

Prince Madog cruise 20/07
POL Coastal Observatory cruise 47
29 – 30 August 2007

1. Objectives

1. At 53° 32' N 3° 21.8' W, half a mile west of the Mersey Bar Light Vessel (site A)

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, a SeaPoint turbidity sensor and an Aanderaa C&T sensor were fitted to the frame. The frame was fitted with a SonTek ADV.
- b) A CEFAS SmartBuoy (with cellulose bags) in a single point mooring with SeaBird 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 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, SeaPoint turbidity sensor were fitted to the frame.
- d) A CEFAS SmartBuoy (with cellulose bags) in a single point mooring with Sea-Bird MicroCat temperature, conductivity loggers at 5 and 10m below the surface and miniloggers at 7.5 and 15 m below the surface.

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

To recover

- 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 were fitted to the frame. A 1200 kHz telemetry ADCP was fitted to the frame.
- f) A CEFAS SmartBuoy (with cellulose bags) in a single point mooring with Sea-Bird MicroCat temperature, conductivity loggers at 5m and 10m below the surface and miniloggers at 7.5 and 15 m below the surface.
- g) A telemetry toroid.

To deploy

- h) 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, a SeaPoint turbidity sensor and an Aanderaa C&T sensor were fitted to the frame. A 1200 kHz telemetry ADCP was fitted to the frame.
- i) A CEFAS SmartBuoy (with cellulose bags and trace metal sensor) in a single point mooring with Sea-Bird MicroCat temperature, conductivity loggers at 5m and 10m below the surface and miniloggers at 7.5 and 15 m below the surface.
- j) A telemetry toroid.

3. 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 and suspended sediment determination. To obtain mid-depth water samples at sites 12, 13, 20, 21, 22, 23, 24, 25 for trace metal determination.

4. Collect 10 vertical net hauls at mooring site A.

2.1 Scientific personnel

John Howarth (Principal)
Chris Balfour
Mike Burke
John Kenny
Eleanor Howlett
Dave Pearce (CEFAS)
Neil Needham (CEFAS)
Anne Hammerstein (School of Ocean Sciences)
Conrad Chapman (Liverpool University)

2.2 Ship's officers and crew

Steve Duckworth (Master)
David Shaw (Chief Officer)
Alan Thompson (Chief Engineer)
Meikle McKay (Second Engineer)
Phil Jones (Bosun)
Dave Leigh (A.B.)
Michael Callaghan (A.B.)
Chris Pusnik (Cook)

3. Narrative (times in GMT)

The SmartBuoy toroid, anchor chain clumps, two sea-bed frames (and stacker) and instrumentation were loaded onto RV Prince Madog on the afternoon of 28 August 2007, just after high water. The ADCP frames were set up on the afterdeck and the tower and instruments fitted to the SmartBuoy toroid.

Prince Madog left Menai Bridge at 07:00 on 29 August 2007. The ship's underway pCO₂, surface monitoring and ADCP were switched on at 08:00, 08:01 and 08:03 respectively, by Puffin Island. No meteorological data was recorded since the weather station sensors had been removed prior to replacement – it is planned to replace them in the next month. Underway fluorescence measurements were not working.

The telemetry toroid at Site B was recovered, between 09:52 and 09:56, so that the telemetry system could be thoroughly checked since telemetry of ADCP data had failed within a few days of its deployment. The Orbcomm modem (new) was found to be faulty and replaced. The toroid added to clutter on the deck but did not unduly hinder mooring deployments.

The Mersey Bar mooring site was reached at 11:11 and a CTD recorded (bottles used: 3 – salinity; 4 -SPM bottom; 9 - SPM top; 10,11 – surface, Cefas; 8 trace metal). The ADCP releases were fired at 11:28 but the frame failed to surface. Therefore a sweep was started and the frame snagged on the first pass. Whilst the ballast weight was being recovered (it was on deck by 12:26) the pellets and ADCP frame surfaced astern. The ADCP was pulled in by hand by the spooler line and the frame was on board by 12:34. The replacement ADCP was deployed at 13:11 and the new SmartBuoy between 13:34 and 13:35. The previous SmartBuoy was recovered between 13:42 and 13:53 – it appeared to have moved slightly westward from its deployed position. A second CTD was recorded at 14:09 and the vertical net hauls started at 14:40.

The CTD grid started at site 10 at 16:20, followed by 35, 2 – 21, sometimes in marginal conditions during the night. The telemetry toroid was deployed at 07:13 on 30 August. Whilst it would have been possible to deploy the ADCP frame and perhaps the SmartBuoy it was too rough to attempt recovery of the existing equipment. The wind was force 5-6 but from the north-west, so generating waves. It was decided not to do further deployments because the instruments could last to the next cruise (in early October), except for the surface fluorimeter which would foul, having two telemetry ADCPs out might confuse the system and having two SmartBuoys out would leave a shortage for the next cruise.

The CTD grid continued from 22 to 33, although progress was slow between stations 27 and 29, when winds gusted up to force 7. Once on a southerly course good speed could again be made. Just after 33 the weather (wind and waves) improved so a detour was taken to the second mooring site to deploy the SmartBuoy (at 18:32) and to recover the existing SmartBuoy (between 18:40 and 18:52). Since light would fail soon no attempt was made to recover the ADCP frame and in consequence to deploy the new frame. A CTD was recorded and a course set for Menai Bridge, stopping on the way for the final CTD at site 34 at 20:32. The surface monitoring system, ship's ADCP and pCO₂ system were switched off at 21:20, by Puffin Island, and Prince Madog docked at Menai Bridge at 22:10.

All the major cruise objectives were accomplished, apart from the ADCP turn round at the site B. Weather conditions for working were not ideal with a moderate swell and winds ranging between force 4-6 (mainly force 6 on Thursday) from the north-west. The strong spring tidal currents affected mooring deployments and recoveries. The water column was generally well mixed, fresher than usual with little signs of phytoplankton productivity.

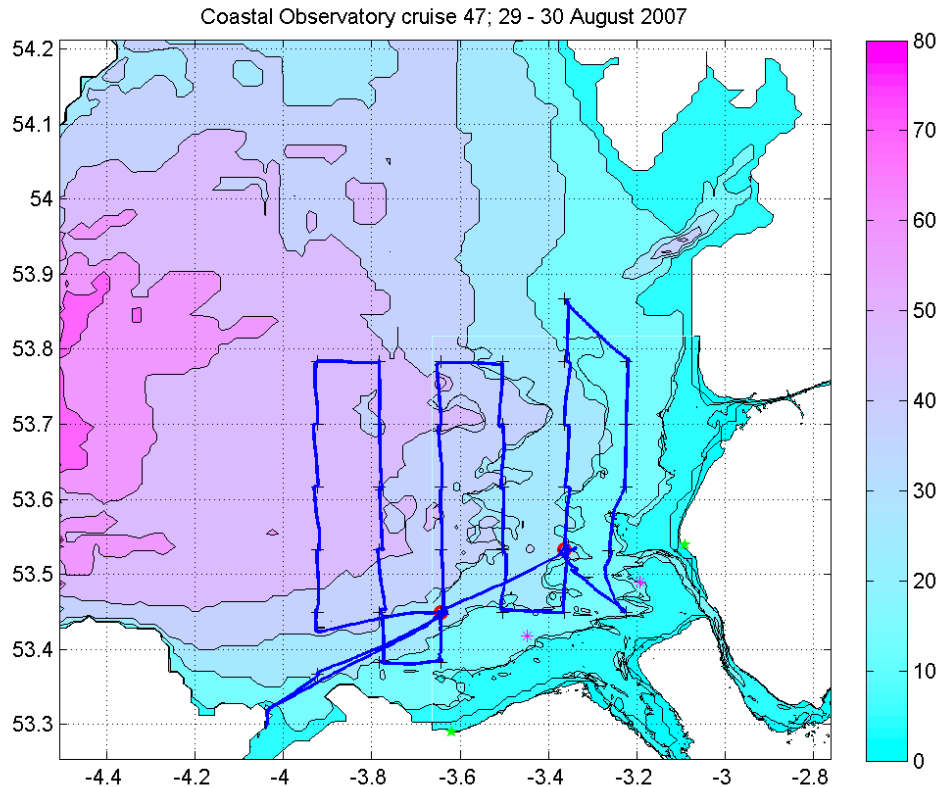


Figure 1. Cruise track.

4. Moorings (times in GMT)

4.1 The set up of the recovered instruments was as follows:

Site A

a) Waves ADCP 600 kHz RDI 2391.

Mode 1: 100 pings every 10 minutes (velocity standard deviation 0.007 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.

1Gb PCMCIA memory; hourly wave recording enabled.

Clock reset at 10:50:00 on 25 July; delayed start 08:00:00 on 26 July 2007; started ok.

Sea-Bird 16plus S/N 4738 on base of frame with pumped conductivity sensor underneath.

SeaPoint turbidity sensor 10320 taped to roll bar; set up for 0 - 125 FTU range.

Aanderaa type 4120 C&T sensor serial number 187.

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

Clock set at 08:28:10 on 25 July 2007; delayed start at 08:00:00 on 26 July 2007.

Stopped at 13:41:00 on 12 September 2007.

SonTek ADV (Acoustic Doppler Velocimeter); ADV Logger G412; head B331.

ADV transmitter 1.25m above bed (deck). Sample rate 16Hz; burst interval 3600s; samples in each burst 19200; burst length 1200s.

Clock set 10:17:05 on 25 July 2007. Delayed start at 08:00 on 26 July 2007.

The frame was fitted with two Benthos releases 70355 – Rx 10.0 kHz, Tx 12.0 kHz, release B and 71919 – Rx 10.5 kHz, Tx 12.0 kHz, release C both with a fizz link, and a spooler with 200m of rope for recovery of the ballast weight.

b) SmartBuoy Mooring.

Sea-Bird MicroCat temperature, conductivity and pressure recorder Serial number 2991 at 5m below the surface. Sample interval 600s.

Clock set at 09:04:00 on 25 July 2007. Delayed start 08:00:00 on 26 July 2007.

Stopped at 20:17:10 on 29 August 2007: clock 12 s fast: 4970 samples.

Sea-Bird MicroCat temperature and conductivity recorder Serial number 2506 at 10m below the surface. Sample interval 600s.

Clock set at 09:13:00 on 25 July 2007. Delayed start 08:00:00 on 26 July 2007.

Stopped at 18:19:54 on 29 August 2007: clock 11 s fast: 4959 samples.

Mini-logger Serial number 2192E at 7.5 m below the surface set to record at 600s intervals.

Clock set at 10:47:56 25 July 2007. Delayed start at 10:00:00 on 26 July 2007.

Stopped at 03:36:59 on 30 August 2007: clock 46 s fast: 5001 samples.

Mini-logger Serial number 2407 at 11.5 m below the surface set to record at 600s intervals.

Clock set at 10:52:10 25 July 2007. Delayed start at 10:00:00 on 26 July 2007.

Stopped at 03:25:10 on 30 August 2007: clock 32 s fast: 5000 samples.

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 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.

Site B

f) SmartBuoy Mooring.

Sea-Bird MicroCat temperature, conductivity and pressure recorder serial number 4966 at 5 m below the surface. Sample interval 600s.

Stopped at 14:15:00 on 27 July 2007. Restarted start 13:30:00 on 27 July 2007 (Still contained data from previous cruise).

Stopped at 10:34:00 on 12 September 2007; clock 12 s fast; 12111 samples.

Sea-Bird MicroCat temperature and conductivity recorder serial number 2010 at 10m below the surface. Sample interval 600s.

Stopped at 13:27 on 27 July 2007. Restarted at 13:40:00 on 27 July 2007 (Still contained data from previous cruise).

Stopped at 11:31:00 on 12 September 2007; 12119 samples.

Mini-logger Serial number 6023E at 7.5 m below the surface set to record at 600s intervals. Clock set at 13:13:00 27 July 2007. Delayed start at 13:30:00 on 27 July 2007. Stopped at 19:20:09 on 30 August 2007: clock 12 s fast: 4931 samples.

Mini-logger Serial number 2421 at 12.5 m below the surface set to record at 600s intervals. Clock set at 13:11:00 27 July 2007. Delayed start at 13:30:00 on 27 July 2007. Stopped at 19:16:49 on 30 August 2007: clock 31 s fast: 4930 samples.

The CEFAS SmartBuoy is fitted with a surface CTD (including turbidity and fluorescence sensors). 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.

	<u>Latitude</u> <u>(N)</u>	<u>Longitude</u> <u>(W)</u>	<u>Water</u> <u>Depth</u> <u>(m)</u>	<u>Recovered</u> <u>Time</u>	<u>Date</u>
Waves ADCP (Site A)	53° 32.078'	3° 21.403'	26.9	12:22	29/08/07
SmartBuoy (Site A)	53° 32.008'	3° 21.703'	25.0	13:42	29/08/07
Smart Buoy (Site B)	53° 27.026'	3° 38.333'	21.7	18:40	30/08/07
Telemetry toroid (Site B)	53° 27.309'	3° 38.168'	29.0	09:52	29/08/07

4.2 The set up of the deployed instruments was as follows:

Site A

c) Waves ADCP 600 kHz RDI 5807.

Mode 1: 100 pings every 10 minutes (velocity standard deviation 0.007 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.

1Gb PCMCIA memory; hourly wave recording enabled.

Clock reset at 14:27:50 on 28 August; delayed start 08:00:00 on 29 August 2007.

Sea-Bird 16plus S/N 4736 on base of frame with pumped conductivity sensor underneath.

SeaPoint turbidity sensor 10490 taped to roll bar; set up for 0 - 125 FTU range.

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

Clock set at 12:38:00 on 28 August 2007; delayed start at 08:00:00 on 29 August 2007.

SonTek ADV (Acoustic Doppler Velocimeter); ADV Logger G250; head B252.

ADV transmitter 1.325m above bed (deck). Sample rate 16Hz; burst interval 3600s; samples in each burst 19200; burst length 1200s.

Clock set 14:50:00 on 28 August 2007. Delayed start at 08:00 on 29 August 2007.

The frame was fitted with two Benthos releases 71904 – Rx 10.0 kHz, Tx 12.0 kHz, release C and 72382 – Rx 10.0 kHz, Tx 12.0 kHz, release A both with a fizz link, and a spooler with 200m of rope for recovery of the ballast weight.

d) SmartBuoy Mooring.

Sea-Bird MicroCat temperature, conductivity and pressure recorder Serial number 4998 at 5m below the surface. Sample interval 600s.

Clock set at 13:30:00 on 28 August 2007. Delayed start 08:00:00 on 29 August 2007.

Sea-Bird MicroCat temperature and conductivity recorder Serial number 2081 at 10m below the surface. Sample interval 600s. Reference pressure=25 dbar.

Clock set at 14:01:30 on 28 August 2007. Delayed start 08:00:00 on 29 August 2007.

Mini-logger Serial number 6028E at 7.5 m below the surface set to record at 600s intervals. Clock set at 16:43:38 28 August 2007. Delayed start at 08:00:00 on 29 August 2007.

Mini-logger Serial number 6022E at 12.5 m below the surface set to record at 600s intervals. Clock set at 16:42:00 28 August 2007. Delayed start at 08:00:00 on 29 August 2007.

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 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.

Site B

i) SmartBuoy Mooring.

Sea-Bird MicroCat temperature, conductivity and pressure (digiquartz) recorder serial number 5433 at 5 m below the surface. Sample interval 600s.

Clock set at 13:48:00 on 28 August 2007. Delayed start 08:00:00 on 29 August 2007.

Stopped at 13:48:00 on 28 August 2007.

Sea-Bird MicroCat temperature, conductivity and pressure (digiquartz) recorder serial number 5434 at 10m below the surface. Sample interval 600s.

Clock set at 13:42:00 on 28 August 2007. Delayed start 08:00:00 on 29 August 2007.

Mini-logger Serial number 2407 at 7.5 m below the surface set to record at 600s intervals. Clock set at 03:33:10 on 30 August 2007. Delayed start at 08:00:00 on 30 August 2007.

Mini-logger Serial number 2192E at 11.5 m below the surface set to record at 600s intervals. Clock set at 03:38:12 on 30 August 2007. Delayed start at 08:00:00 on 30 August 2007.

The CEFAS SmartBuoy is fitted with a surface CTD (including turbidity and fluorescence sensors). 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 2. Deployed mooring positions and times.

<u>Latitude</u>	<u>Longitude</u>	<u>Water</u>	<u>Deployed</u>
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	<u>(N)</u>	<u>(W)</u>	<u>Depth</u> <u>(m)</u>	<u>Time</u>	<u>Date</u>
Waves ADCP (Site A)	53° 32.102'	3° 21.442'	26.1	13:11	29/08/07
SmartBuoy (Site A)	53° 32.036'	3° 21.726'	26.0	13:35	29/08/07
(Waves ADCP (Site B)	53° 27.321'	3° 38.347'	23.9	14:29	27/07/07)
Smart Buoy (Site B)	53° 26.982'	3° 38.780'	21.4	18:32	30/08/07
Telemetry toroid (Site B)	53° 26.995'	3° 38.648'	22.4	07:13	30/08/07

5. CTD

The Sea-Bird 911 CTD recorded downwelling PAR light levels (CEFAS light sensor), temperature, conductivity, transmittance, oxygen (no calibration samples) and fluorescence at 24 Hz. The frame was fitted with an altimeter, which was not totally reliable, so that measurements were taken to within an estimated 3 m above the bed. The rosette will take twelve 10 l water bottles although the capacity is reduced by one (for the LISST-25). One/two water bottles were fired near bed and one/two/three near the surface, when needed. The CTD temperature data was checked against a Sea-Bird SBE35 precision thermometer. Water samples were taken from a near bed bottle for calibration of the CTD salinity data. Water samples were taken from the near surface and near bed bottles and frozen for nutrient analysis by NOC (nitrate, phosphate, silicate), and also were filtered to determine suspended sediment load and calibrate the CTD transmissometer, by the School of Ocean Sciences. Water samples from the second near surface bottle from stations 1 and 21 were filtered for chlorophyll and suspended sediment determination and some filtrate was preserved with mercuric chloride for nutrient determination by CEFAS, (in addition samples at station 1 were taken for oxygen analysis). A LISST-100C particle sizer with internal logging was also attached to the CTD frame and its data periodically downloaded for analysis by SOS. Copies of the Sea-Bird binary files were taken off for processing and calibration at BODC / POL. A LISST-25 particle sizer was fitted to the CTD and its data logged on the Sea-Bird data logging system.

Table 3. Nominal CTD positions. (Ss – Suspended sediments, Nu – Nutrients)

<u>Site</u>	<u>Latitude</u> (N)	<u>Longitude</u> (W)	<u>Visited</u> <u>on this</u> <u>cruise</u>	<u>Cefas</u> Chlorophyll & Nu & Ss	<u>POL</u> Nu	<u>POL</u> Ss	<u>Trace</u> <u>metal</u>
1	53° 32'	3° 21.8'	yes	yes	yes	yes	
2	53° 37'	3° 13.4'	yes		yes	yes	
3	53° 42'	3° 13.4'	yes		yes	yes	
4	53° 47'	3° 13.4'	yes		yes	yes	
5	53° 52'	3° 21.8'	yes	yes	yes	yes	
6	53° 47'	3° 21.8'	yes	yes	yes	yes	
7	53° 42'	3° 21.8'	yes	yes	yes	yes	
8	53° 37'	3° 21.8'	yes	yes	yes	yes	
9	53° 32'	3° 21.8'	yes	yes	yes	yes	
10	53° 27'	3° 13.4'	yes		yes	yes	
11	53° 27'	3° 21.8'	yes	yes	yes	yes	
12	53° 27'	3° 30.2'	yes		yes	yes	yes
13	53° 32'	3° 30.2'	yes		yes	yes	yes
14	53° 37'	3° 30.2'	yes		yes	yes	
15	53° 42'	3° 30.2'	yes		yes	yes	
16	53° 47'	3° 30.2'	yes		yes	yes	
17	53° 47'	3° 47.0'	yes		yes	yes	
18	53° 42'	3° 38.6'	yes		yes	yes	
19	53° 37'	3° 38.6'	yes		yes	yes	
20	53° 32'	3° 38.6'	yes		yes	yes	yes
21	53° 27'	3° 38.6'	yes	yes	yes	yes	yes
22	53° 23'	3° 38.6'	yes		yes	yes	yes
23	53° 23'	3° 47.0'	yes		yes	yes	yes
24	53° 27'	3° 47.0'	yes		yes	yes	yes
25	53° 32'	3° 47.0'	yes		yes	yes	yes
26	53° 37'	3° 47.0'	yes		yes	yes	
27	53° 42'	3° 47.0'	yes		yes	yes	
28	53° 47'	3° 47.0'	yes		yes	yes	
29	53° 47'	3° 55.4'	yes		yes	yes	
30	53° 42'	3° 55.4'	yes		yes	yes	
31	53° 37'	3° 55.4'	yes		yes	yes	
32	53° 32'	3° 55.4'	yes		yes	yes	
33	53° 27'	3° 55.4'	yes		yes	yes	
34	53° 22'	3° 55.4'	yes		yes	yes	
35	53° 32'	3° 15.9'	yes		yes	yes	

Table 4. Surface and bottom parameters from CTD, noted in log book.

<u>CTD</u> <u>no</u>	<u>Site</u>	<u>Nuts</u>	Nominal positions.		<u>Water</u> <u>depth</u> <u>(m)</u>	<u>Temp</u>	<u>Salinity</u>
			<u>Latitude</u> <u>(N)</u>	<u>Longitude</u> <u>(W)</u>		<u>(deg)</u>	
		T/ B				T / B	T / B
1	1-1		53° 32'	3° 21.8'	25	16.9 / 16.7	31.8 / 32.1
2	1-2	73/74	53° 32'	3° 21.8'	26	17.1 / 16.6	31.7 / 32.2
3	10	75/76	53° 27'	3° 13.4'	14	17.1 / 17.1	30.3 / 30.3
4	35	77/78	53° 31.9'	3° 15.9'	10	16.9 / 17.0	30.2 / 30.4
5	2	79/80	53° 37'	3° 13.4'	9	17.2 / 17.2	31.6 / 31.6
6	3	81/82	53° 42'	3° 13.4'	14	17.0 / 17.0	32.2 / 32.2
7	4	83/84	53° 47'	3° 13.4'	14	16.9 / 16.9	32.2 / 32.2
8	5	85/86	53° 52'	3° 21.8'	13	16.7 / 16.7	32.3 / 32.3
9	6	87/88	53° 47'	3° 21.8'	20	16.9 / 16.9	32.4 / 32.4
10	7	89/90	53° 42'	3° 21.8'	25	16.8 / 16.6	32.4 / 32.5
11	8	91/92	53° 37'	3° 21.8'	28	16.8 / 16.7	32.2 / 32.3
12	9	93/94	53° 32'	3° 21.8'	28	16.8 / 16.6	32.0 / 32.2
13	11	95/96	53° 27'	3° 21.8'	23	16.8 / 16.8	31.8 / 31.8
14	12	97/98	53° 27'	3° 30.2'	23	16.6 / 16.6	32.3 / 32.4
15	13	99/100	53° 32'	3° 30.2'	34	16.5 / 16.5	32.6 / 32.7
16	14	101/102	53° 37'	3° 30.2'	33	16.4 / 16.4	32.7 / 32.8
17	15	103/104	53° 42'	3° 30.2'	39	16.4 / 16.1	32.6 / 33.1
18	16	105/106	53° 47'	3° 30.2'	25	16.6 / 16.4	32.7 / 32.8
19	17	107/108	53° 47'	3° 38.6'	35	16.3 / 16.1	32.9 / 33.1
20	18	109/110	53° 42'	3° 38.6'	37	16.3 / 16.1	32.7 / 33.1
21	19	111/112	53° 37'	3° 38.6'	29	16.4 / 16.3	32.8 / 32.9
22	20	113/114	53° 32'	3° 38.6'	31	16.5 / 16.5	32.3 / 32.5
23	21-1	115/116	53° 27'	3° 38.6'	22	16.6 / 16.6	32.0 / 32.1
24	22	117/118	53° 23'	3° 38.6'	14	16.8 / 16.8	31.5 / 31.5
25	23	119/119	53° 23'	3° 47.0'	13	16.7 / 16.7	32.0 / 32.0
26	24	125/126	53° 27'	3° 47.0'	34	16.3 / 16.3	33.0 / 33.0
27	25	127/128	53° 32'	3° 47.0'	46	16.2 / 16.1	33.1 / 33.3
28	26	129/130	53° 37'	3° 47.0'	44	16.4 / 16.1	33.0 / 33.3
29	27	131/132	53° 42'	3° 47.0'	44	16.1 / 16.1	33.3 / 33.3
30	28	133/134	53° 47'	3° 47.0'	45	16.1 / 16.1	33.3 / 33.3
31	29	135/136	53° 47'	3° 55.4'	43	16.0 / 15.9	33.5 / 33.5
32	30	137/138	53° 42'	3° 55.4'	42	16.1 / 16.1	33.4 / 33.4
33	31	139/140	53° 37'	3° 55.4'	44	16.2 / 16.0	33.3 / 33.4
34	32	141/142	53° 32'	3° 55.4'	45	16.2 / 16.0	33.2 / 33.4
35	33	143/144	53° 27'	3° 55.4'	35	16.6 / 16.3	32.8 / 33.1
36	21-2		53° 27'	3° 38.6'	21	16.8 / 16.7	31.8 / 32.0
37	34	121/123	53° 22'	3° 55.4'	23	16.8 / 16.8	32.1 / 32.1

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, Solar Radiation (W m^{-2}), PAR ($\mu\text{mols} / \text{m}^2\text{s}$), Air Temperature ($^{\circ}\text{C}$), Relative Humidity, Relative Wind Speed (m s^{-1}), Relative Wind Direction ($^{\circ}$) – zero indicates wind on the bow, Transmittance, Hull Temperature ($^{\circ}\text{C}$), Barometric Pressure (mbar), Fluorescence, Turbidity, Salinity, Minimum Air Temp ($^{\circ}\text{C}$), Maximum Air Temp ($^{\circ}\text{C}$), Wind Gust (m s^{-1}), GPS Time, Latitude, Longitude, Barometric Pressure Minimum (mbar), Barometric Pressure Maximum (mbar), Conductivity sensor water temperature ($^{\circ}\text{C}$). Sea surface temperature, salinity and transmittance were calibrated against the CTD by BODC. In addition a pCO_2 sensor was incorporated into the surface sampling system.

A new high quality temperature sensor has been fitted. The meteorological sensors had been removed prior to replacement, so no wind speed, direction, air temperature, relative humidity or solar radiation data were recorded. Flow through fluorescence was not working.

Underway, including navigation, data were recorded every minute from 08:01 on 29 August until 21:18 on 30 August 2007, starting and ending at Puffin Island.

pCO_2 data were recorded from 08:00 on 29 August until 21:21 on 30 August 2007, starting and ending at Puffin Island.

The ship was fitted with a 300 kHz ADCP set to record 25 x 2m bins, the bin nearest the surface was at 5.1 m depth, every 30 seconds with 29 pings / ensemble. Data were recorded from 08:03 on 29 August to 21:19 on 30 August 2007, starting and ending at Puffin Island.

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