

Prince Madog cruise 47/09
POL Coastal Observatory cruise 65
2-4 December 2009

1. Cruise objectives

1. At site A 53° 32'N, 3° 21.8'W (CTD station 1 and 9)

To recover:

- a) A sea bed frame containing a 600kHz ADCP (waves ADCP) to measure the mean current profile, pressures and directional waves; Sea-Bird SBE 16*plus* with pumped conductivity sensor, digiquartz pressure sensor and SeaPoint turbidity sensor with wiper; Sea-Bird 16*plus* with an Aanderra oxygen optode, and FSI CTD.
- b) CEFAS SmartBuoy in a single point mooring. Attached to the mooring wire are Sea-Bird MicroCat temperature, conductivity loggers at 5 and 10m below the surface and miniloggers at 7.5 and 15 m below the surface.

To deploy:

- c) A sea bed frame containing a 600kHz ADCP (waves ADCP) to measure the mean current profile, pressures and directional waves; Sea-Bird SBE 16*plus* with pumped conductivity sensor, digiquartz pressure sensor and a SeaPoint turbidity sensor with wiper; Sea-Bird SBE 16*plus* with an Aanderra oxygen optode.
- d) CEFAS SmartBuoy in a single point mooring. Attached to the mooring wire are Sea-Bird MicroCat temperature, conductivity loggers at 5m and 10m below the surface and miniloggers at 7.5 and 15 m below the surface.
- e) Collect 10 vertical zooplankton net hauls (CEFAS).
- f) Carry out a Benthic survey for Lucy Abram (University of Liverpool)

2. At site B 53° 27'N, 3° 38.6'W (CTD station 21)

To recover

- a) A sea bed frame for a 600 kHz ADCP (waves ADCP) to measure the mean current profile, pressures and directional waves. A Sea-Bird SBE 16*plus* with pumped conductivity sensor, digiquartz pressure sensor and a SeaPoint turbidity sensor fitted with a wiper.
- b) A CEFAS SmartBuoy in a single point mooring. Attached to the mooring wire are Sea-Bird MicroCat temperature, conductivity loggers at 5 and 10m below the surface and miniloggers at

7.5 and 15 m below the surface. AIS (Automatic Identification System), a collision avoidance system, attached to SmartBuoy.

To deploy:

c) A sea bed frame for a 600 kHz ADCP (waves ADCP) to measure the mean current profile, pressures and directional waves. A Sea-Bird SBE 16*plus* with pumped conductivity sensor, digiquartz pressure sensor and a SeaPoint turbidity sensor fitted with a wiper.

d) A CEFAS SmartBuoy in a single point mooring. Attached to the mooring wire are Sea-Bird MicroCat temperature, conductivity loggers at 5m and 10m below the surface and miniloggers at 7.5 and 15 m below the surface. AIS (Automatic Identification System), a collision avoidance system, attached to SmartBuoy.

3. CTD and LISST survey

To conduct a CTD / LISST survey of 34 sites every 5 miles covering the eastern Irish Sea between the North Wales coast and Blackpool, and the Lancashire coast and the Great Orme, to determine the effects of the rivers Dee, Mersey and Ribble on Liverpool Bay. To obtain calibration samples for salinity, transmittance, suspended sediment and for chlorophyll at selected stations. To obtain near surface and bed water samples for nutrient (nitrate, phosphate, silicate) and suspended sediment determination. To obtain surface samples for a Defra pH study by David Hydes (NOCS). To obtain mid-depth water samples for trace metal analysis (on board for Arsenic III and Antimony III).

4. Sediment samples

Collect sediment samples at each CTD site with a Day grab for Andy Plater (University of Liverpool).

Collect sediment samples (to be sieved) for a benthic survey at sites 1 and 32 for Lucy Abram (University of Liverpool).

2. Cruise Personnel

Scientific Personnel

Jo Hopkins (Principal Scientist)
John Kenny
Terry Doyle
Ray Edun
Lucy Abram (Liverpool University)
Zhaoshun Bi (Liverpool University)
Anne Hammerstein (University of Wales, Bangor)
Jennie Keable (CEFAS)
Gary Batchelor (CEFAS)

Ships officers and crew

Steve Duckworth (Master)
David Shaw (Chief Officer)
Leslie Black (Chief Engineer)
Meikle Mackay (2nd Engineer)
Phil Jones (Bosun)
Dave Leigh (A.B.)
Gary Barnes (A.B.)
Colin Hughes (Cook)

3. Narrative

(All times in GMT)

The day grab and table, anchor chain clumps, two sea-bed frames with instrumentation and a SmartBuoy were loaded onto the RV Prince Madog at Vittoria Wharf, Birkenhead by 21:00 on 01/12/2009.

The RV Prince Madog left Birkenhead at 09:30 on 02/12/2009. The underway surface monitoring system, pCO₂ system, ADCP and Environment systems were switched on at 10:23 while passing the Crosby Radar Tower. Wind direction was 150° at speeds of 9-10m/s.

All mooring work was completed on the 2nd December 2009 due to unfavorable conditions forecast for the following day. The first CTD cast (pre-deployment) was recorded at site 1 at 11:46. The ADCP bed frame was released acoustically at 12:09 and on deck at 12:23. Deployment of a new frame was completed at 12:42. The new SmartBuoy (with modified frame to prevent the wire being trapped while on deck) was deployed at 13:03 and the old buoy recovered by 13:23. A post-deployment CTD was then recorded with a full suite of samples (nutrients, SPM, metals, pH). During mooring operations a disruption of the ships ADCP and EK60 recordings was noted whilst the Madog was reversing, possibly due to bubbles. A sediment grab was also taken at site 1.

The Madog then headed directly to Site 21 to ensure recovery of the second ADCP frame during daylight hours. No AIS signal was detected upon approach. A pre-mooring cast at site 21 was recorded at 14:57 followed by a second sediment grab. The ADCP frame and ballast were on deck at 15:53. The new ADCP frame was deployed at 16:08.

Bolts/brackets used to attach the AIS to the SmartBuoy at site 21 had not been loaded onto the Madog. At 16:22 the SmartBuoy was therefore partially recovered and held at the stern (slack water and low winds) for 10-15 minutes to allow the necessary bolts from the incoming system to be removed, and re-used on the new setup. The incoming AIS was temporarily lashed down and the buoy released again. The new refurbished SmartBuoy was released at 18:21. Recovery of the old SmartBuoy was completed at 18:39 with all equipment present and intact. A post-mooring CTD cast was taken at 18:51 with a full suite of samples. During deployment and recovery of the ADCP frames and SmartBuoy wind speeds were between 5 and 6 m/s blowing from 136°.

To allow the ships crew and engineers to rest the Madog headed to Menai Bridge for the night, arriving alongside the pier at 21:48.

The Madog left Menai Bridge at 07:30 on 03/12/2009 running into a heavy N/NW swell at 09:00 (Winds 17m/s, 290°). CTD and grab deployment was not possible under these conditions.

Sites 34, 33, 24, 21, 12, 11, 10 and 35 were visited (west to east) and surface nutrient samples taken from the flow through system (approx. 3m below SL). The AIS showed up 2.5 miles away from site 21 in storm conditions. A heavy swell driven by 10-17 m/s, 290-320° winds persisted throughout this time. At 16:31 (site 35) the Madog turned towards Birkenhead rather than heading west into the oncoming waves and potentially dangerous working conditions.

Just before the Crosby radar tower (53° 28.750' N, 3° 4.541' W) the underway and ADCP (18:47), and pCO₂ (18:51) systems were stopped. Since the Madog was running more slowly than usual recording was terminated early to prevent silt running through the system and damaging instruments. The Madog berthed in Vittoria Dock at 21:25 on 03/12/2009.

No zooplankton nets for CEFAS were completed due to time pressures on 02/12/2009 and poor weather on 03/12/2009.

n.b. The latitude and longitude of each CTD deployment is now recorded in the header file for each cast.

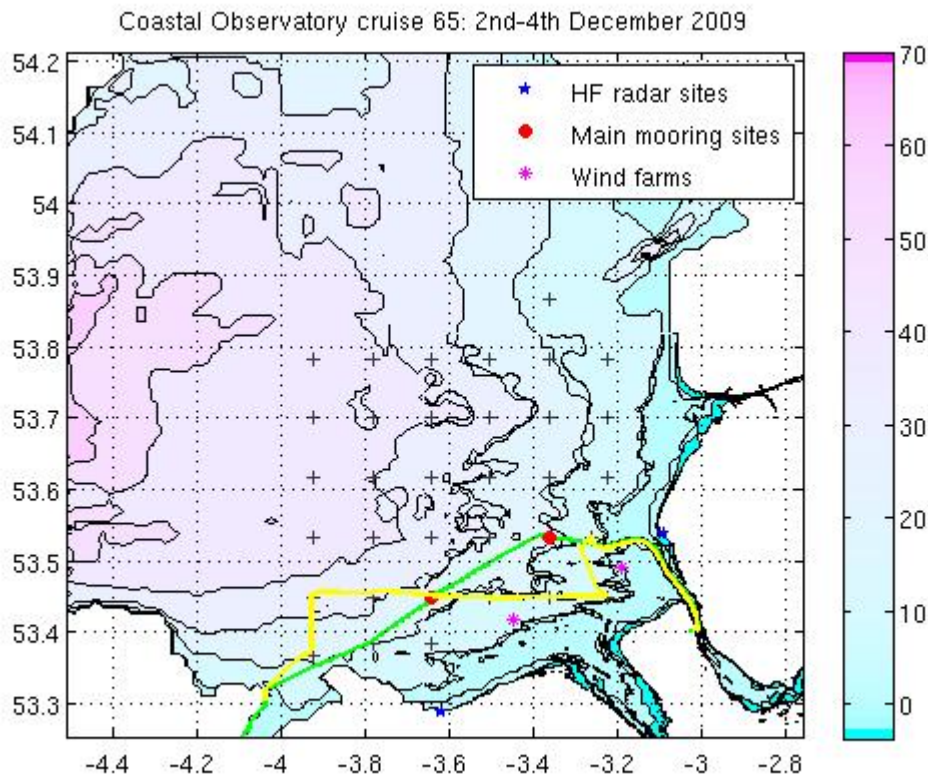


Figure 1. Track from coastal observatory cruise number 65. Red dots mark sites A (53° 32' N, 3° 21.8' W) and B (53° 27' N, 3° 38.6' W). Bathymetry scale is in m's. Green track on 02/12/09 and yellow track on 03/12/09.

4. Moorings

4.1. Recovered instruments

The setup of the **recovered** instruments (all times in GMT) was as follows:

Site A: Bedframe

Waves ADCP 600kHz RDI S/N 12239

Mode 1: 100 pings every 10 minutes.

35 x 1m bins (2.65-36.65 m above the bed)

Beam coordinates – speeds, correlation, echo intensity, % good.

Sound velocity calculated from temperature, depth and salinity of 32.

Clock set at 14:06:00 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009.

SeaBird 16*plus* S/N 4737 on base of frame with pumped conductivity sensor and SeaPoint turbidity sensor (S/N 10537) taped to roll bar; setup for 0-125 FTU range and fitted with wiper.

Sample interval 600s; digiquartz integration time 40s, range 400; pump 0.5s, 1 s delay.

Clock set at 13:25:00 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009

SeaBird 16*plus* S/N 4741 upright on top of frame and (not pumped) conductivity sensor underneath. Sample interval 600s. Aanderaa optode (S/N 675)

Clock set at 13:33:30 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009

The frame was fitted with a fizz link, a spooler with 50m of rope for recovery of the ballast weight and two Benthos releases S/N 72381 (Rx=11 kHz, Tx=12kHz, RC=B) and S/N 72382 (Rx=10.0kHz, Tx=12kHz, RC=A).

Site A: SmartBuoy Mooring

SeaBird microcat temperature and conductivity recorder S/N 5791 at 5m below the surface.

Clock set at 15:16:00 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009.

SeaBird microcat temperature and conductivity recorder S/N 2081 at 10m below the surface.

Clock set at 14:49:00 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009.

Mini-logger (StarOddi) S/N 2836 at 7.5m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 15/09/2009. Serial number not noted during deployment. This will need to be recorded upon recovery.

Mini-logger (StarOddi) S/N 2838 at 15m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 15/09/2009. Serial number not noted during deployment. This will need to be recorded upon recovery.

The CEFAS SmartBuoy is fitted with sensors for conductivity, temperature and optical back scatter at 1m below surface, light sensors at 1 and 2 m below the surface, a fluorometer (SeaPoint), oxygen sensor (Aanderaa Optode), an in-situ NAS2E nutrient analyzer and a water sampler which obtains samples every fourth day for laboratory analysis (TOXN and silicate) and every eighth day (phytoplankton species, composition and abundance). The conductivity, temperature, optical back scatter and light data are transmitted back to CEFAS via Orbcomm.

The single point mooring was composed of ½" long link chain, marked by a 1.8 m diameter toroid and anchored by a half tonne clump of scrap chain.

Site B: Bedframe

Waves ADCP 600kHz RDI S/N 5807

Mode 1: 100 pings every 10 minutes.

35 x 1m bins (2.65-36.65 m above the bed)

Beam coordinates – speeds, correlation, echo intensity, % good.

Sound velocity calculated from temperature, depth and salinity of 32.

Clock reset at 14:00:00 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009

SeaBird 16*plus* S/N 5309 on base of frame with pumped conductivity sensor and SeaPoint turbidity sensor (S/N 10471) taped to roll bar; setup for 0-125 FTU range and fitted with wiper. Sample interval 600s; digiquartz integration time 40s, range 400; pump 0.5s, 1 s delay.

Clock reset at 13:40:30 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009

The frame was fitted with a fizz link, a spooler with 50m of rope for recovery of the ballast weight and two Benthos releases S/N 69676 (Rx=11.5kHz, Tx=12kHz, RC=C) and S/N 70358 (Rx=11kHz, Tx=12kHz, RC=A).

Site B: SmartBuoy Mooring + AIS

SeaBird microcat temperature and conductivity recorder S/N 5793 at 5m below the surface.

Clock set at 15:10:00 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009.

SeaBird microcat temperature and conductivity recorder S/N 5790 at 10m below the surface.

Clock set at 15:05:30 on 14/09/2009. Delayed start at 06:00:00 on 15/09/2009.

Mini-logger (StarOddi) S/N 2841 @7.5 m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 15/09/2009.

Mini-logger (StarOddi) S/N 2849 @15 m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 15/09/2009.

The CEFAS SmartBuoy is fitted with a sensors for conductivity, temperature and optical back scatter and a fluorometer at 1m below surface. The single point mooring was composed mainly of ½" long link chain, marked by a 1.8 m diameter toroid and anchored by a half tonne clump of scrap chain.

The AIS was fitted to the SmartBuoy frame.

MMSI number: 992351051.

Name: POL_Scientific_Buoy_B1

Table 1. Recovered mooring positions and times (GMT)

	Latitude (N)	Longitude (W)	Water depth (m)	Date	Time
ADCP frame (Site A)	53° 32.001'N	3° 21.477'W	25.9	02/12/09	12:22
SmartBuoy (Site A)	53° 32.008'N	3° 21.583'W	24.3	02/12/09	13:22
ADCP frame (Site B)	53° 26.973'N	3° 38.483'W	21.8	02/12/09	15:53
SmartBuoy (Site B)	53° 27.021'N	3° 38.504'W	21.6	02/12/09	18:39

4.2. Deployed instruments

The setup of the **deployed** instruments (all times in GMT) was as follows:

Site A: Bedframe

Waves ADCP 600kHz RDI S/N 2390. Firmware updated to v50.36.

Mode 1: 100 pings every 10 minutes.

35 x 1m bins (2.65-36.65 m above the bed)

Beam coordinates – speeds, correlation, echo intensity, % good.

Sound velocity calculated from temperature, depth and salinity of 32.

Clock set at 18:24:50 on 01/12/2009. Delayed start at 06:00:00 on 02/12/2009.

SeaBird 16*plus* S/N 4736 on base of frame with pumped conductivity sensor and SeaPoint turbidity sensor (S/N 10320) taped to roll bar; setup for 0-125 FTU range and fitted with wiper. Sample interval 600s; digiquartz integration time 40s, range 400; pump 0.5s, 1 s delay.

Clock set at 08:39:00 on 02/12/2009. Delayed start at 10:00:00 on 02/12/2009

SeaBird 16*plus* S/N 4490 upright on top of frame and (not pumped) conductivity sensor underneath. Sample interval 600s. Aanderaa optode (S/N 674)

Clock set at 09:00:15 on 02/12/2009. Delayed start at 10:00:00 on 02/12/2009

The frame was fitted with a fizz link, a spooler with 50m of rope for recovery of the ballast weight and two Benthos releases S/N 70355 (Rx=10 kHz, Tx=12kHz, RC=B) and S/N 72378 (Rx=10.5kHz, Tx=12kHz, RC=A).

Site A: SmartBuoy Mooring

SeaBird microcat temperature and conductivity recorder S/N 5434 at 5m below the surface.

Clock set at 18:35:50 on 01/12/2009. Delayed start at 06:00:00 on 02/12/2009.

SeaBird microcat temperature and conductivity recorder S/N 4966 at 10m below the surface.

Clock set at 18:04:00 on 01/12/2009. Delayed start at 06:00:00 on 02/12/2009.

Mini-logger (StarOddi) S/N 2842 at 7.5m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 02/12/2009.

Mini-logger (StarOddi) S/N 2843 at 15m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 02/12/2009.

The CEFAS SmartBuoy is fitted with sensors for conductivity, temperature and optical back scatter at 1m below surface, light sensors at 1 and 2 m below the surface, a fluorometer (SeaPoint), oxygen sensor (Aanderaa Optode), an in-situ NAS2E nutrient analyzer and a water sampler which obtains samples every fourth day for laboratory analysis (TOXN and silicate) and every eighth day (phytoplankton species, composition and abundance). The conductivity, temperature, optical back scatter and light data are transmitted back to CEFAS via Orbcomm.

The single point mooring was composed of ½" long link chain, marked by a 1.8 m diameter toroid and anchored by a half tonne clump of scrap chain.

Site B: Bedframe

Waves ADCP 600kHz RDI S/N 5806. Firmware updated to v50.36.

Mode 1: 100 pings every 10 minutes.

35 x 1m bins (2.65-36.65 m above the bed)

Beam coordinates – speeds, correlation, echo intensity, % good.

Sound velocity calculated from temperature, depth and salinity of 32.

Clock reset at 19:13:40 on 01/12/2009. Delayed start at 06:00:00 on 02/12/2009

SeaBird 16*plus* S/N 4738 on base of frame with pumped conductivity sensor and SeaPoint turbidity sensor (S/N 10538) taped to roll bar; setup for 0-125 FTU range and fitted with wiper. Sample interval 600s; digiquartz integration time 40s, range 400; pump 0.5s, 1 s delay.

Clock reset at 08:48:30 on 02/12/2009. Delayed start at 10:00:00 on 02/12/2009

The frame was fitted with a fizz link, a spooler with 50m of rope for recovery of the ballast weight and two Benthos releases S/N 72863 (Rx=13.5kHz, Tx=12kHz, RC=A) and S/N 71919 (Rx=10.5kHz, Tx=12kHz, RC=C).

Site B: SmartBuoy Mooring + AIS

SeaBird microcat temperature and conductivity recorder S/N 5792 at 5m below the surface.

Clock set at 18:58:00 on 01/12/2009. Delayed start at 06:00:00 on 02/12/2009.

SeaBird microcat temperature and conductivity recorder S/N 4998 at 10m below the surface.

Clock set at 18:53:00 on 01/12/2009. Delayed start at 06:00:00 on 02/12/2009.

Mini-logger (StarOddi) S/N 2852 @7.5 m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 02/12/2009.

Mini-logger (StarOddi) S/N 2844 @15 m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 02/12/2009.

The CEFAS SmartBuoy is fitted with sensors for conductivity, temperature and optical back scatter and a fluorometer at 1m below surface. The single point mooring was composed mainly

of ½" long link chain, marked by a 1.8 m diameter toroid and anchored by a half tonne clump of scrap chain.

The AIS was fitted to the SmartBuoy frame.

MMSI number: 992351051.

Name: POL_Scientific_Buoy_B1

Table 2. Deployed mooring positions and times (GMT)

	Latitude (N)	Longitude (W)	Water depth (m)	Date	Time
ADCP frame (Site A)	53° 31.983'N	3° 21.478'W	25.2	02/12/09	12:42
SmartBuoy (Site A)	53° 32.049'N	3° 21.832'W	24.8	02/12/09	13:04
ADCP frame (Site B)	53° 27.004'N	3° 38.513'W	22.0	02/12/09	16:08
SmartBuoy (Site B)	53° 26.997'N	3° 38.332'W	22.7	02/12/09	18:21

5. CTD

The Sea-Bird 911 CTD recorded downwelling PAR light levels, temperature, conductivity, oxygen concentration, transmittance and fluorescence at 24 Hz. The frame was fitted with an altimeter. The CTD temperature data was checked against a Sea-Bird SBE35 precision thermometer. Water samples were taken from a near bed (3mab) bottle for calibration of the CTD salinity data by Anne Hammerstein (SOS). Water samples were taken from the near surface (1m) and near bed (3mab) bottles and filtered to determine suspended sediment load concentration, nutrient concentration, ammonia oxidation/nitrification rate assessment, surface pH (DEFRA) and for CEFAS calibration. A LISST-25 particle sizer was fitted to the CTD and its data logged on the Sea-Bird data logging system. A LISST100-C particle sizer with internal logging was attached to the CTD frame. A bottle at 7m was fired to obtain samples for trace metal analysis.

Bottles used on the CTD were as follows:

Bottle 3: bottom nutrients

Bottle 4: bottom SPM

Bottle 5: bottom CEFAS

Bottle 8: trace metals at ~7m below surface

Bottle 9: surface SPM

Bottle 10: surface nutrients and pH

Bottle 11: surface CEFAS

Bottle 12: surface CEFAS

Table 3. Nominal CTD positions. (nuts = nutrients, SPM = suspended sediments)
(U) indicates that surface samples were taken from the flow through system.

Site	Latitude (N)	Longitude (W)	Done on cruise	CEFAS chlorophyll, nuts, SPM & salinity	POL nuts	POL SPM	Grab. No.	pH
1	53° 32'	3° 21.8'	yes	yes	yes	yes	1	yes
2	53° 37'	3° 13.4'	no	no	no	no	none	no
3	53° 42'	3° 13.4'	no	no	no	no	none	no
4	53° 47'	3° 13.4'	no	no	no	no	none	no
5	53° 52'	3° 21.8'	no	no	no	no	none	no
6	53° 47'	3° 21.8'	no	no	no	no	none	no
7	53° 42'	3° 21.8'	no	no	no	no	none	no
8	53° 37'	3° 21.8'	no	no	no	no	none	no
9	53° 32'	3° 21.8'	no	no	no	no	none	no
10	53° 27'	3° 13.4'	yes (U)	chloro + nuts + salinity	yes	no	none	no
11	53° 27'	3° 21.8'	yes (U)	no	yes	no	none	no
12	53° 27'	3° 30.2'	yes (U)	no	yes	no	none	no
13	53° 32'	3° 30.2'	no	no	no	no	none	no
14	53° 37'	3° 30.2'	no	no	no	no	none	no
15	53° 42'	3° 30.2'	no	no	no	no	none	no
16	53° 47'	3° 30.2'	no	no	no	no	none	no
17	53° 47'	3° 47.0'	no	no	no	no	none	no
18	53° 42'	3° 38.6'	no	no	no	no	none	no
19	53° 37'	3° 38.6'	no	no	no	no	none	no
20	53° 32'	3° 38.6'	no	no	no	no	none	no
21	53° 27'	3° 38.6'	yes	yes	yes	yes	2	yes
22	53° 23'	3° 38.6'	no	no	no	no	none	no
23	53° 23'	3° 47.0'	no	no	no	no	none	no

24	53° 27'	3° 47.0'	yes (U)	no	yes	no	none	no
25	53° 32'	3° 47.0'	no	no	no	no	none	no
26	53° 37'	3° 47.0'	no	no	no	no	none	no
27	53° 42'	3° 47.0'	no	no	no	no	none	no
28	53° 47'	3° 47.0'	no	no	no	no	none	no
29	53° 47'	3° 55.4'	no	no	no	no	none	no
30	53° 42'	3° 55.4'	no	no	no	no	none	no
31	53° 37'	3° 55.4'	no	no	no	no	none	no
32	53° 32'	3° 55.4'	no	no	no	no	none	no
33	53° 27'	3° 55.4'	yes (U)	no	yes	no	none	no
34	53° 22'	3° 55.4'	yes (U)	chloro + nuts + salinity	yes	no	none	no
35	53° 32'	3° 15.9'	yes (U)	no	yes	no	none	no

Table 4. Surface (T) and bottom (B) parameters from CTD, noted in log book. Nominal CTD positions.

CTD No.	Site	Latitude (N)	Longitude (W)	Water depth (m)	Temp (°C)		Salinity	
					T/B	T/B	T/B	T/B
1	1-1	53° 32'	3° 21.8'	27.7	10.26/10.28	33.71/33.72		
2	1-2	53° 32'	3° 21.8'	24.4	10.25/10.27	33.76/33.77		
3	21-1	53° 27'	3° 38.6'	24.7	10.06/10.13	33.77/33.80		
4	21-2	53° 27'	3° 38.6'	23.3	9.51/10.28	33.31/33.85		

6. Surface sampling

The intake for the surface sampling system is located underneath RV Prince Madog, at about 3 m below sea level. The parameters recorded every minute by the WS Oceans system are:

Date, Transmittance, Hull Temperature (°C), Barometric Pressure (mbar), Fluorescence, Oxygen concentration, Turbidity, Salinity and Conductivity sensor water temperature (°C). In addition, a pCO₂ sensor is incorporated into the surface sampling system.

Met package measures and records Barometric pressure (mbar), Solar Radiation ($W\ m^{-2}$), PAR ($\mu\text{mols} / m^2s$), Air Temperature (°C), Relative Humidity, Relative Wind Speed ($m\ s^{-1}$), Relative Wind Direction (°) – zero indicates wind on the bow, Minimum Air Temp (°C), Maximum Air Temp (°C) and Wind Gust ($m\ s^{-1}$).

The ship was fitted with a 300 kHz ADCP set to record 25 x 2m bins (bin nearest the surface at 5.1 m depth), every 30 seconds with 29 pings / ensemble.

Underway data, pCO₂ and ship's ADCP data were recorded every minute.

On 2nd December 2009 the systems started recording at the Crosby radar tower at 10:23 and were stopped at 20:54 (Underway and ADCP) and 21:00 (pCO₂) near Puffin Island.

On 3rd December 2009 the systems were started at Puffin Island at 08:27 and were stopped just before the Crosby radar tower (53° 28.750' N, 3° 4.541' W) at 18:47 (Underway and ADCP) and 18:51 (pCO₂). Since the Madog was running more slowly than usual recording was terminated early to prevent silt running through the system and damaging instruments.

Acknowledgments

The assistance of the master, officers and crew is appreciated in ensuring the success of this cruise.