

**Prince Madog cruise 33/09**  
**POL Coastal Observatory cruise 63**  
**2-4<sup>th</sup> August 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 a SeaPoint turbidity sensor with wiper; Sea-Bird SBE 16*plus* with an Aanderra oxygen optode; FSI CTD.
- b) 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.

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 SeaPoint turbidity sensor with wiper; Sea-Bird 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 5 and 10m below the surface and miniloggers at 7.5 and 15 m below the surface.
- e) Collect 10 vertical zooplankton net hauls (CEFAS)

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

To recover:

- a) 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.
- b) 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.

## To deploy

- c) 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.
- d) AIS (Automatic Identification System), a collision avoidance system, attached to SmartBuoy.
- e) 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.

### **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)

## **2. Cruise Personnel**

### **Scientific Personnel**

Jo Hopkins (Principal Scientist)  
Rose Player  
Andy Lane  
Chris Balfour  
John Kenny  
Ray Edun  
Pascal Salaun (Liverpool University)  
Anne Hammerstein (University of Wales, Bangor)  
Jennie Keable (CEFAS)  
Tom McGowan (CEFAS)

### **Ships officers and crew**

Steve Duckworth (Master)  
David Shaw (Chief Officer)  
Leslie Black (Chief Engineer)  
Meikle Mackay (2<sup>nd</sup> Engineer)  
Phil Jones (Bosun)  
Dave Leigh (A.B.)  
James McNamee (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 09:30 on 02/08/2009.

The RV Prince Madog left Birkenhead at 17:20 on 02/08/2009. The underway surface monitoring system, pCO<sub>2</sub> system, ADCP and Environment systems were switched on at 18:24 while passing the Crosby Radar Tower.

Site 10 was reached at 19:45 on 02/08/2009 and the CTD grid was started proceeding east to west, from north to south (sites 10, 11, 12, 21, 24, 33, 34, 23, 22).

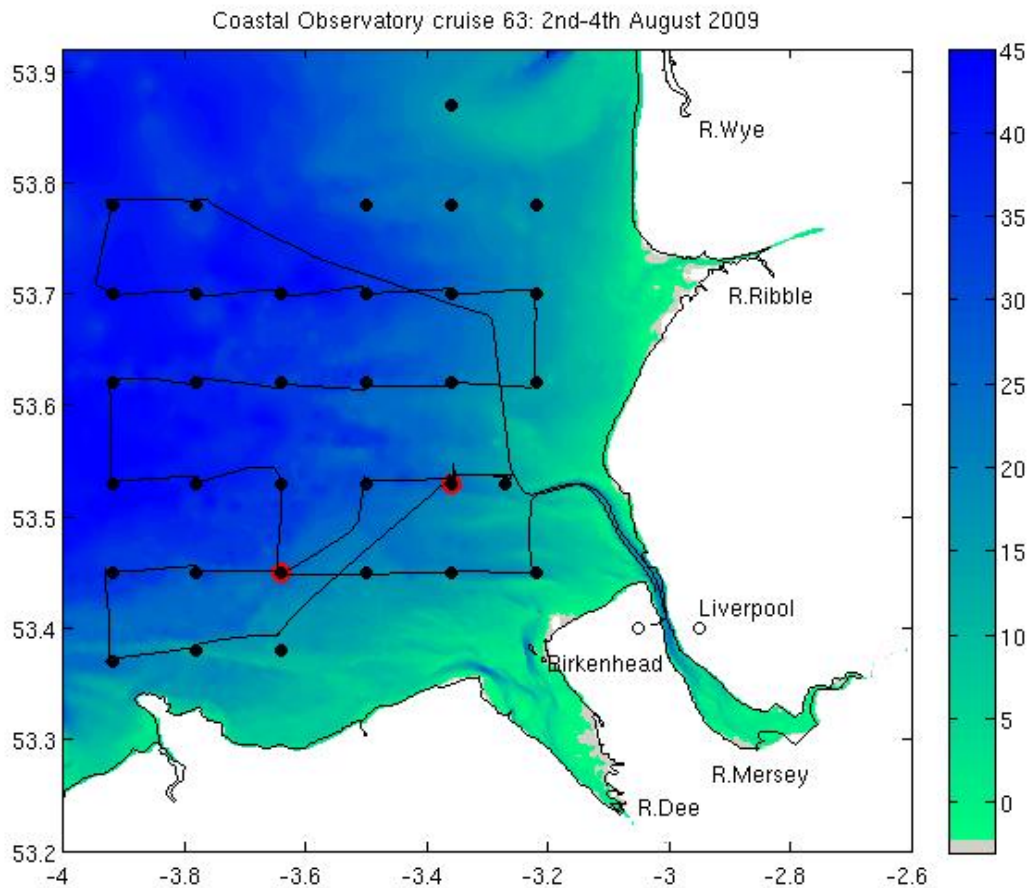
Upon completion of the CTD cast at site 22 the RV Madog headed to site 1 arriving at 03:51 on 03/08/2009. Vertical zooplankton net hauls (5 with small net, 5 with large net) were completed by 04:55.

At 05:17 the first CTD cast at site 1 was recorded and surface (chlorophyll, salinity, nutrients, suspended load & oxygen) and bottom (oxygen) samples taken for CEFAS. The ADCP frame and ballast weight were recovered by 06:03 and the new ADCP frame deployed at 06:24. The new SmartBuoy was deployed at 07:23 and the old buoy recovered by 07:44. A CTD was then recorded with a full suite of samples. During deployment and recovery of the ADCP frames and SmartBuoy wind speeds were between 9 and 12 m/s blowing from 160°.

The CTD grid was then restarted from site 35 at 08:39 preceding east-west (sites 35, 9, 13) while the recovered SmartBuoy was refurbished and the AIS system attached. The RV Madog then headed to site 21 to complete mooring work while the weather and sea state were favorable. A pre-mooring cast was recorded at 11:37 and surface samples taken for CEFAS. The ADCP frame was recovered and on deck at 12:02 and the replacement frame deployed at 12:21. The SmartBuoy (+ new AIS system) was deployed at 13:21 and the AIS system seen to be working. SmartBuoy recovery was completed by 13:34. The minilogger at 7.5m was not on the chain and thought to have been lost during recovery. A post mooring CTD cast was recorded at 13:57.

The CTD grid was restarted from site 20 at 14:35 and proceeded east-west from south to north (sites 20, 25, 32, 31, 26, 19, 14, 8, 2, 3, 7, 15, 18, 27, 30, 29, 28). Heading east between sites 29 and 28 the RV Prince Madog was moving against wind and tide and progress therefore slowed considerably. At 03:55 on 04/08/2009 after completion of site 28 the ship turned south and headed for port in order to arrive in time for a 10:00 lock on 04/08/2009. This left sites 17, 16, 6, 4 and 5 unsampled.

The ADCP, pCO<sub>2</sub>, surface monitoring and Environment systems were stopped at 08:18 on 04/08/2009. The RV Prince Madog docked at Vittoria Wharf at 09:25.



**Figure 1.** Cruise track from coastal observatory cruise number 63. Red dots mark sites A ( $53^{\circ} 32' \text{ N}$ ,  $3^{\circ} 21.8' \text{ W}$ ) and B ( $53^{\circ} 27' \text{ N}$ ,  $3^{\circ} 38.6' \text{ W}$ ). Bathymetry scale is in m's.

## 4. Moorings

### 4.1. Recovered instruments

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

#### Site A: Bedframe

Waves ADCP 600 kHz RDI 5803

Mode 1: 100 pings every 10 minutes (velocity standard deviation  $0.007 \text{ m s}^{-1}$ ).

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

Beam co-ordinates - speeds, correlation, echo intensity, % good.

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

Clock set at 07:29:00 on 12 June 2009. Delayed start at 06:00:00 on 17 June 2009.

Sea-Bird 16plus S/N 4737 on base of frame with pumped conductivity sensor and SeaPoint turbidity sensor No. 10537 taped to roll bar; set up for 0 - 125 FTU range, fitted with a wiper.

Sample interval 600 s; digiquartz integration time 40 s, range 400; pump 0.5s, 1 s delay. Clock set at 08:52:00 on 12 June 2009. Delayed start at 06:00:00 on 17 June 2009.

Sea-Bird 16plus S/N 4741 upright on top of frame (NOT pumped) conductivity sensor underneath. Sample interval 600 s. Aanderaa optode S/N 674. Clock set at 08:31:00 on 12 June 2009. Delayed start at 06:00:00 on 17 June 2009.

FSI CTD S/N 2195. Sample interval 600 s; sample rate 4 Hz, sample average 40s; record time 40 s. Clock set at 07:59:00 on 12 June 2009. Delayed start at 06:00:00 on 12 June 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 11.5 kHz, Tx 12.0 kHz, release C) and s/n 72858 (Rx 14.5 kHz, Tx 12.0 kHz, release A).

### **Site A: SmartBuoy Mooring**

Sea-Bird MicroCat temperature and conductivity recorder s/n 2081 at 5m below the surface. Sample interval 600s. Clock set at 09:17:00 on 12 June 2009. Delayed start at 06:00:00 on 17 June 2009.

Sea-Bird MicroCat temperature, conductivity and pressure recorder s/n 5790 at 10m below the surface. Sample interval 600s. Clock set at 09:24:30 on 12 June 2009. Delayed start at 06:00:00 on 17 June 2009.

Mini-logger (StarOddi) s/n 2838 at 7.5 m below the surface set to record at 600s intervals. Delayed start at 06:00:00 on 17 June 2009.

Mini-logger (StarOddi) s/n 2841 at 15 m below the surface set to record at 600s intervals. Delayed start at 06:00:00 on 17 June 2009.

The CEFAS SmartBuoy is fitted with one surface CTD, light sensors at 1 and 2 m below the surface, a water sampler which obtains water samples once per day for laboratory nutrient (TOXN and silicate; no filtration therefore no phosphate), fluorometer (SeaPoint), oxygen (Aanderaa Optode) and chlorophyll determination and an in situ NAS2E nutrient analyser. The CTD 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 600 kHz RDI 12239

Mode 1: 100 pings every 10 minutes (velocity standard deviation 0.007 m s<sup>-1</sup>).

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

Beam co-ordinates - speeds, correlation, echo intensity, % good.

Sound velocity calculated from temperature, depth and salinity of 32. Clock reset at 07:41:00 on 12 June 2009. Delayed start at 06:00:00 on 17 June 2009.

Sea-Bird 16plus S/N 5309 on base of frame with pumped conductivity sensor underneath and SeaPoint turbidity sensor (Serial No. 10471) taped to roll bar; set up for 0 - 125 FTU range, fitted

with a wiper. Sample interval 600 s; digiquartz integration time 40 s, range 400; pump 0.5s, 1 s delay. Clock reset at 08:42:00 on 12 June 2009. Delayed start at 06:00:00 on 17 June 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 70356 (Rx 10.5 kHz, Tx 12.0 kHz, release D) and s/n 67679 (Rx 11.5 kHz, Tx 12.0 kHz, release B).

**Site B: SmartBuoy Mooring – deployed on cruise 61**

Sea-Bird MicroCat temperature, conductivity and pressure recorder s/n 5793 at 5 m below the surface. Sample interval 600s. Clock reset at 13:31:00 on 7 May 2009. Delayed start at 14:00:00 on 11 May 2009.

Sea-Bird MicroCat temperature, conductivity and pressure recorder s/n 5791 at 10 m below the surface. Sample interval 600s. Clock reset at 13:19:30 on 7 May 2009. Delayed start at 14:00:00 on 11 May 2009.

Mini-logger (StarOddi) s/n 2847 at 7.5 m below the surface set to record at 600s intervals. Delayed start at 14:00:00 on 11 May 2009. The instrument was missing from the anchor chain upon recovery.

Mini-logger (StarOddi) s/n 2849 at 15 m below the surface set to record at 600s intervals. Delayed start at 14:00:00 on 11 May 2009.

The CEFAS SmartBuoy is fitted with a surface CTD (including turbidity sensor and fluorometer). The frame was fitted with bags for the determination of bacterial degradation. 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.

**Table 1.** Recovered mooring positions and times (GMT)

	<b>Latitude (N)</b>	<b>Longitude (W)</b>	<b>Water depth (m)</b>	<b>Date</b>	<b>Time</b>
<b>ADCP frame (Site A)</b>	53° 31.999'N	3° 21.327'W	21.6	03/08/09	06:03
<b>SmartBuoy (Site A)</b>	53° 32.038'N	3° 21.500'W	24.6	03/08/09	07:44
<b>ADCP frame (Site B)</b>	53° 27.015'N	3° 38.523'W	25.3	03/08/09	12:02
<b>SmartBuoy (Site B)</b>	53° 27.120'N	3° 38.406'W	23.4	03/08/09	13:34

## **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 5806

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 10:00:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009.

SeaBird 16*plus* S/N 4736 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 15:09:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009

SeaBird 16*plus* S/N 4490 upright on top of frame and (not pumped) conductivity sensor underneath. Sample interval 600s. Aanderaa optode (S/N 675)

Clock set at 11:24:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009

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 71919 (Rx=10.5kHz, Tx=12kHz, RC=C).

### **Site A: SmartBuoy Mooring**

SeaBird microcat temperature and conductivity recorder S/N 4966 @5m below the surface.

Clock set at 11:11:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009.

SeaBird microcat temperature and conductivity recorder S/N 5792 @10m below the surface.

Clock set at 11:04:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009.

Mini-logger (StarOddi) @7.5 m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 03/08/2009. Serial number not noted during deployment. This will need to be recorded upon recovery.

Mini-logger (StarOddi) @15 m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 03/08/2009. 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 2390

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 09:53:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009

SeaBird 16*plus* S/N 4738 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 15:04:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009

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 72378 (Rx=10.5kHz, Tx=12kHz, RC=A) and S/N 72863 (Rx=13.5kHz, Tx=12kHz, RC=A).

### **Site B: SmartBuoy Mooring + AIS**

SeaBird microcat temperature and conductivity recorder S/N 5433 @5m below the surface.

Clock set at 11:15:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009.

SeaBird microcat temperature and conductivity recorder S/N 5434 @10m below the surface.

Clock set at 11:07:00 on 02/08/2009. Delayed start at 06:00:00 on 03/08/2009.

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 03/08/2009.

Mini-logger (StarOddi) S/N 2844 @15 m below the surface. Set to record at 600s intervals. Delayed start at 06:00:00 on 03/08/2009.

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 2.** Deployed mooring positions and times (GMT)

	Latitude (N)	Longitude (W)	Water depth (m)	Date	Time
<b>ADCP frame (Site A)</b>	53° 32.023'N	3° 21.402'W	23.0	03/08/09	06:24
<b>SmartBuoy (Site A)</b>	53° 32.041'N	3° 21.822'W	24.4	03/08/09	07:23
<b>ADCP frame (Site B)</b>	53° 26.984'N	3° 38.468'W	24.7	03/08/09	12:21
<b>SmartBuoy (Site B)</b>	53° 26.940'N	3° 38.555'W	24.3	03/08/09	13:21

## 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.

33 CTD profiles were recorded at 29 sites.

*Bottles used on the CTD were as follows:*

Bottle 3: bottom SPM

Bottle 4: bottom nutrients and salinity

Bottle 5: bottom CEFAS oxygen

Bottle 8: trace metals at ~7m below surface

Bottle 9: surface SPM

Bottle 10: surface nutrients and CEFAS oxygen

Bottle 11: surface CEFAS (chlorophyll, nutrients, SPM, salinity)

Bottle 12: surface pH

### **CEFAS sampling**

Surface samples for chlorophyll, nutrients (TOXN, PO<sub>4</sub>, NH<sub>4</sub>, NO<sub>2</sub>, Si) and suspended sediments and salinity were taken at the following sites by CEFAS: 34, 10, 20, 32, 19, 2, 7, 30, 17, 5, 9 and at site 21 (CTD 15 pre-buoy recovery), site 1 (CTD 10, pre buoy recovery), and site 1 (CTD 11 - post buoy recovery). Surface oxygen samples were taken at site 1 (pre and post buoy recovery), site 21 (pre buoy recovery) and site 9. A bottom oxygen sample was also taken at site 1 (pre buoy recovery).

**Table 3.** Nominal CTD positions. (nuts = nutrients, SPM = suspended sediments)

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	none taken	yes
2	53° 37'	3° 13.4'	yes	yes	yes	yes	21	yes
3	53° 42'	3° 13.4'	yes	no	yes	yes	22	yes
4	53° 47'	3° 13.4'	no	no	no	no	no	no
5	53° 52'	3° 21.8'	no	no	no	no	no	no
6	53° 47'	3° 21.8'	no	no	no	no	no	no
7	53° 42'	3° 21.8'	yes	yes	yes	yes	23	yes
8	53° 37'	3° 21.8'	yes	no	yes	yes	20	yes
9	53° 32'	3° 21.8'	yes	yes	yes	yes	11	yes
10	53° 27'	3° 13.4'	yes	yes	yes	yes	1	yes
11	53° 27'	3° 21.8'	yes	no	yes	yes	2	yes
12	53° 27'	3° 30.2'	yes	no	yes	yes	3	yes
13	53° 32'	3° 30.2'	yes	no	yes	yes	12	yes
14	53° 37'	3° 30.2'	yes	no	yes	yes	19	yes
15	53° 42'	3° 30.2'	yes	no	yes	yes	24	yes
16	53° 47'	3° 30.2'	no	no	no	no	no	no
17	53° 47'	3° 47.0'	no	no	no	no	no	no
18	53° 42'	3° 38.6'	yes	no	yes	yes	25	yes
19	53° 37'	3° 38.6'	yes	yes	yes	yes	19	yes
20	53° 32'	3° 38.6'	yes	yes	yes	yes	13	yes
21	53° 27'	3° 38.6'	yes	yes	yes	yes	4	yes
22	53° 23'	3° 38.6'	yes	no	yes	yes	9	yes
23	53° 23'	3° 47.0'	yes	no	yes	yes	8	yes
24	53° 27'	3° 47.0'	yes	no	yes	yes	5	yes
25	53° 32'	3° 47.0'	yes	no	yes	yes	14	yes

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26	53° 37'	3° 47.0'	yes	no	yes	yes	17	yes
27	53° 42'	3° 47.0'	yes	no	yes	yes	26	yes
28	53° 47'	3° 47.0'	yes	no	yes	yes	no, unsuccessful	yes
29	53° 47'	3° 55.4'	yes	no	yes	yes	27	yes
30	53° 42'	3° 55.4'	yes	yes	yes	yes	no, unsuccessful	yes
31	53° 37'	3° 55.4'	yes	no	yes	yes	16	yes
32	53° 32'	3° 55.4'	yes	yes	yes	yes	15	yes
33	53° 27'	3° 55.4'	yes	no	yes	yes	6	yes
34	53° 22'	3° 55.4'	yes	yes	yes	yes	7	yes
35	53° 32'	3° 15.9'	yes	no	yes	yes	10	yes

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**Table 4.** Surface (T) and bottom (B) parameters from CTD, noted in log book. Nominal CTD positions. \* = information not recorded in log book.

CTD No.	Site	Latitude (N)	Longitude (W)	Water depth (m)	Temp (°C)		Salinity	
					T/B	T/B	T/B	T/B
1	10	53° 27'	3° 13.4'	18.3	16.5 / 16.5	32.5 / 32.5		
2	11	53° 27'	3° 21.8'	20.9	16.4 / 16.4	32.9 / 32.9		
3	12	53° 27'	3° 30.2'	20.9	16.2 / 16.2	33.0 / 33.1		
4	21-1	53° 27'	3° 38.6'	26.8	15.8 / 15.8	33.5 / 33.5		
5	24	53° 27'	3° 47.0'	32.2	15.9 / 15.7	33.4 / 33.4		
6	33	53° 27'	3° 55.4'	37.4	15.2 / 15.2	33.9 / 33.9		
7	34	53° 22'	3° 55.4'	23.6	16.2 / 15.8	33.1 / 33.5		
8	23	53° 23'	3° 47.0'	12.3	16.2 / 16.0	32.9 / 33.2		
9	22	53° 23'	3° 38.6'	14.7	16.4 / 16.4	32.8 / 32.8		
10	1-1	53° 32'	3° 21.8'	21.5	16.4 / 16.3	32.9 / 33.0		
11	1-2	53° 32'	3° 21.8'	25.3	16.1 / 16.1	33.2 / 33.2		
12	35	53° 32'	3° 15.9'	15.8	15.5 / 15.5	32.9 / 32.9		
13	9	53° 32'	3° 21.8'	26.3	16.0 / *	33.2 / *		
14	13	53° 32'	3° 30.2'	33.5	15.9 / 15.8	33.4 / 33.4		
15	21-2	53° 27'	3° 38.6'	26.1	15.8 / 15.7	33.4 / 33.5		
16	21-3	53° 27'	3° 38.6'	24.4	16.0 / 15.7	33.2 / 33.4		
17	20	53° 32'	3° 38.6'	33.2	15.9 / 15.7	33.3 / 33.4		
18	25	53° 32'	3° 47.0'	42.5	15.5 / 15.0	33.7 / 33.9		
19	32	53° 32'	3° 55.4'	44.5	15.2 / 14.9	33.9 / 34.0		
20	31	53° 37'	3° 55.4'	44.6	15.7 / 14.7	33.6 / 34.0		
21	26	53° 37'	3° 47.0'	39.6	15.6 / 15.1	33.6 / 33.9		
22	19	53° 37'	3° 38.6'	35.9	15.8 / 15.7	33.4 / 33.5		
23	14	53° 37'	3° 30.2'	31.8	15.9 / 15.8	33.4 / 33.4		
24	8	53° 37'	3° 21.8'	29.0	16.1 / 16.1	33.2 / 33.2		
25	2	53° 37'	3° 13.4'	16.6	16.6 / 16.6	32.6 / 32.6		

26	3	53° 42′	3° 13.4′	20.9	16.6 / 16.6	32.7 / 32.8
27	7	53° 42′	3° 21.8′	27.7	15.9 / 15.9	33.3 / 33.3
28	15	53° 42′	3° 30.2′	40.0	15.6 / 15.6	33.4 / 33.4
29	18	53° 42′	3° 38.6′	40.8	15.4 / 15.3	33.6 / 33.6
30	27	53° 42′	3° 47.0′	43.1	15.5 / 15.2	33.7 / 33.7
31	30	53° 42′	3° 55.4′	42.0	15.4 / 15.1	33.7 / 33.7
32	29	53° 47′	3° 55.4′	39.9	15.1 / 14.9	33.8 / 33.9
33	28	53° 47′	3° 47.0′	38.1	15.3 / 15.2	33.7 / 33.8

## 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 pCO<sub>2</sub> sensor is incorporated into the surface sampling system.

Met package measures and records Barometric pressure (mbar), Solar Radiation (W m<sup>-2</sup>), PAR (μmols / m<sup>2</sup>s), Air Temperature (°C), Relative Humidity, Relative Wind Speed (m s<sup>-1</sup>), Relative Wind Direction (°) – zero indicates wind on the bow, Minimum Air Temp (°C), Maximum Air Temp (°C) and Wind Gust (m s<sup>-1</sup>).

Underway data, pCO<sub>2</sub> and ship's ADCP data were recorded every minute. 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. The systems ran continually beyond the Mersey radio tower between 18:24 02/08/2009 and 08:18 04/08/2009.

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