benthos acoustic transponder	72863	Receive frequency 13.5 kHz, Transmit 12.0 kHz Release code A				
Benthos acoustic transponder	70355	Receive frequency 10.0 kHz, Transmit 12.0 kHz Release code B				

IM2

Table10: NMF-SS RDI ADCP setup (IM2) and details of the instruments

Number of depth cells	112
Depth cell size	1m
Time per ensemble	5 minutes
Time per ping	6.66 s
Number of pings per ensemble	45
Data recorded	Velocity, correlation, echo intensity, percent good, heading, temperature, pitch, roll
Coordinates	Earth coordinates
Pitch and roll correction	Pitch and roll used in coordinate transformation

Frame IM2 – RDI ADCP deployment						
Instrument	*Serial number*	*Deployment details*		*Recovery details*		*Data*
		Clock set	*First data*	*Last data*	*Drift (s)*	
RD Instruments 300 kHz ADCP, broadband	???	???	16:00:00 01/06/2010	???	???	???
Acoustic transponder	???	???				

??? information not received from NMF-SS

IM3

Table 10: NOCL RDI ADCP setup (IM3) and details of the instruments

Number of depth cells	37
Depth cell size	4 m
Time per ensemble	2 minutes
Time per ping	4 s
Number of pings per ensemble	30
Data recorded	Velocity, correlation, echo intensity, percent good, heading, temperature, pitch, roll
Coordinates	Radial beam coordinates

Pitch and roll correction	No correction applied

Frame IM3 – RDI ADCP deployment						
Instrument	*Serial number*	*Deployment details*		*Recovery details*		*Data*
		Clock set	*First data*	*Last data*	*Drift (s)*	
RD Instruments 150 kHz ADCP, broadband	1148	09:35:00 31/05/2010	09:00:00 01/06/2010	16:00:00 18/06/2010	+3	10360 kbytes
Benthos acoustic transponder	72858	Receive frequency 14.5 kHz, Transmit 12.0 kHz Release code A				
Benthos acoustic transponder	70354	Receive frequency 13.0 kHz, Transmit 12.0 kHz Release code A				
Benthos acoustic transponder (spooler)	71919	Receive frequency 10.5 kHz, Transmit 12.0 kHz Release code C				

Mid-water ADCP (Chris Old)

Overview

At mooring IM1 an upward-looking 600 kHz ADCP was deployed in a mid-water float to provide a high vertical resolution measure of the velocity field from the base of the thermocline into the surface mixed layer. Two separate configurations were trialed. The first was a 3 day high frequency times series, the second a low frequency deployment which continued until the moorings were recovered.

Two difficulties arose with this deployment. The water depth at the mooring location was 20m deeper than estimated from the navigation charts and the surface mixed layer was 10m shallower than expected. The mooring had to be extended by 20m to get the float close to the base of the thermocline. The nominal range for a 600 kHz ADCP is approximately 60m, realistically you get about 45m, so the instrument would not be able to measure to the surface and while the mixed layer was shallow it would not see into the mixed layer.

The high frequency configuration was a compromise between collecting turbulence data and covering the needs of the inertial oscillations experiment. It was decided that Mode 12 would be used for the high frequency configuration to give the required measurement range while reducing the measurement noise for the turbulence measurements.

For the high-frequency deployment the ADCP was pre-programmed to start collecting data at 1200 on 05/06/2010, for the low-frequency deployment the instrument was programmed to start immediately.

Deployment details

4	5 High Freq.	6 Low Freq.
7 ADCP Serial Number	8 8275	9 7301
10 Deploy date	11 05 / 06 / 2010	12 09 / 06 / 2010
13 Deploy time	14 11:36	15 13:28
16 Latitude	17 49° 25.1’ N	18 49° 25.18’ N
19 Longitude	20 008° 59.2’ W	21 008° 59.26’ W
22 Water depth at deploy	23 138m	24 139m
25 Recovery date	26 09 / 06 / 2010	27 19 / 06 / 2010
28 Recovery time	29 12:00	30 10:15
31 Config. File	32 im1_adcp600_hf_cfg.txt	33 im1_adcp600_lf_cfg.txt

The mooring was designed so that the anchor weight was left behind when the mooring was recovered. A 600 kg weight was used for the high-frequency mooring and a 1000kg weight was used for the low-frequency mooring.

Mid-water ADCP Configuration Files

High-frequency configuration

```
CR1
CF11101
EA0
EB0
ED580
ES35
EX00000
EZ1111101
WA50
WB0
WD111100000
WF88
WM12
WN190
WP1
WS20
WO10,6
WV40
TE00:00:03.00
TP00:00.00
RNIM1MW
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 614400
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = NO
;High Rate Pinging = YES
;Shallow Bottom Mode= NO
;Wave Gauge        = NO
;Lowered ADCP      = NO
;Beam angle        = 20
;Temperature       = 11.00
;Deployment hours  = 24.00
;Battery packs     = 1
;Automatic TP      = YES
;Memory size [MB]  = 256
;Saved Screen      = 3
;
;Consequences generated by PlanADCP version 2.02:
;First cell range  = 2.13 m
;Last cell range   = 39.93 m
;Max range         = 45.56 m
;Standard deviation = 2.28 cm/s
;Ensemble size     = 3948 bytes
;Storage required  = 108.44 MB (113702400 bytes)
;Power usage       = 55.80 Wh
;Battery usage     = 0.1
;
; WARNINGS AND CAUTIONS:
; The number of pings is too low for reasonable sampling of the currents.
; Advanced settings has been changed.
; Expert settings has been changed.
```

Low-frequency configuration

```
CR1
CF11101
```

```
EA0
EB0
ED580
ES35
EX00000
EZ1111101
WA50
WB0
WD111100000
WF88
WM12
WN130
WP2
WS50
WO20,10
WV80
TE00:00:30.00
TP00:15.00
RNIM1M2
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 614400
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = YES
;High Rate Pinging = YES
;Shallow Bottom Mode= NO
;Wave Gauge        = NO
;Lowered ADCP      = NO
;Beam angle        = 20
;Temperature       = 11.00
;Deployment hours  = 480.00
;Battery packs     = 1
;Automatic TP      = YES
;Memory size [MB]  = 2048
;Saved Screen      = 3
;
;Consequences generated by PlanADCP version 2.02:
;First cell range  = 1.90 m
;Last cell range   = 66.40 m
;Max range         = 43.84 m
;Standard deviation = 1.44 cm/s
;Ensemble size     = 2748 bytes
;Storage required  = 150.95 MB (158284800 bytes)
;Power usage       = 366.14 Wh
;Battery usage     = 0.8
;
; WARNINGS AND CAUTIONS:
; The number of pings is too low for reasonable sampling of the currents.
; Advanced settings has been changed.
; Expert settings has been changed.
```

11. Meteorological Stations (John Kenny)

Airmar PB200 weather stations were deployed on the surface buoys at all mooring sites. The PB200 sensors were approximately 1.8m above sea level. Each weather station has a delay offset from the ensemble interval of approximately +115s. This is the sum of the initialisation of the CR800 from 'sleep mode' (aprox. 50s) and the time it take for the PB200 to get a GPS fix (60s). For example, a typical cycle would be; at time 00:00:00 system wakes up. At time 00:01:55 system starts sampling. At time 00:02:55 system stops sampling, processes data and goes into 'sleep mode.

The system measures average wind speeds, wind direction, max wind speed and max wind speed direction, air pressure, air temperature, pitch, roll and heading. Measurements are made relative to earth (using GPS, heading pitch and roll data, directional information recorded in degrees from true north and magnetic north) and relative to the PB200 sensor (using heading data, directional information is recorded in degrees from magnetic north). See weather station documentation contained with the data for further information.

NOCL Weather Station system setup and details of the instruments

Ensemble interval	10 minutes from the hour
Time per ensemble	1 minutes
Time per ping	1 s
Number of pings per ensemble	60
Ensemble start offset	+115s
Data recorded	Average wind speed, wind direction, max wind speed and max wind speed direction, air pressure, air temperature, pitch, roll and heading. Measurements made relative to earth and relative to instrument.

<u>IM1</u>

NOCL Weather Station four – IM1						
Instrument	*Serial number*	*Deployment details*		*Recovery details*		*Data*
		Clock set	*First data*	*Last data*	*Drift (s)*	
Airmar PB200 System CR800	18587544	14:08:00 31/05/2010	14:50:00 31/05/2010	17:50:00 20/06/2010	In sync	923 kbytes

IM2

NOCL Weather Station one – IM2						
Instrument	*Serial number*	*Deployment details*		*Recovery details*		*Data*
		Clock set	*First data*	*Last data*	*Drift (s)*	
Airmar PB200 System CR800	1858750 1	10:30:00 31/05/2010	11:00:00 31/05/2010	11:20:00 18/06/2010	In sync	858 kbytes

IM3

NOCL Weather Station three – IM3						
Instrument	*Serial number*	*Deployment details*		*Recovery details*		*Data*
		Clock set	*First data*	*Last data*	*Drift (s)*	
Airmar PB200 System CR800	1858753 3	14:21:00 31/05/2010	14:30:00 31/05/2010	16:30:00 18/06/2010	In sync	865 kbytes

WIS

NOCL Weather Station two – WIS						
Instrument	*Serial number*	*Deployment details*		*Recovery details*		*Data*
		Clock set	*First data*	*Last data*	*Drift (s)*	
Airmar PB200 System CR800	1858755 2	11:09:00 31/05/2010	14:20:00 31/05/2010			kbytes

12. Nutrient Analysis (Charlotte Williams, Claire Mahaffey)

Seawater samples were collected at discrete depths through the water column and analysed onboard for inorganic nutrients in order to determine the vertical and horizontal distribution of nutrients in the Celtic Sea. A rosette frame supporting a Seabird CTD instrument and twenty-four 10L Niskin bottles was used to collect samples between the surface water and a maximum depth of 1750m. Sampling was performed at a higher spatial resolution through the subsurface chlorophyll maximum (SCM) region.

Seawater samples were collected directly from each Niskin bottle into acid-washed, deionised water rinsed 250ml HDPE screwcap bottles. Bottles were rinsed 3 times with sample seawater before being filled to 90% volume. Samples were collected from 37 CTD casts and nutrient concentrations were determined within 2 hours of sample collection. In addition, seawater samples were collected into acid-washed, deionised water rinsed 60ml HDPE bottles from 32 of the 37 CTD casts and frozen immediately at -20°C. Nutrient samples were labelled with cruise number (D352), CTD cast number, Niskin bottle number and depth (m) (Table 1). Frozen seawater samples were packed into cool boxes containing dry ice and transported to the University of Liverpool.

Inorganic nutrient concentrations were determined using a Bran and Luebbe QuAAtro 5-channel segmented flow nutrient analyser. Nitrate plus nitrite, silicate, phosphate and nitrite concentrations were determined using standard colorimetric techniques (NIOZ method). Ammonium concentrations were determined by fluorometric techniques using a JASCO FP-2020 Intelligent fluorescence detector (Kerouel & Aminot, 1997). Reagents were prepared onboard every 3 to 5 days from analytical or HPLC grade pre-weighed dry and wet chemicals.

Calibration standards were prepared daily using primary nutrient stock standards (10mM) which were stored in plastic amber bottles in the fridge. Typical calibration standard concentrations ranged from 1 to 10 µM for nitrate and silicate and 0.1 to 1 µM for nitrite, phosphate and ammonium. All calibration standards were prepared in artificial seawater (35g of sodium chloride, 0.5g of sodium bicarbonate). Correlation coefficients were typically better than 0.9995. To check accuracy of analysis and calibration standards, an independent OSIL nutrient standard (Ocean Scientific, 10mM stock standards in seawater) was prepared every 3 to 5 days in artificial seawater and the concentrations determined in triplicate during each analytical run. If OSIL standard concentrations deviated significantly (> 5%) from the expected value (5 µM for nitrate and silicate, 0.5 µM for nitrite and phosphate), the analysis was stopped and either calibration standards or reagents adjusted.

Peak heights, representative of concentration, were captured using the Bran and Luebbe AACE software and included corrections for baseline and calibration standard drift. Calibration and sample data were processed in Microsoft Excel and the mean and standard deviation of each triplicate analysis calculated. The OSIL concentration, regression correlation and calibration data were recorded. The typical limits of detection for each nutrient analysed were (a) nitrate plus nitrite, 0.05 µM (b) silicate, 0.1 µM (c) phosphate

0.05 µM, (d) ammonium 0.1 µM and (e) nitrite, 0.05 µM. The typical precision of analysis for each nutrient analysed was (a) nitrate plus nitrite ± 0.02 µM, (b) silicate ± 0.06 µM, (c) phosphate ± 0.02 µM (d) ammonium ± 0.1 µM (e) nitrite ± µM

Problems within the nutrient analysis

(1) Ammonium reagents: During initial reagent preparation onboard, it was noted that the ammonium mixed reagent was contaminated (standard peaks showed a negative rather than positive peak relative to the baseline, showing dilution of the reagent). Each ingredient of the mixed reagent was replaced and it was found that the sodium tetraborate was the source of contamination, potentially due to storage in plastic containers. Fortunately, smaller amounts of sodium tetraborate had been stored in glass vials and were used to reagent preparation. However, due to the risk of contamination and sensitivity of the reagent to light, the mixed reagent was prepared fresh every 1-2 days. All glassware was acid soaked and rinsed at least 5 times with deionised water before the reagent was prepared.

(2) Cadmium column regeneration: Every 2 to 3 days, the efficiency of the cadmium column, used to convert nitrate to nitrite, decreased due to the surface of the cadmium column becoming oxidised. This reduction in cadmium column efficiency was manifested as an increase in the gain of the high standard (e.g. typical gain of 173, increased to > 230). Online cadmium column regeneration was therefore performed on a regular basis and consisted of pumping 10% hydrochloric acid and copper sulphate through the imadizole buffer line for 1, 2 and 5 minutes respectively.

References

Kerouel, R. & A. Aminot, 1997: Fluorometric determination of ammonia in sea and estuarine waters by direct segmented flow analysis. *Mar. Chem.* **57,** 3-4, pp 265-275

Table 1. Date, time and CTD number where nutrient samples were collected. 'DNF' and 'L' mean that the Niskin bottle did not fire or leaked, respectively. 60ml frozen samples marked 'x*' signifies samples that were labelled 1 to 9 instead of Niskin bottle number.

DATE	TIME	CTD CAST	NISKIN BOTTLE	DEPTH	200ML SAMPLE	60ML FROZEN SAMPLE
03/06/2010	03:30	2	1	42m	x	x
			3	17m	x	x
			5	14m	x	x
			7	11m	x	x
			9	5m	x	x
03/06/2010	14:00	3	1	97m	x	x
			3	77m	x	x
			5	62m	x	x
			7	52m	x	x
			9	42m	x	x

			11	37m	x	x
			13	30m	x	x
			15	25m	x	x
			17	22m	x	x
			19	17m	x	x
			21	7m	x	x
			23	surface	x	x
04/06/2010	16:40	4	1	100m	x	x
			2	80m	x	x
			3	60m	x	x
			4	50m	x	x
			5	40m	x	x
			6	36m	x	x
			7	31m	x	x
			8	26m	x	x
			9	20m	x	x
			10	15m	x	x
			11	10m	x	x
			12	3m	x	x
05/06/2010	03:30	6	1	127m	x	x
			2	60m	x	x
			4	55m	x	x
			5	48m	x	x
			7	46m	x	x
			8	42m	x	x
			9	38m	x	x
			12	33m	x	x
			14	20m	x	x
			16	surface	x	x
06/06/2010	03:38	7	1	126m	x	x
			2	52m	x	x
			4	48m	x	x
			5	43.5m	x	x
			7	41.9m	x	x
			8	36.6m	x	x
			12	31.7m	x	x
			14	16.6m	x	x
			16	2m	x	x
06/06/2010	04:45	8	1	70m	x	x
			5	37m	x	x
07/06/2010	06:00	12	1	110m	x	x
			3	90m	x	x
			5	70m	x	x
			7	50m	x	x
			9	45m	x	x
			11	35m	x	x

			13	30m	x	x
			15	20m	x	x
			17	5m	x	x
07/06/2010	16:00	13	1	121m	x	x
			3	91m	x	x
			5	70.7m	x	x
			7	51.3m	x	x
			9	43m	x	x
			11	40.2m	x	x
			13	36.6m	x	x
			15	30m	x	x
			17	20m	x	x
			19	5m	x	x
07/06/2010	22:24	14	1	120m	x	x
			3	90m	x	x
			5	70m	x	x
			7	50m	x	x
			9	45m	x	x
			12	40m	x	x
			13	35m	x	x
			15	20m	x	x
			17	5m	x	x
08/06/2010	04:15	15	1	120m	x	x*
			2	90m	x	x*
			3	70m	x	x*
			4	50m	x	x*
			5	45m	x	x*
			6	40m	x	x*
			7	35m	x	x*
			8	20m	x	x*
			9	5m	x	x*
08/06/2010	21:30	16	1	120m	x	x*
			3	90m	x	x*
			5	70m	x	x*
			7	50m	x	x*
			9	45m	x	x*
			11	37m	x	x*
			13	34m	x	x*
			15	20m	x	x*
			17	5m	x	x*
09/06/2010	03:36	17	1	120m	x	x
			2	55m	x	x
			4	47m	x	x
			5	43m	x	x
			7	41m	x	x
			8	40m	x	x

			12	30m	x	x
			14	15m	x	x
			16	surface	x	x
09/06/2010	16:40	19	1	120m	x	x
			2	90m	x	x
			3	70m	x	x
			4	50m	x	x
			5	45m	x	x
			6 - L	40m	x	x
			7	35m	x	x
			8	20m	x	x
			9	5m	x	x
10/06/2010	05:30	21	1	120m	x	x
			2	90m	x	x
			3	70m	x	x
			4	50m	x	x
			5	47m	x	x
			6	40m	x	x
			7	35m	x	x
			8	20m	x	x
			9	5m	x	x
10/06/2010	13:18	22	1	120m	x	x
			3	90m	x	x
			5	70m	x	x
			7	50m	x	x
			9	43m	x	x
			11	35m	x	x
			13	33m	x	x
			15	20m	x	x
			17	5m	x	x
10/06/2010	22:00	23	1	120m	x	x*
			3	90m	x	x*
			5	70m	x	x*
			7	50m	x	x*
			9	45m	x	x*
			11	35m	x	x*
			13	30m	x	x*
			15	20m	x	x*
			17	5m	x	x*
11/06/2010	11:00	24	1	120m	x	x
			3	90m	x	x
			5	70m	x	x
			7	50m	x	x
			9	45m	x	x
			11	35m	x	x
			13	30m	x	x

			15	20m	x	x
			17	5m	x	x
11/06/2010	21:00	25	1	120m	x	x
			3	90m	x	x
			5	70m	x	x
			7	50m	x	x
			9	45m	x	x
			11	35m	x	x
			13	30m	x	x
			15	20m	x	x
			17	5m	x	x
12/06/2010	03:30	26	1	120m	x	x
			3	90m	x	x
			5	70m	x	x
			7	50m	x	x
			9	45m	x	x
			11	35m	x	x
			13	30m	x	x
			15	20m	x	x
			17	5m	x	x
13/06/2010	03:30	29	1	150m	x	x
			2	65m	x	x
			4	50m	x	x
			5	45m	x	x
			7	42m	x	x
			8	40m	x	x
			9	36m	x	x
			14	25m	x	x
			16	15m	x	x
			18	surface	x	x
13/06/2010	22:40	31	1	140m	x	x
			3	90m	x	x
			5	70m	x	x
			7	50m	x	x
			9	45m	x	x
			11	40m	x	x
			13	35m	x	x
			15	20m	x	x
			17	5m	x	x
16/06/2010	03:30	38	1	120m	x	x
			2	50m	x	x
			4	40m	x	x
			5	35m	x	x
			7	33m	x	x
			8	29m	x	x
			12	25m	x	x

			14	15m	x	x
			16	surface	x	x
16/06/2010	07:30	40	1	125m	x	x
			3	80m	x	x
			5	50m	x	x
			7	45m	x	x
			9	40m	x	x
			11	35m	x	x
			13	30m	x	x
			15	20m	x	x
			17	3m	x	x
16/06/2010	10:20	41	1	130m	x	x
			3	80m	x	x
			5	50m	x	x
			7	45m	x	x
			9	40m	x	x
			11	35m	x	x
			13	30m	x	x
			15	20m	x	x
			17	5m	x	x
16/06/2010	11:48	42	1	120m	x	x
			3	80m	x	x
			5	45m	x	x
			7	40m	x	x
			9	35m	x	x
			11	30m	x	x
			13	20m	x	x
			15	10m	x	x
			17	surface	x	x
16/06/2010	01:40	43	1	85m	x	x
			3	50m	x	x
			5	40m	x	x
			7	30m	x	x
			9	22m	x	x
			11	17m	x	x
			13	12m	x	x
			15	2m	x	x
16/06/2010	17:05	44	1	90m	x	x
			3	50m	x	x
			5	30m	x	x
			7	26m	x	x
			9	24m	x	x
			11	15m	x	x
			13	10m	x	x
			15	2m	x	x
16/06/2010	16:12	45	1	95m	x	x

			3	50m	x	x
			5	35m	x	x
			7	27m	x	x
			9	25m	x	x
			11	20m	x	x
			13	10m	x	x
			15	1m	x	x
17/06/2010	05:00	46	1	120m	x	x
			3	50m	x	x
			5	40m	x	x
			7	35m	x	x
			9	32m	x	x
			14	28m	x	x
			16	20m	x	x
			18	10m	x	x
			20	surface	x	x
19/06/2010	06:00	48	1	120m	x	
			2	70m	x	
			5	60m	x	
			8	52m	x	
			9	45m	x	
			10	41m	x	
			13	35m	x	
			15	25m	x	
			17	10m	x	
			19	surface	x	
19/06/2010	21:30	50	1	135m	x	
			3	70m	x	
			5	40m	x	
			7	35m	x	
			9	30m	x	
			11	20m	x	
			13	10m	x	
			15	surface	x	
19/06/2010	23:22	51	1	150m	x	x
			3	100m	x	x
			5	65m	x	x
			7	55m	x	x
			9	45m	x	x
			11	40m	x	x
			13	30m	x	x
			15	20m	x	x
			17	10m	x	x
			19	surface	x	x
20/06/2010	00:15	52	1	155m	x	
			3	90m	x	

			5	62m	x	
			7	45m	x	
			9	35m	x	
			11	25m	x	
			13	20m	x	
			15	10m	x	
			17	2m	x	
20/06/2010	03:29	53	1	180m	x	x
			2	60m	x	x
			4	40m	x	x
			5	30m	x	x
			7	25m	x	x
			8	22m	x	x
			12	18m	x	x
			14	10m	x	x
			16	surface	x	x
20/06/2010	13:30	55	1	540m	x	
			3	400m	x	
			5	300m	x	
			7	200m	x	
			9	100m	x	
			11	50m	x	
			13	30m	x	
			15	20m	x	
			17	8m	x	
			19	surface	x	
20/06/2010	13:30	55	1	540m	x	
			3	400m	x	
			5	300m	x	
			7	200m	x	
20/06/2010	15:50	56	1	1750m	x	x
			2	1400m	x	x
			3	1100m	x	x
			4	950m	x	x
			5	700m	x	x
			6	600m	x	x
			7	500m	x	x
			8	450m	x	x
			9	400m	x	x
			10	350m	x	x
			11	300m	x	x
			12	250m	x	x
			13	200m	x	x
			14	150m	x	x
			15	100m	x	x
			16	60m	x	x

			17	40m	x	x
			18	30m	x	x
			19	20m	x	x
			20	10m	x	x
			21	5m	x	x
			22	surface	x	x

13. RAS Sampling (Charlotte Williams, Claire Mahaffey, Jo Hopkins)

Two McLane Remote Access Samplers (RAS) were used to collect daily water samples at mooring IM1. The RAS is a time series water sampler that can collect up to 48 individual samples at pre-programmed times at depths of up to 5,500m. A RAS-500 (500ml samples) was moored within the DCM at 40m, and a RAS-100 (100ml samples) was placed in the upper mixed layer 20 m below the surface (nominal depths).

RAS-500 during tank tests

RAS-100 during tank tests

Individual sample holders each contain a sample bag (500ml or 100ml). A multi-port rotary valve directs seawater to each collapsed bag mounted inside the holder. The top head has a single intake valve and 50 exhaust ports (connected in series to the tops of the sample holders); the bottom head has 50 intake ports (connected in series to the bottom of each sample holder), and one exhaust port. Ports 0 and 49 are 'home' and acid ports respectively, 1-48 are for water samples. The pump draws water out of the sample holder in which a collapsed sample bag is mounted. This pumping creates a pressure gradient that drives the ambient seawater through the intake and into the sample bags. After each sample the multi-port valve returns to 'home' sealing the sample in the bag.

To prevent sample contamination and reduce bio-fouling the valve flushes resident water from the intake tube and valve head before each sample is collected. Furthermore, a pre-sample acid flush (10ml) of the tubing and valves was also performed with 10% hydrochloric acid. A 25mm filter holder placed in-line with the flush port ('home') to protect the valve from damage to large particles was NOT fitted with a filter. Firstly, suspended particle concentration in the area was expected to be low and secondly, we didn't want to exclude a particular size of phytoplankton from the sampling.
Further details of the RAS can be found in the McLane Remote Access Sampler (RAS) User Manual - http://www.mclanelabs.com/ras.html.

Sampling strategy

Both RAS were programmed to take two samples daily at 12:00 between 05/06/2010 and 23/06/2010, the first for inorganic nutrients, the second for phytoplankton identification and ennumeration. On 14/06/2010 an additional two samples were taken at 14:00, 16:00, 18:00, 20:00 and 22:00 in order to capture any changes over a spring to neap transition.

Clear bags (odd sample numbers) were used to collect inorganic nutrient samples (nitrate+nitrite, phosphate, silicate, and nitrite). Mercuric chloride was pre-loaded into the bags such that its final concentration, once a sample had been taken, was 20mg/l. Nutrient samples were passed through a 1 micron polyester filter (25mm and 47mm diameter for RAS-100 and -500 respectively) loaded into a filter cap directly above the sample holder intake. This was to exclude phytoplankton cells from the sample that may absorb or release nutrients thus changing the concentrations during storage. The 25mm and 47mm 1µm Polyester Membrane Filters were ordered from STERLITECH (P/N PET1025100 and P/N PET1047100 respectively).

Metallic bags (even sample numbers) pre-loaded with the preservative lugols iodine were used for the collection of phytoplankton samples. 500ml and 100ml bags contained 10ml and 2ml of preservative respectively. i.e. a final 2% concentration of lugols. The metallic bags were used to cut out any light and prevent the iodine from photo-degrading.

Instrument configuration/setup

<u>RAS-500 (serial # ML12500-01)</u>

Header A| D352 RAS 500 Jun 2010
B| 49 25.6N, 8 58.5W
C| IM1 in DCM
Acid D| Pre-sample acid flush: Enabled
E| Flushing volume = 10 [ml]
F| Flushing time limit = 1 [min]
G| Exposure time delay = 1 [min]
Water H| Flushing volume = 100 [ml]
I| Flushing time limit = 5 [min]
Sample J| Sample volume = 500 [ml]
K| Sample time limit = 25 [min]
Acid L| Post-sample acid flush: Disabled
M| Flushing volume = NA [ml]
N| Flushing time limit = NA [min]
Timing P| Pump data period = 15 [sec]

RAS-100 (serial # ML12500-02)

Header	A| D352 RAS 100 Jun 2010		Water	H| Flushing volume =	100 [ml]
	B| 49 25.6N, 8 58.5W			I| Flushing time limit =	5 [min]
	C| IM1 in Surface		Sample	J| Sample volume =	100 [ml]
				K| Sample time limit =	6 [min]
Acid	D| Pre-sample acid flush:	Enabled	Acid	L| Post-sample acid flush:	Disabled
	E| Flushing volume =	10 [ml]		M| Flushing volume =	NA [ml]
	F| Flushing time limit =	1 [min]		N| Flushing time limit =	NA [min]
	G| Exposure time delay =	1 [min]	Timing	P| Pump data period =	15 [sec]

Recovery

Both RAS were recovered on 19/06/2010, therefore only the first 40 samples from each instrument were taken.

39 samples from the RAS-500 were successfully collected and the bags chilled for future analysis at Liverpool University. All sample bags from the RAS-100 split (see sample collection problems).

Sample collection problems

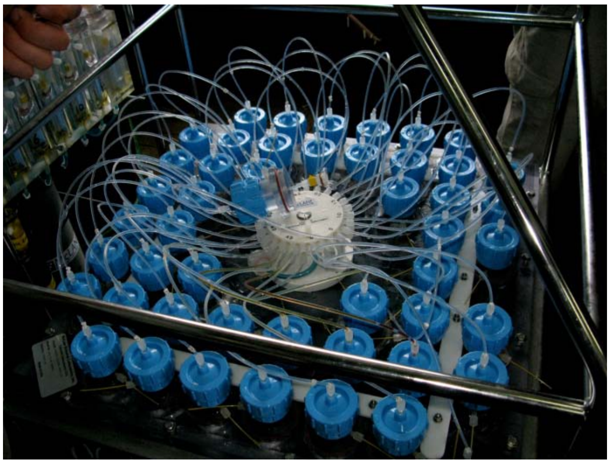
When the frames were deployed they were turned upside down while being fixed to the mooring. This resulted in both lugols iodine and mercuric chloride being pushed back through each of the individual intake tubes and filters. Chemicals were found in the top intake tube (between the intake value and protective filter) and could therefore potentially have reached each sample.

Sample tube number 5 and its sample bag were lost during either recovery or deployment of the RAS-500. Surrounding tubes and the hold down brackets were undamaged.
The top tubing from sample number 42 on the RAS-100 was found detached from the filter holder upon recovery. However this sample was programmed for the 20th June and therefore not taken.

All sample bags from the RAS-100 split. It is thought that the 100-101 ml of sample plus the small amount of preservative added to each bag was a volume that exceeded the capacity of the bag. The possibility of contamination meant that all nutrient samples were discarded. The outer metallic layer of the phytoplankton sample bags split but despite some leakage the inner bag lining was just about intact enough for the sample to be worth saving.

Sample tube 5 missing from RAS-500 upon recovery

Lugols leaked from bags in RAS-100



Lugols in in-take tubing in RAS-500

RAS-500 sample times and volumes

Sample	Date - Time	Sample Vol. (ml)
1	06/05/10 12:00:00	502
2	06/05/10 12:09:47	502
3	06/06/10 12:00:00	502
4	06/06/10 12:09:58	502
5	06/07/10 12:00:00	502
6	06/07/10 12:10:06	502
7	06/08/10 12:00:00	502
8	06/08/10 12:10:14	502
9	06/09/10 12:00:00	502
10	06/09/10 12:10:22	502
11	06/10/10 12:00:00	502
12	06/10/10 12:10:30	502
13	06/11/10 12:00:00	502
14	06/11/10 12:10:38	502
15	06/12/10 12:00:00	502
16	06/12/10 12:10:46	502
17	06/13/10 12:00:00	501
18	06/13/10 12:11:55	502
19	06/14/10 12:00:00	501
20	06/14/10 12:11:08	502
21	06/14/10 14:00:00	502
22	06/14/10 14:11:10	502
23	06/14/10 16:00:00	502
24	06/14/10 16:11:18	502
25	06/14/10 18:00:00	502
26	06/14/10 18:11:26	502
27	06/14/10 20:00:00	501
28	06/14/10 20:11:22	501
29	06/14/10 22:00:00	502
30	06/14/10 22:11:14	502
31	06/15/10 12:00:00	502
32	06/15/10 12:11:06	502
33	06/16/10 12:00:00	501
34	06/16/10 12:10:58	502
35	06/17/10 12:00:00	501
36	06/17/10 12:10:50	502
37	06/18/10 12:00:00	502
38	06/18/10 12:10:42	501
39	06/19/10 12:00:00	502
40	06/19/10 12:10:34	502

RAS-100 Sample times and volumes

Sample	Date-Time	Sample Vol. (ml)
1	06/05/10 12:00:00	101
2	06/05/10 12:04:28	101
3	06/06/10 12:00:00	101
4	06/06/10 12:04:40	101
5	06/07/10 12:00:00	101
6	06/07/10 12:04:47	101
7	06/08/10 12:00:00	101
8	06/08/10 12:04:56	101
9	06/09/10 12:00:00	101
10	06/09/10 12:05:04	100
11	06/10/10 12:00:00	101
12	06/10/10 12:05:11	101
13	06/11/10 12:00:00	100
14	06/11/10 12:05:21	101
15	06/12/10 12:00:00	101
16	06/12/10 12:05:27	101
17	06/13/10 12:00:00	101
18	06/13/10 12:05:35	100
19	06/14/10 12:00:00	101
20	06/14/10 12:05:43	100
21	06/14/10 14:00:00	101
22	06/14/10 14:05:51	101
23	06/14/10 16:00:00	101
24	06/14/10 16:05:59	101
25	06/14/10 18:00:00	101
26	06/14/10 18:06:07	101
27	06/14/10 20:00:00	100
28	06/14/10 20:06:03	101
29	06/14/10 22:00:00	101
30	06/14/10 22:05:56	101
31	06/15/10 12:00:00	101
32	06/15/10 12:05:48	101
33	06/16/10 12:00:00	101
34	06/16/10 12:05:39	101
35	06/17/10 12:00:00	101
36	06/17/10 12:05:31	101
37	06/18/10 12:00:00	100
38	06/18/10 12:05:23	101
39	06/19/10 12:00:00	101
40	06/19/10 12:05:15	100

14. 15-N Labelled Nitrate & Ammonium experiments (Charlotte Williams)

An investigation into the uptake and assimilation of two different forms of nitrogen (ammonium and nitrate) in the surface, peak subsurface chlorophyll maximum (SCM) and base of the SCM was performed using a ^{15}N-labelled stable isotope approach. Experiments were conducted at three stations in the Celtic Sea (Table 1). At each of the three stations seven seawater samples (volume 1.5L) were transferred in 2L precleaned (pre-washed with 10% hydrochloric acid, rinsed 3 times with deionised water and 3 times with sample seawater) polycarbonate bottles at each of the three defined depths. One bottle was filtered immediately and represented the initial natural stable isotope abundance at each specified depth. The remaining bottles were divided into 2 groups for each depth, where half were spiked with ^{15}N labelled ammonium and the other half were spiked with ^{15}N labelled nitrate (Table 2). These 'labelled' bottles (18 in total) were incubated according to the depth-dependent light intensity for 24 hours. The polycarbonate bottles were pre-washed with 10% HCl acid and rinsed 3 times with deionised water, followed by being rinsed 3 times with the actual seawater sample.

Table 1**:** Location and time for seawater collection for ^{15}N experiments.

CTD number	**Location**	**DATE**	**TIME**	**LAT**	**LONG**
30	(SHELF EDGE)	13/06/2010	06:15	48 57.41N	9 42.62W
39		16/06/2010	05:25	49 25.95N	9 2.03W
57		21/06/2010	12:33	49 03.83N	9 29.44W

The volume and concentration of ^{15}N-labelled ammonium or nitrate used for spiking was calculated to be less than 10% of the natural concentration in the surface, peak SCM and base SCM with reference to recent CTD profiles in the area. The amount used for spiking had to be minimised in order to avoid stimulating nutrient uptake by phytoplankton, which would not be representative of the preference of a particular nutrient source or the in situ uptake rate.

After the 24 hour incubation period, samples were filtered through a pre-combusted (450°C for 4 hours) 25mm Whatman Glass Fibre Filter to capture the labelled particles. The filters were placed in plastic microcentrifuge tubes, labelled and frozen at 20°C. The ^{15}N content of particulate matter will be determined using an elemental analyser-isotope ratio mass spectrometry at the University of Liverpool. The rate of nitrate and ammonium uptake will be determined using equations outlined by Dugdale & Goering (1967).

Table 2: Details of the 15N experiment and all bottles used. 18 bottles incubated for 24 hours for each of the three CTD stations described in Table 1.

Bottle ID	Depth (CTD 30)	Depth (CTD 39)	Depth (CTD 57)	Sample size	Spike?	Natural Concentration (μM)	Spike Concentration (>10% natural conc.) (μM)	Incubation Light level
1	3.5	5	1	1.5L	^{15}N-nitrate	0.1	0.01	35%
2	3.5	5	1	1.5L	^{15}N-nitrate	0.1	0.01	35%
3	3.5	5	1	1.5L	^{15}N-nitrate	0.1	0.01	35%
4	3.5	5	1	1.5L	^{15}N-ammonium	0.1	0.01	35%
5	3.5	5	1	1.5L	^{15}N-ammonium	0.1	0.01	35%
6	3.5	5	1	1.5L	^{15}N-ammonium	0.1	0.01	35%
A (ctrl)	3.5	5	1	2L	Control	0.1	n/a	n/a
7	33	35	26	1.5L	^{15}N-nitrate	1	0.1	4%
8	33	35	26	1.5L	^{15}N-nitrate	1	0.1	4%
9	33	35	26	1.5L	^{15}N-nitrate	1	0.1	4%
10	33	35	26	1.5L	^{15}N-ammonium	1	0.1	4%
11	33	35	26	1.5L	^{15}N-ammonium	1	0.1	4%
12	33	35	26	1.5L	^{15}N-ammonium	1	0.1	4%
B (ctrl)	33	35	26	2L	Control	1	n/a	n/a
13	40	45	40	1.5L	^{15}N-nitrate	5	0.5	2%
14	40	45	40	1.5L	^{15}N-nitrate	5	0.5	2%
15	40	45	40	1.5L	^{15}N-nitrate	5	0.5	2%
16	40	45	40	1.5L	^{15}N-ammonium	5	0.5	2%
17	40	45	40	1.5L	^{15}N-ammonium	5	0.5	2%
18	40	45	40	1.5L	^{15}N-ammonium	5	0.5	2%
C (ctrl)	40	45	40	2L	Control	5	n/a	n/a

References

Dugdale, R. C. & Goering, J. J. 1967: Uptake of new and regenerated forms of nitrogen in primary productivity. *Limnol. Oceanog.* **12**, 196-206.

15. Water-column carbon dynamics (Anouska Bailey)

Routine sampling:

Niskin samples were taken from each pre-dawn full profile to measure the following rates:

- Size-fractionated primary production – triplicate 100ml samples from each depth were collected in 125ml polycarbonate bottles and spiked with 12µCi $NaH^{14}CO_3$ and incubated at in-situ temperature and light regime from dawn until dusk in on-deck incubators. One 100ml dark sample and one 100ml control were also sampled per depth. Once the incubation was completed samples were filtered sequentially through 10µm, 2µm and 0.2µm polycarbonate filters. Filters were fumed with 1ml 10% HCl for 24 hours before adding 5ml Ultima Gold scintillation cocktail and reading on a Perkin Elmer Tricarb 3100TR scintillation counter.
- Bacterial production – triplicate 10ml samples from each depth were collected in 30ml polycarbonate bottles and spiked with 10nM (final concentration) leucine (1 part ^{3}H-Leucine and 9 parts L-leucine) and incubated in dark bags for 2 hours in on-deck incubators. Triplicate surface samples were also incubated at in-situ light conditions. Controls were killed with 5% ice-cold trichloracetic acid (final concentration) and incubated alongside samples. At the end of the incubations all samples were killed with 5% ice-cold TCA (final concentration) and filtered onto 0.2µm cellulose nitrate filters. Filters were rinsed with 1ml 5% TCA twice and once with 1ml 80% ethanol before being dissolved with 1ml ethyl acetate. Five ml of Ultima Gold were added to each vial and samples were read using the onboard scintillation counter.
- Net community production – fifteen 125ml oxygen bottles were filled from each depth. Five of these were fixed with 1ml manganese (II) chloride and 1ml alkaline iodide immediately to act as Tzeros, five were incubated at in-situ temperature and light conditions for 24 hours and the final five were incubated in the dark for 24 hours. ‘Light’ bottles were placed within dark bags at sunset and removed at sunrise to prevent stimulation by deck lights. After 24 hours the ‘light’ and ‘dark’ bottles were fixed as above and analysed on a Metrohm Titrando after 24 hours.

Samples were also taken from these profiles for:

- Dissolved organic carbon (DOC) – sample was filtered onto combusted GF/F on a glass filtration rig pre-rinsed with sample three times. Twenty millilitres of sample were pipetted into an acid-washed and combusted glass vial pre-filled with 20µl 50% (v/v) HCl. Duplicate samples were taken at each depth.
- Size-fractionated chlorophyll *a* – 500ml samples were sequentially filtered through 10µm, 2µm and 0.2µm (100ml) polycarbonate filters. Filters were stored in capped test tubes, wrapped in foil and frozen at -80°C for several days. When ready for analysis 5ml of acetone were added to each tube and fluorescence was read after 24 hours.

- Phytoplankton abundance – duplicate 100ml samples from each depth were measured from the Niskin bottles and added to 125ml glass amber jars pre-filled with 2% (final conc.) acid Lugol's iodine. Samples were stored in the fridge in the dark.
- Bacterial abundance – duplicate 50ml samples were taken directly from Niskin bottles into Sterilins pre-filled with 2% (final conc.) formaldehyde. Samples were stored in the fridge in the dark.
- Dissolved oxygen concentration – triplicate samples from each depth were fixed immediately and analysed onboard using a Metrohm Titrando once settled for at least 24 hours.

Additional samples and incubations:

- Particulate silicate – one litre of water was filtered onto a 0.8µm polycarbonate filter which was subsequently stored at -80°C in a microcentrifuge tube.
- Bacterial kinetics incubations – the duration of incubation time as well as the concentration of the initial leucine spike were examined using on deck incubations of bacterial production. For the time-course experiment triplicate 10ml samples were spiked with 10nM leucine and incubated in the dark for 15mins, 30 mins, 1 hour, 2 hours or 4 hours. For the leucine concentration experiment triplicate 10ml samples were incubated for 2 hours in the dark having received a leucine spike of 0, 2.5, 5, 10, or 20nM. Killed controls were incubated alongside each treatment, and each of these incubations was run with both surface and DCM water replicates.

Diurnal variability – two 10L carboys were filled with surface water and 2 with water from the DCM. Bottles were incubated at in-situ light and temperature conditions for 30 hours and sub-sampled every 6 hours for bacterial production. Bacterial abundance and bulk primary production were also measured at the start of the incubations and again the following morning.

The following tables represent a log of all samples taken.

Date	CTD #	Stn	Depth (m)	Routine samples taken	Additional samples
03/06/2010	**3**	**Liverpool Bay**	5	Size-frac. chl. *a*, DOC, NCP, BP, size-frac. PP, phyto. + bact. abundance, DO_2	Particulate silicate
			15	DO_2	
			40	DO_2	
05/06/2010	**6**	**IM1**	2	Size-frac. chl. *a*, DOC, NCP, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			20	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			33	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			38	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			42	DO_2	
			46	DO_2	
			48	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			55	DO_2	
			60	Size-frac. chl. *a*, DOC, BP, phyto. + bact. abundance, DO_2	
			127	DO_2, DOC	
06/06/2010	**7**	**IM1**	2	DO_2	
			16.6	DO_2	
			31.7	DO_2	
			36.6	DO_2	
			41.9	DO_2	
			43.5	DO_2	
			48	DO_2	
			52	DO_2	
			126	DO_2	
09/06/2010	**17**	**IM1**	3	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			15	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			30	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			40	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto.	

				+ bact. abundance, DO_2	
			41	DO_2	
			43	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			47	DO_2	
			55	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			120	DO_2, DOC	

09/06/2010	**18**	**IM1**	2.8	NCP, size-frac chl. *a*, phyto. abundance	
			37	NCP, size-frac chl. *a*, phyto. abundance	
12/06/2010	**26**		5	DO_2	
			20	DO_2	
			35	DO_2	
			40	DO_2	
			42	DO_2	
			45	DO_2	
			50	DO_2	
			70	DO_2	
			90	DO_2	
			120	DO_2	
13/06/2010	**29**	**SW3**	3.5	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			15	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			25	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			36	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			40	DO_2	
			42	DO_2	
			45	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			50	DO_2	
			65	Size-frac. chl. *a*, DOC, phyto. + bact. abundance, DO_2	
			150	DO_2, DOC	

13/06/2010	**30**	**SW3**	3.5	NCP	
			33	NCP	
16/06/2010	**38**		Surf	DO_2	
			15	DO_2	
			25	DO_2	
			29	DO_2	
			33	DO_2	
			35	DO_2	
			40	DO_2	
			50	DO_2	
			120	DO_2	
16/06/2010	**40**	**NE2**	Surface		BP kinetics
			DCM		BP kinetics
16/06/2010	**45**	**NE6**	Surface		BP kinetics
			DCM		BP kinetics
17/06/2010	**46**		Surface	Bact. abundance	BP diurnal, bulk PP
			DCM	Bact. abundance	BP diurnal, bulk PP
19/06/2010	**50**		3	DOC	
			10	DOC	
			20	DOC	
			30	DOC	
			35	DOC	
			40	DOC	
			70	DOC	
			135	DOC	
19/06/2010	**51**		2	DOC	
			20	DOC	
			30	DOC	
			45	DOC	
			55	DOC	
			65	DOC	
			100	DOC	
			150	DOC	
19/06/2010	**52**		2	DOC	
			10	DOC	
			20	DOC	
			35	DOC	
			45	DOC	
			62	DOC	
			90	DOC	
			155	DOC	
20/06/2010	**53**	**SW5**	3	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	

			10	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			18	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			22	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			25	DO_2	
			30	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			40	DO_2	
			60	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			180	DO_2, DOC	

20/06/2010	**54**	**SW5**	Surface	NCP	
			24	NCP	
			45	Phyto. abundance	
			80	Phyto. abundance	
			120	Phyto. abundance	
			160	Phyto. abundance	
20/06/2010	**55**		Surface	DOC	
			8	DOC	
			20	DOC	
			30	DOC	
			50	DOC	
			100	DOC	
			200	DOC	
			300	DOC	
20/06/2010	**56**		5	DOC	
			20	DOC	
			30	DOC	
			60	DOC	
			100	DOC	
			150	DOC	
			300	DOC	
			400	DOC	
24/06/2010	**58**	**Irish Sea**	2	Size-frac. chl. *a*, DOC, NCP, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			15	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	

			30	Size-frac. chl. *a*, DOC, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			35	Size-frac. chl. *a*, DOC, NCP, BP, size-frac. PP, phyto. + bact. abundance, DO_2	
			40	DO_2, DOC	
			50	Size-frac. chl. *a*, DOC, phyto. + bact. abundance, DO_2	
			70	DO_2, DOC	
			80	Size-frac. chl. *a*, DOC, phyto. + bact. abundance, DO_2	
			90	DO_2	

16. Phosphorus Dynamics (Clare Davis)

Dissolved organic matter (DOM) cycling was investigated through a detailed study of phosphorus dynamics. As the most labile component of DOM, phosphorus gives a good indication of how the bioavailable DOM pool is exchanged between respective nutrient pools (dissolved inorganic, organic and particulate) and how bioavailability may vary through the water column.

Together, the measurements taken can indicate the relative turnover times of the dissolved organic phosphorus (DOP) pool resolved through the water column and associate observed remineralisation with the responsible planktonic communities. These results can potentially indicate the proportion of labile DOM mixed below the thermocline.

Bulk dissolved organic phosphorus (DOP)

Samples from 9 depths were collected at pre-dawn CTDs and also during both transects. Samples were UV oxidised for 2 hours using a Metrohm UV oxidiser and analysed for total dissolved phosphorus using a Bran and Luebbe Quaatro 5-channel autoanalyser on board. The DOP fraction was calculated to be the difference between phosphate concentrations determined before and after UV oxidation (limit of detection 0.02 mM).

Enzyme hydrolysable phosphorus (EHP)

Samples were spiked with commercially available enzyme mixtures and incubated in the dark at ambient room temperature overnight. The difference between the phosphate concentration measured before and after incubation was taken to be the relevant DOP fraction hydrolysable by respective enzymes. The labile phosphomonoester and phosphodiester pools were determined through addition of alkaline phosphatase and phosphdiesterase (Sigma Aldrich), respectively. Phytase (Sigma Aldrich) was used to determine the less labile fraction of bioavailable DOP. After the incubation period had elapsed, samples were frozen at -20°C for later analysis in the laboratory.

Alkaline phosphatase activity (APA)

Samples were spiked with the commercially available enzyme substrate methylumbelliferyl phosphate (Sigma Aldrich) and incubated on deck at depth-corrected ambient light and sea surface temperature for up to 12 hours. Upon hydrolysis of the phosphomonoester bond, facilitated by the enzyme alkaline phosphatase present in the sample, a fluorescent compound is released – methylumbelliferone. The change in sample fluorescence was measured at regular intervals throughout the incubation using a Turner 10 AU fluorometer, thus allowing the rate of phosphomonoester hydrolysis to be determined.

Enzyme labelled fluorescence (ELF)

In accompaniment to APA and EHP assays, up to 1 L of sample was filtered from each depth. Once filtration was completed, the filter was transferred to a petri dish and incubated with the commercially available enzyme substrate ELF-97 (Molecular Probes). This enzyme produces a compound that binds to the enzyme active site and fluoresces green when viewed under an epifluorescent microscope later in the laboratory. Thus, the origins of bulk APA can be identified.

Particulate organic phosphorus

At each depth, 1 L of sample was filtered onto GFF and stored at -20°C for later analysis of particulate phosphorus in the laboratory. This serves as a proxy for biomass, but more importantly indicates over time how phosphorus may be transferred between the particulate and dissolved pools.

Cast number	Niskin	Depth	DOP	EHP	APA	ELF	POP
2	9	5	X	X	X	X	X
6	3	60	X	X	X	X	X
6	6	48	X	X	X	X	X
6	10	38	X	X	X	X	X
6	13	33	X				X
6	15	20	X				X
6	17	2	X	X	X	X	X
17	3	55	X	X	X	X	X
17	6	43	X	X	X	X	X
17	9	40	X	X	X	X	X
17	13	30	X				X
17	15	15	X	X	X	X	X
17	17	3	X				X
29	3	65	X	X	X	X	X
29	6	45	X	X	X	X	X
29	10	36	X	X	X	X	X
29	15	25	X				X
29	17	15	X	X	X	X	X
29	19	2	X				X
38	1	120	X				X
38	2	50	X	X	X	X	X
38	4	40	X				X
38	5	35	X				X

38	7	33	X				X
38	8	29	X	X	X	X	X
38	12	25	X	X	X	X	X
38	14	15	X	X	X	X	X
38	16	2	X				X
40	1	125	X				
40	3	80	X				
40	5	50	X				
40	7	45	X				
40	9	40	X				
40	11	35	X				
40	13	30	X				
40	15	20	X				
40	17	3	X				
41	1	130	X				
41	3	80	X				
41	5	50	X				
41	7	45	X				
41	9	40	X				
41	11	35	X				
41	13	30	X				
41	15	20	X				
41	17	3	X				
42	1	120	X				
42	3	80	X				
42	5	45	X				
42	7	40	X				
42	9	35	X				
42	11	30	X				
42	13	20	X				
42	15	10	X				
42	17	2	X				
43	1	85	X				
43	3	50	X				
43	5	40	X				
43	7	30	X				
43	9	22	X				

43	11	17	X				
43	13	2	X				
44	1	90	X				
44	3	50	X				
44	5	30	X				
44	7	26	X				
44	9	24	X				
44	11	15	X				
44	13	10	X				
44	15	2	X				
50	1	135	X				
50	3	70	X				
50	5	40	X				
50	7	35	X				
50	9	30	X				
50	11	20	X				
50	13	10	X				
50	15	3	X				
51	1	150	X				
51	3	100	X				
51	5	65	X				
51	7	55	X				
51	9	45	X				
51	15	20	X				
51	19	2	X				
52	1	155	X				
52	3	90	X				
52	5	62	X				
52	7	45	X				
52	9	35	X				
52	11	20	X				
52	13	10	X				
52	15	2	X				
53	1	180	X				
53	3	60	X	X	X	X	X
53	4	40	X				
53	6	30	X	X	X	X	X

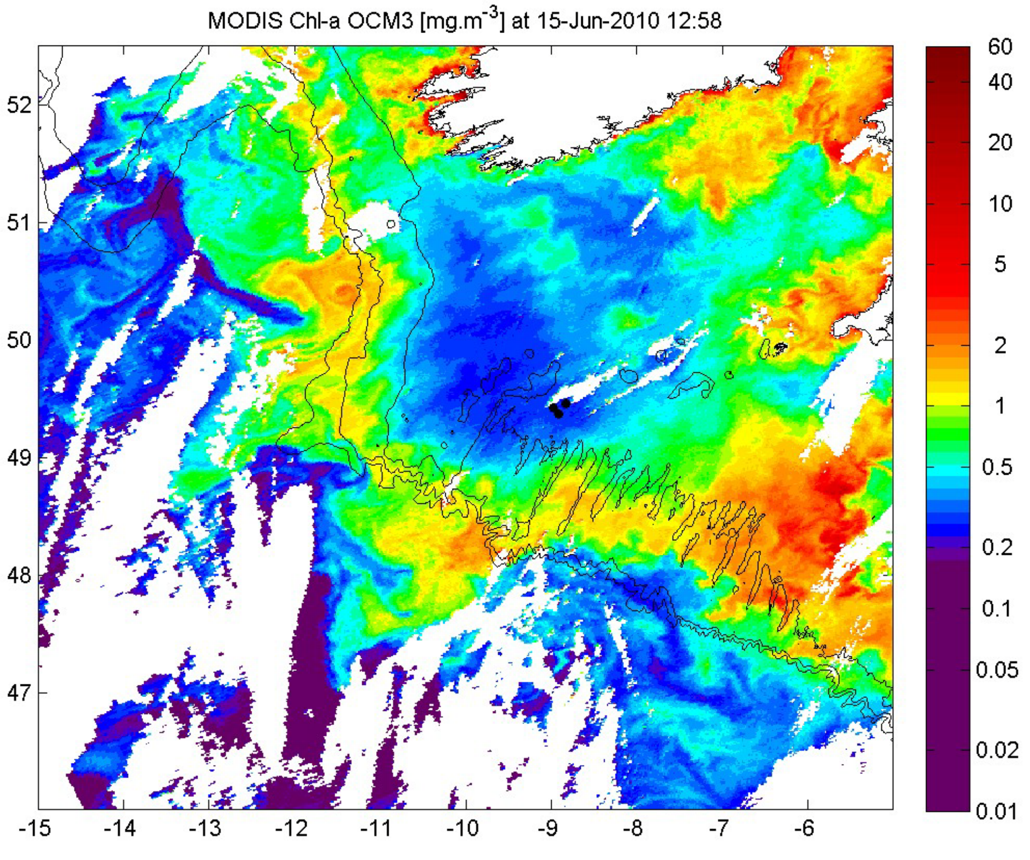
53	7	25	X				
53	9	22	X	X	X	X	X
53	13	18	X				
53	15	10	X	X	X	X	X
53	17	2	X				
55	5	300	X				
55	7	200	X				
55	9	100	X				
55	11	50	X				
55	13	30	X				
55	15	20	X				
55	17	8	X				
55	19	2	X				
56	9	400	X				
56	11	300	X				
56	14	150	X				
56	15	100	X				
56	16	60	X				
56	18	30	X				
56	19	20	X				
56	21	5	X				

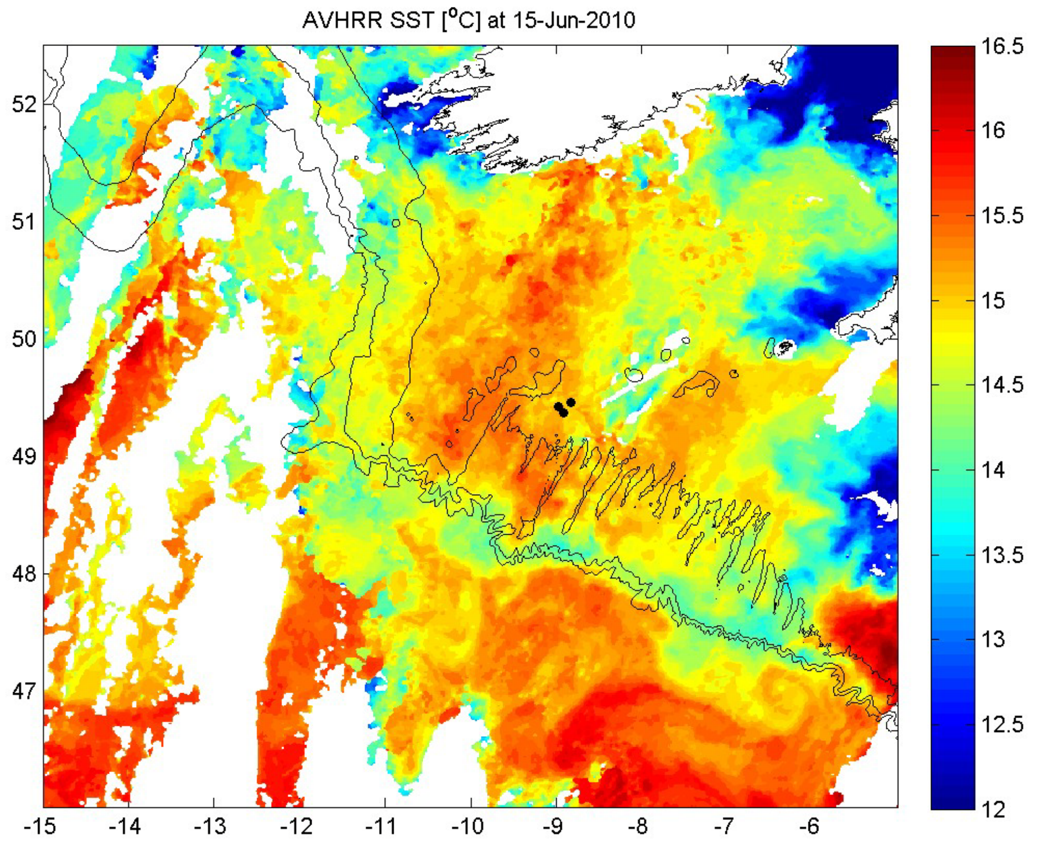
17. D352 Satellite Imagery and Underway Chlorophyll Sampling (Jo Hopkins)

The following 1km resolution images were sent daily from NEODAAS Plymouth:

- Daily AVHRR (Advanced Very High Resolution Radiometer) SST (°C)
- MODIS in-water diffuse chlorophyll-a concentration calculated using the OCM3 algorithm ($mg.m^{-3}$)
- MODIS in-water diffuse attenuation coefficient at 490nm (m^{-1})
- MERIS in-water chlorophyll-a concentration calculated using the case 1 algorithm ($mg.m^{-3}$)

The following MODIS and AVHRR images from 15th June 2010 show the upwelling of cold water along the shelf break and associated elevated chlorophyll-a concentration. The black dots mark the positions of moorings IM1, IM2 and IM3. Black contours are the 150, 500 and 1000m isobaths.





128 samples from the ships underway nontoxic supply were taken approximately every half hour between 10.30 and 15:30 BST to determine chlorophyll concentration. 200ml was passed through a 25mm GFF filter. The filter was left in 8ml of 90% acetone at approx. 4°C for at least 24 hours. Chlorophyll concentration was subsequently determined using a Turner Designs – 700 Fluorometer (serial # 0315). The following table lists the dates, times, latitudes and longitudes of each sample.

Date	Jday	Time (BST)	Station	Latitude	Longitude
03/06/2010	154	11:17	uw1	53.72	-5.19
03/06/2010	154	15:14	uw2	53.50	-5.50
04/06/2010	155	10:54	uw3	50.12	-8.05
04/06/2010	155	11:58	uw4	49.97	-8.25
04/06/2010	155	13:26	uw5	49.76	-8.54
04/06/2010	155	14:31	uw6	49.60	-8.74
05/06/2010	156	10:51	uw7	49.41	-8.98
05/06/2010	156	12:27	uw8	49.47	-8.82
05/06/2010	156	13:35	uw9	49.45	-8.84
06/06/2010	157	10:05	uw10	49.42	-9.01
06/06/2010	157	11:02	uw11	49.43	-9.01
06/06/2010	157	12:42	uw12	49.52	-8.87
07/06/2010	158	10:02	uw13	49.43	-9.00
07/06/2010	158	10:55	uw14	49.42	-9.00

07/06/2010	158	11:52	uw15	49.40	-9.00
07/06/2010	158	13:42	uw16	49.45	-8.96
08/06/2010	159	10:01	uw17	49.42	-9.00
08/06/2010	159	10:57	uw18	49.42	-9.00
08/06/2010	159	12:48	uw19	49.41	-9.01
09/06/2010	160	09:50	uw20	49.37	-9.07
09/06/2010	160	11:42	uw21	49.42	-9.00
09/06/2010	160	12:37	uw22	49.42	-8.98
09/06/2010	160	13:45	uw23	49.43	-9.00
10/06/2010	161	10:49	uw24	49.41	-9.01
10/06/2010	161	13:44	uw25	49.39	-9.00
11/06/2010	162	10:00	uw26	49.41	-8.97
11/06/2010	162	10:52	uw27	49.40	-9.02
11/06/2010	162	12:39	uw28	49.43	-8.99
11/06/2010	162	13:40	uw29	49.45	-9.00
12/06/2010	163	09:39	uw30	49.54	-8.78
12/06/2010	163	10:07	uw31	49.58	-8.72
12/06/2010	163	11:03	uw32	49.67	-8.59
12/06/2010	163	12:16	uw33	49.79	-8.69
12/06/2010	163	13:12	uw34	49.76	-8.81
12/06/2010	163	14:17	uw35	49.67	-8.94
12/06/2010	163	14:55	uw36	49.62	-9.01
13/06/2010	164	09:39	uw37	49.08	-9.45
13/06/2010	164	13:07	uw38	49.13	-9.52
13/06/2010	164	13:44	uw39	49.16	-9.64
13/06/2010	164	14:03	uw40	49.18	-9.70
14/06/2010	165	09:40	uw41	49.10	-9.45
14/06/2010	165	06:43	uw42	49.10	-9.44
14/06/2010	165	10:59	uw43	49.10	-9.44
14/06/2010	165	11:28	uw44	49.11	-9.46
14/06/2010	165	12:02	uw45	49.11	-9.47
14/06/2010	165	13:20	uw46	49.12	-9.48
14/06/2010	165	14:12	uw47	49.12	-9.47
15/06/2010	166	09:59	uw48	49.48	-9.07
15/06/2010	166	10:24	uw49	49.52	-9.12
15/06/2010	166	11:28	uw50	49.62	-9.26
15/06/2010	166	11:58	uw51	49.67	-9.33
15/06/2010	166	12:29	uw52	49.72	-9.41
15/06/2010	166	13:12	uw53	49.74	-9.53
15/06/2010	166	13:59	uw54	49.66	-9.64
15/06/2010	166	14:28	uw55	49.61	-9.72
15/06/2010	166	09:08	mm1	49.40	-8.95
15/06/2010	166	09:08	mm2	49.40	-8.95
16/06/2010	167	09:28	uw56	49.81	-8.37
16/06/2010	167	09:55	uw57	49.87	-8.28

16/06/2010	167	10:21	uw58	49.93	-8.20
16/06/2010	167	10:55	uw59	49.97	-8.14
16/06/2010	167	11:29	uw60	49.16	-8.10
16/06/2010	167	12:09	uw61	50.08	-7.98
16/06/2010	167	12:30	uw62	50.12	-7.91
16/06/2010	167	12:59	uw63	50.15	-7.87
16/06/2010	167	13:23	uw64	50.15	-7.87
16/06/2010	167	14:03	uw65	50.23	-7.75
16/06/2010	167	14:38	uw66	50.30	-7.63
17/06/2010	168	09:48	uw67	49.42	-9.00
17/06/2010	168	10:22	uw68	49.42	-9.01
17/06/2010	168	10:59	uw69	49.40	-9.02
17/06/2010	168	11:29	uw70	49.40	-9.03
17/06/2010	168	12:01	uw71	49.40	-9.04
17/06/2010	168	12:30	uw72	49.40	-9.05
17/06/2010	168	13:01	uw73	49.40	-9.06
17/06/2010	168	13:30	uw74	49.40	-9.08
17/06/2010	168	13:57	uw75	49.40	-9.09
17/06/2010	168	14:35	uw76	49.40	-9.11
18/06/2010	169	09:26	uw77	49.47	-8.82
18/06/2010	169	09:59	uw78	49.46	-8.82
18/06/2010	169	10:29	uw79	49.46	-8.83
18/06/2010	169	10:57	uw80	49.46	-8.83
18/06/2010	169	11:30	uw81	49.39	-8.90
18/06/2010	169	12:01	uw82	49.37	-8.92
18/06/2010	169	12:25	uw83	49.37	-8.93
18/06/2010	169	13:01	uw84	49.36	-8.92
18/06/2010	169	13:31	uw85	49.37	-8.91
18/06/2010	169	14:03	uw86	49.37	-8.92
18/06/2010	169	14:30	uw87	49.37	-8.92
19/06/2010	170	09:35	uw88	49.42	-8.98
19/06/2010	170	10:00	uw89	49.42	-8.97
19/06/2010	170	10:27	uw90	49.42	-8.99
19/06/2010	170	11:02	uw91	49.42	-8.96
19/06/2010	170	11:29	uw92	49.41	-8.98
19/06/2010	170	11:58	uw93	49.41	-8.98
19/06/2010	170	12:29	uw94	49.41	-8.98
19/06/2010	170	12:59	uw95	49.42	-8.99
19/06/2010	170	13:29	uw96	49.41	-8.99
19/06/2010	170	14:04	uw97	49.41	-9.00
19/06/2010	170	14:38	uw98	49.36	-9.07
20/06/2010	171	09:06	uw99	48.83	-10.01
20/06/2010	171	09:39	uw100	48.84	-10.00
20/06/2010	171	10:28	uw101	48.84	-9.99
20/06/2010	171	10:59	uw102	48.78	-10.05

20/06/2010	171	11:32	uw103	48.69	-10.13
20/06/2010	171	12:35	uw104	48.62	-10.22
20/06/2010	171	13:32	uw105	48.59	-10.26
20/06/2010	171	14:32	uw106	48.46	-10.45
21/06/2010	172	09:38	uw107	48.28	-9.57
21/06/2010	172	09:59	uw108	48.29	-9.57
21/06/2010	172	10:27	uw109	48.34	-9.62
21/06/2010	172	11:00	uw110	48.40	-9.67
21/06/2010	172	11:49	uw111	48.48	-9.75
21/06/2010	172	12:22	uw112	48.54	-9.80
21/06/2010	172	12:47	uw113	48.54	-9.88
21/06/2010	172	13:16	uw114	48.54	-9.97
21/06/2010	172	13:51	uw115	48.55	-10.08
21/06/2010	172	14:16	uw116	48.56	-10.16
21/06/2010	172	14:45	uw117	48.60	-10.25
22/06/2010	173	09:30	uw118	49.30	-9.19
22/06/2010	173	10:07	uw119	49.35	-9.10
22/06/2010	173	10:34	uw120	49.40	-9.02
22/06/2010	173	11:02	uw121	49.45	-8.94
22/06/2010	173	11:30	uw122	49.50	-8.87
22/06/2010	173	11:58	uw123	49.55	-8.79
22/06/2010	173	12:30	uw124	49.61	-8.71
22/06/2010	173	12:56	uw125	49.66	-8.64
22/06/2010	173	13:30	uw126	49.72	-8.54
22/06/2010	173	13:59	uw127	49.77	-8.47
22/06/2010	173	14:27	uw128	49.82	-8.39

18. Phytoplankton taxonomy and photophysiology (Anna Hickman, Mark Moore, Jo Hopkins)

Introduction.

Phytoplankton growth in the oceans is fundamentally dependent on the availability of 2 key resources, nutrients and light. In shelf seas, the interaction of physical and biogeochemical processes results in a dynamic environment where the availability of these resources varies in both time and space. In highly stratified shelf sea regions, the deep chlorophyll maximum and surface layer above represent very different environments, the former characterized by very low mean light levels, but a potential supply of nutrients, while the latter has higher mean light levels, but generally low nutrient availability. Our previous work in such shelf sea regions has indicated strong vertical gradients in both photoacclimation (physiological acclimation to ambient light) and taxonomy between natural populations living in the surface and DCM (Moore et al. 2006; Hickman et al. 2009). Despite a general understanding of the underlying mechanisms behind such vertical ecophysiological gradients, many details of the processes involved remain unclear. Additionally, we have previously observed less well understood physiological variability in these environments, so called 'Ek-independent' variability (Behrenfeld et al. 2004, J. Phycol, 40: 2-25). A series of phytoplankton physiological experiments and measurement of associated variables including detailed taxonomic and spectral light absorption characteristics was thus performed on D352. The development of new techniques should enable us to investigate the ecophysiology of natural phytoplankton populations in a shelf sea environment at a previously unprecedented level.

CTD sampling: *(Anna Hickman, Mark Moore)*

The following measurements and samples were collected from CTD casts:

Bulk Chlorophyll-a (Chl-a): Total phytoplankton chlorophyll-a was measured following the fluorescence method of Welschmeyer (1984). Water samples (100 or 200 ml) were filtered onto GFF filters and 8ml of 90% Acetone solution was added. Samples were left in the fridge to extract for >24hrs before measurement on a Turner A-10 Fluorometer on board (see the detailed section below on Chl-a calibration). Values in this report (and subsequently those used for CTD fluorometer calibrations quoted herein) are provisional, subject to further calibration of the chl-a standard on return to the lab.

Pigments (HPLC): Water samples (1000-2000 ml) were filtered onto GFF filters and stored in -80'C freezer for identification of pigments using High Performance Liquid Chromatography (HPLC) on return to the lab.

Phytoplankton Light Absorption (PABS): Water samples (1000-2000 ml) were filtered only GFF filters and stored in a -80^{o}C freezer for analysis on return to the lab. Analysis will be by spectrophotometry, providing the wavelength-resolved light absorption by the phytoplankton.

Species composition by Analytical Flow Cytometry (AFC): Water samples (1.9 ml) were added to pre-spiked vials containing 100 ☐ of a 20% Gluteraldehyde solution and stored in a -80^{o}C freezer. On return to the lab, quantification of pico-phytoplankton will be obtained by Analytical Flow Cytometry (AFC).

Species composition by microscope counts (Lugols): Water samples (100 ml) were added to glass bottles containing 2 ml Lugols iodine solution. Microscope analysis of large phytoplankton will be carried out on return to the lab.

Proteins: Water samples (around 10 litres) were filtered onto GFF filters and flash frozen in liquid nitrogen before storage in -80^{o}C freezer. On return to the lab, proteins relevant to light absorption and photosynthesis will be analysed using quantitative immunoblotting.

Fast Repetition Rate Fluorometry (FRRF): Photophysiological parameters (F_v, F_m, $□_{PSII}$, $□_{PSII}$) and / or the photophysiological response to incremental light dosage, were measured on a Mk II Chelsea Instruments Fast Repetition Rate fluorometer (FRRf) (e.g. see Moore et al. 2006).

^{14}C Photosynthesis vs. Irradiance curves (PvsE): Water samples from each of (typically) two depths were sub-sampled into 18 bottles (15 opaque and 3 darkened). Each bottle was spiked with 4.63 □Ci ^{14}C (as a buffered sodium bicarbonate solution, $NaH^{14}CO_3$) and incubated in a light gradient for 2 hours while chilled to the sea surface temperature. After incubation, samples were filtered onto 0.2 □m polycarbonate filters, which were then fumed with concentrated HCl for 30 minutes. Filters were then placed in scintillation vials and 5 ml UltimaGold scintillation cocktail was added. After at least 12 hours, samples were analysed using the on-board scintillation counter. Spike activity was checked by removing 100 □ from 3 of the spiked bottles (prior to incubation) and adding to 300 □ of phenylethylamine. 5 ml of UltimaGold was then added to these standards, which were then left in the dark for 24 hours before analysing on the scintillation counter. The working stock was made up by taking 200 □ of initial stock (1 mCu ml^{-1}) and adding it to 1.96 ml of filtered sea-water, thus generating 2.16 ml of a 92.6 □Ci solution.

Table 1. CTD sampling. Number of depths sampled for taxonomy and photophysiological measurements.

CTD	Chl-a	AFC	HPLC	PABS	FRRF	Proteins	PvsE	SEM	Lugols
2	5	5	5						
6	10	10	6	6	2	2	2		
7	9	9	6	6	2	2	2		
17	9	9	6	6	2	2	2	2	
26	10	10	7	7					
29	10	10	6	6	2	2	2	2	
38	9	9	6	6	2	2	2	2	
40	9	6							5
41	9	5							5
42	9	5							5
43	9	5							5
44	9	5							5
45	9	5							5
47	4	4	4	4	4	4	2	2	

48	6	6	6	6				2	
50	8	8							8
51	10	10							10
52	9	9							9
53	9	9	6	6	4	2	2	2	
54	4	4							
55	10	9						1	9
56	9	9						1	9
57	2	2	2	2	2	2	2	2	
58		7							

Underway Sampling: *(Jo Hopkins)*
Bulk Chl-a measurements were routinely collected form the ship's underway non-toxic supply. Samples were generally collected every half an hour between the hours of 10:00 and 14:00 (ship time).

Pump Sampling: *(Anna Hickman, Mark Moore)*
On 17th June, a hose attached to a weighted cable was lowered to the base of the thermocline and water was continuously pumped to the wet lab using a peristaltic pump. A temperature logger was attached at the end of the hose to monitor temperature at the in-flow. A Mk I FRR fluorometer was set up at the out-flow to continuously monitor $F_{m,}$ the maximum fluorescence, a relative indicator of Chl-a. Flow rate was estimated by timing the filling of a 20 liter carbuoy. The time taken for water to travel from the in-flow at depth to the out-flow in the lab was estimated at 7 minutes. The outflow was raised in increments of 1 m after which time we waited 7 mins before starting to collect water.

5 litres were collected at each depth and sub-samples were taken for the following measurements: Chl-a, AFC, HPLC, PABS, Lugols and nutrients. In addition, samples were collected for particulate carbon and nitrogen (POC/N). For this, water samples (1000 ml) were filtered onto ash dried GFFs and stored in the -80'C freezer for analysis on return to the lab. Given the 7 minute delay between sampling, the filtrations and taking of the various samples was achieved as we went along. There was no need for sample storage.

Sample times and initial data are shown in Table 1 and Figs. 1 and 2. The experiment setup worked well, and the pump performed excellently. However, despite the relatively high-resolution of sampling throughout the thermocline, samples did not resolve the subsurface chlorophyll maximum, or nitrate gradient, very well (as evidenced by the gap in the F_m values in the lower-left panel in Figure 1). Subsequently, although in practice the approach approach worked, some more consideration should be given to the sampling strategy in order to successfully resolve the region of interest.

Table 2. Pump sampling times and initial data. In situ temperature was estimated from that recorded by the logger at the in-flow, 7 minutes prior to sampling. F_m was monitored at the out-flow at the time of sampling. Nitrate was measured from the water samples.

Sample #	Sample Time Start	Sample Time End	Depth (m)	Temp. (^oC)	F_m (a.u.)	Nitrate (□M)
P1	09:28	09:30	45.15	9.99	400	8.06
P2	09:50	09:51	43.72	9.80	169	8.80
P3	10:04	10:06	42.42	9.83	255	8.52
P4	10:17	10:19	40.94	9.80	174	9.04
P5	10:48	10:49	41.01	9.83	242	8.87
P6	11:03	11:05	40.08	9.80	210	8.81
P7	11:13	11:15	39.16	10.35	1962	7.40
P8	11:24	11:26	38.84	9.93	606	7.43
P9	11:56	11:58	37.36	9.96	530	7.65
P10	12:09	12:11	36.71	9.90	424	8.05
P11	12:22	12:24	36.13	10.61	1471	3.38
P12	12:34	12:36	34.38	10.32	1115	5.47
P13	12:48	12:50	33.62	12.70	501	0.02
P14	13:03	13:05	32.52	11.98	1400	0.03
P15	13:15	13:16	32.19	13.09	482	0.01
P16	13:26	13:28	30.84	12.15	708	0.01
P17	13:40	13:41	29.78	13.25	429	0.01
P18	13:53	13:55	28.72	13.93	334	0.01
P19	14:09	14:10	27.39	14.85	227	0.01
P20	14:19	14:21	26.85	14.66	229	0.01
P21	14:32	14:33	26.04	14.81	242	0.02
P22	14:43	14:45	24.88	14.09	307	0.03
P23	14:53	14:55	24.25	15.01	207	0.02
P24	15:04	15:06	23.01	15.41	160	0.02
P25	15:16	15:18	21.85	15.01	219	0.02

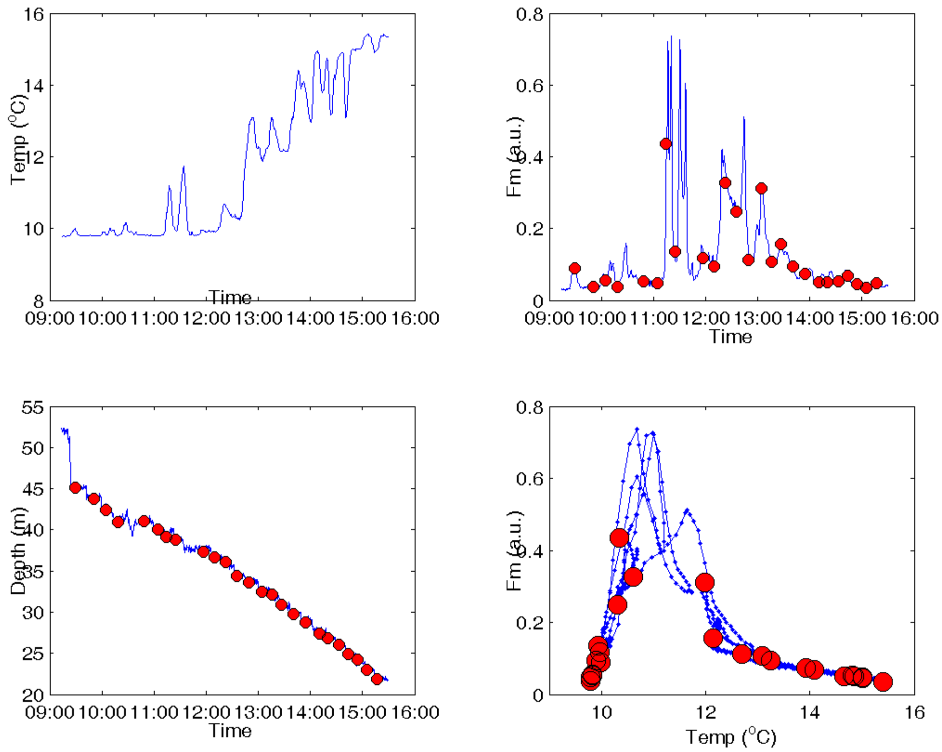


Figure 1. Initial data from pumped sampling. Blue lines indicate continuous monitoring; circles indicate water sample properties.

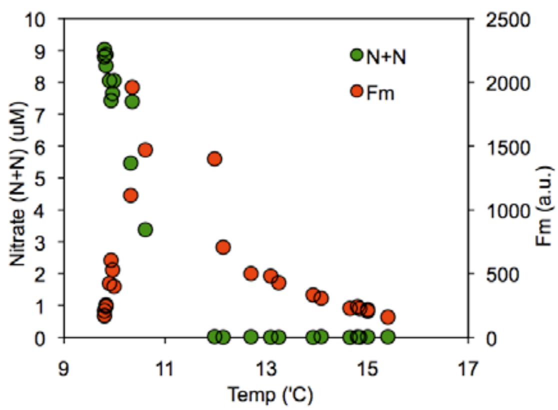


Figure 2. Nitrate (Nitrate + Nitrite, N+N) and F_m against temperature for pumped water samples.

Chromatic Competition Experiments: *(Anna Hickman)*

Incubation experiments were carried out to investigate the response of the phytoplankton community to light of different spectral qualities. Water was collected from the base of the thermocline and incubated in light fields of different spectral composition. Shifts in phytoplankton species and photophysiology as a response to the different light fields, were investigated.

CTD Sampling: Water from each of 14 Niskin bottles from the CTD rosette were sampled into 36 x 2 litre incubation bottles (about 150 ml from each Niskin was added to each incubation bottle).

Incubations: For each experiment, 3 different light qualities were tested (Green, Turquoise, Blue). All treatments yielded the same total PAR. 6 incubators were used so that experiments were carried out in duplicate. Each incubator housed 6 incubation bottles. Incubations were for a duration of 4 days. Sampling was carried out after 0, 24, 48 and 96 hours, with two incubation bottles removed for each time point.
Measurements: Samples were collected for Chl-a, nutrients, FRRF, HPLC, PABS, AFC and Lugols.
Experiments: A total of three 4-day incubation experiments were carried out. The first experiment was carried out under low-light (PAR around 0.5 % surface irradiance). The second experiment, under high-light (PAR around 10 % surface irradiance), and the third under intermediate light level (PAR around 5 % surface irradiance).

<u>**Calibration of on-board fluorometer for Chlorophyll-a measurements:**</u> *(Jo Hopkins, Mark Moore, Anna Hickman)*

Chlorophyll-a concentrations were obtained from fluorescence measured on board using a Turner A-10 Fluorometer (Welschmeyer 1984). The instrument was calibrated against chlorophyll-a standards of known concentration on 11th June. Daily fluoresence readings of a solid standard were also recorded. There was considerable instrument drift during the cruise, as evidenced by the readings for the solid standards (Figure 4).

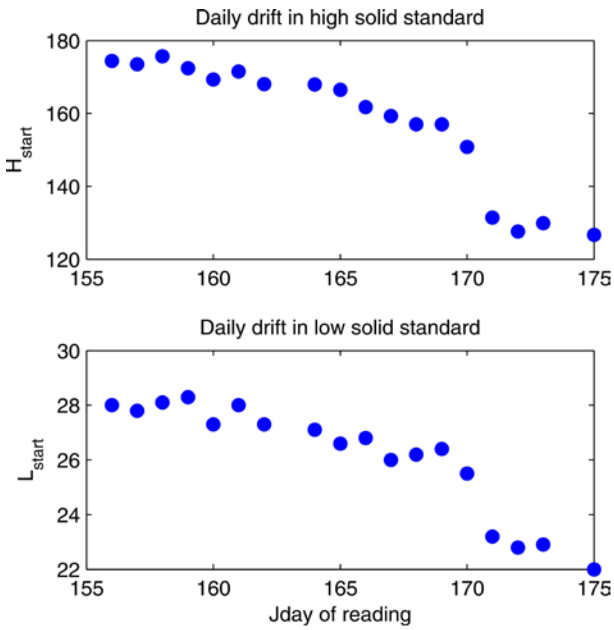


Figure 3. Fluorescence readings for ‘high’ and ‘low’ solid standards during the cruise.

To account for the drift of the instrument over time, chlorophyll-a values (BotCHL) were obtained from the fluorometer readings as follows:

BotCHL = (Reading - AcetoneBlank) × R_f × (AcetoneVolume/FilteredVolume) / R_{HL}

Where R_f is the instrument response factor obtained on 11th June and R_{HL} is a daily correction factor for instrument drift:

$$R_{HL} = [H_{start} / H_{calib} + L_{start}/L_{calib}] /2$$

H_{start} and L_{start} are the fluorescence readings of the high and low solid standards measured each day, and H_{calib} and L_{calib} fluorescence readings of the high and low solid standards measured on 11th June.

19. SurfMet Data (Tom Millgate)

Throughout the duration of the cruise, the ship mounted *Surfmet* system collected readings every 30 seconds. Information about the instruments, mounting location and calibration dates can be found in the technical section of the cruise report. The observations recorded consisted of:

- Ships heading, speed and position
- Absolute wind direction and speed
- Relative wind direction and speed
- Air temperature
- Air pressure
- Humidity
- Fluorescence
- Transmittance
- Water column depth
- Sea surface temperature
- Salinity
- Light sensors

Data Processing

Ships heading, speed and position

The ship's heading and speed were not filtered, and only two of the ships positions were removed as they lay outside the ranges 45^{o}N to 60^{o}N and 15^{o}W to 0^{o}W.

Absolute and relative wind direction and speed

Absolute wind directions of 0^{o} and absolute wind speeds of 0 m/s were removed as these appeared as anomalous readings. The relative wind directions and wind speeds which corresponded to the removed absolute readings were removed. Relative wind speeds of either 0 m/s or greater than 50 m/s were removed.

Air temperature and pressure

Temperatures outside the range of 5 to 30 were removed. Noise was removed from the results by smoothing the readings with a moving window, 250 points in length. Results which lay more than 2 standard deviations from the block mean were removed. Air pressure readings outside the range 900 mbars to 2000 mbars were removed.

Humidity

Humidity readings outside the range 50% to 100% were removed as anomalous results.

Fluorescence and Transmittance

Fluorescence readings outside of the range 0V to 5V were removed. The Transmittance data has not been used on the cruise and has therefore not been altered.

Water depth

Depth readings were removed if they were less than expected for the region. The readings were also smoothed to remove noise in a similar manner to air temperature.

Sea surface temperature

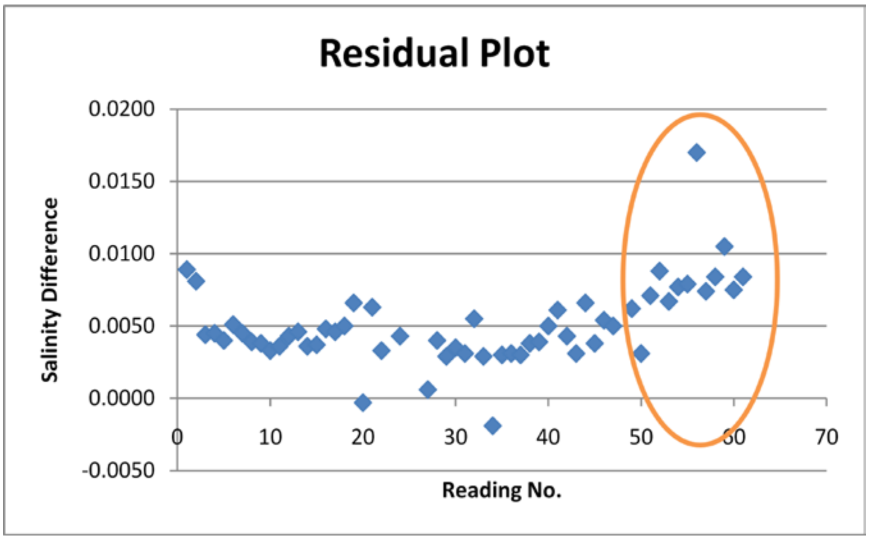
Sea surface temperatures of less than 1 were removed and the remaining readings were smoothed using the same technique as air temperature.

Salinity

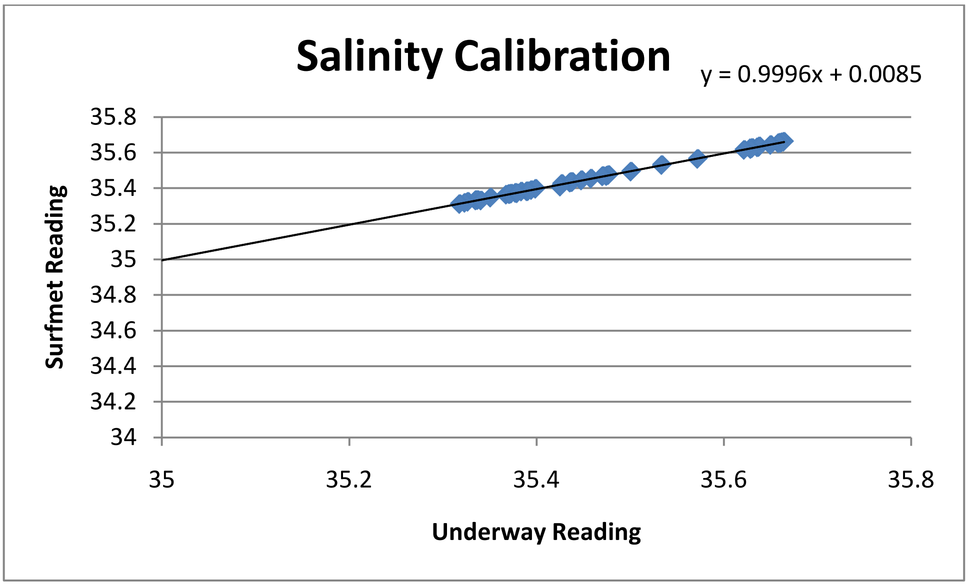
Surfmet salinity readings which lay outside the range 25-50 were removed as anomalous results. The salinity readings were calibrated using water samples collected periodically throughout the cruise from the ships non-toxic underway supply. Sixteen samples, between midday 21/06/10 and midday 23/06/10, were omitted from calibration as they had not been left in the constant temperature lab for 24 hours prior to processing. This led to higher differences between Surfmet and underway salinity readings than those samples which were in the constant temperature lab for at least 24 hours. These are indicated by the circle in the residual plot below. A further five samples were also omitted from the calibration as they did not pass the following criteria:

The difference between sample and Surfmet salinities must lie within one standard deviation of the mean of the differences. This resulted in the following calibration which was obtained by linear regression:

Surfmet salinity = 0.0085 + 0.9996 x sample salinity, R^2=0.9996



Residual plot of differences between Surfmet and underway salinity readings.



Surfmet salinity reading calibration plot.

Light sensors

PAR and TIR readings were taken on both port and starboard sides of the vessel. Readings of greater than 3000 mW/m^2 were removed and the remaining readings were smoothed using the same technique as used for air temperature.

Jonathan Sharples

28th October 2011