Irish Sea Observatory cruise 76

Dates: 18th–21st April 2011
Ship: R.V. Prince Madog (cruise 11/11)
Principal Scientist: Andy Lane (NOC)

The science driver for the Irish Sea Observatory is '*to monitor and understand the impacts of natural and anthropogenic forcing of a shelf sea, and to provide a framework for research into the functioning of a shelf-sea in a changing climate*'.

Started in 2002, the Observatory integrates (near) real-time measurements with coupled models into a pre-operational coastal prediction system, results of which are displayed online at http://cobs.pol.ac.uk/ . Further details about the Observatory may be found on this website.

1. Cruise and scientific objectives

1.1 Mooring deployment and recovery

Two monitoring sites were maintained at the two locations marked in Figure 1. At each of these sites instruments are mounted in a sea bed frame, on a surface buoy and along its mooring chain. Maintaining a long time series of observations will ultimately facilitate the determination of natural and anthropogenic variability within Liverpool Bay. The primary aim of the cruise is to recover and redeploy this instrumentation.

Site A, 53° 32' N, 3° 21.8' W (CTD station 1)
To recover:

a) A sea bed frame containing a 600 kHz RDI ADCP (acoustic Doppler current profiler, measuring mean current profile, pressures and directional waves), SeaBird SBE 16*plus* (with pumped conductivity sensor), Digiquartz pressure sensor, a SeaPoint turbidity sensor with wiper and SeaBird SBE 16*plus* with an Aanderaa oxygen Optode.

b) Cefas SmartBuoy (including the new weather station system) in a single point mooring. Temperature mini-loggers are attached to the mooring wire at 7.5 m and 15 m below the surface and a SeaBird MicroCAT temperature and conductivity logger at 10 m below the surface. A frame containing a WET Labs ac-s unit (measuring spectra of absorption and attenuation), WET Labs fluorometer and SeaBird MicroCAT is attached at 5 m below the surface.

To deploy:

c) A sea bed frame containing a 600 kHz RDI ADCP (measuring mean current profile, pressures and directional waves), SeaBird SBE 16*plus* (with pumped conductivity sensor), Digiquartz pressure sensor, a SeaPoint turbidity sensor with wiper and SeaBird SBE 16*plus* with an Aanderaa oxygen Optode.

d) Cefas SmartBuoy in a single point mooring. Temperature mini-loggers are attached to the mooring wire at 7.5 m and 15 m below the surface and a SeaBird MicroCAT temperature and conductivity logger at 10 m below the surface. A frame containing a WET Labs ac-s unit, WET Labs fluorometer and SeaBird MicroCAT is attached at 5 m below the surface.

Site B, 53° 32.3′ N, 3° 38.4′ W (CTD station 20)

To recover:

a) A sea bed frame for a 600 kHz RDI ADCP measuring mean current profile, pressures and directional waves, a SeaBird 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 SeaBird MicroCAT temperature, conductivity loggers at 5 m and 10 m below the surface and temperature mini-loggers at 7.5 m, 15 m and 20 m below the surface.

There will be no further deployments at Site B.

1.2 CTD and LISST 25-hour station with ac-s

The second cruise objective is to complete a 25-hour station of half-hourly conductivity, temperature and depth (CTD) profiles. Water samples were obtained in Niskin bottles at on-the-hour profiles for determining concentrations of: suspended particulate matter (SPM), chlorophyll-*a* and chromomorphic or coloured dissolved organic matter (CDOM) and nutrients. Cefas also took water for dissolved oxygen analysis. Samples were obtained for isotope analysis to determine groundwater content.

Following the on-the-hour CTD profile, a frame containing a WET Labs ac-s, WET Labs ECO triplet (multiple simultaneous scattering and fluorescence) and SeaBird CTD was deployed: after an initial four-minute flushing time for the ac-s at 10 m, measurements were taken for approximately two-minutes each at near-surface, 5 m and 10 m below the surface, and near-bed.

1.3 CTD and LISST survey

The third cruise objective is to undertake a CTD survey of 34 stations every five nautical miles covering the eastern Irish Sea (see Figure 1 and Table 11). The survey grid covers the area from the North Wales coast to a line extending westwards from Blackpool, and from the Lancashire coast to a line extending northwards from Great Ormes Head. The grid and sampling are designed to determine the effects of the rivers Dee, Mersey and Ribble on the dynamics and biogeochemistry of Liverpool Bay. Additional near-shore stations 2a, 3a, 4a, 5a, 11a and 12a were introduced in Cruise 75 (15–18th April 2011).

At each station, samples are taken for the analysis of nutrients. Nutrients are essential for phytoplankton growth; therefore, understanding the magnitude and changes in sources and inputs of nutrients into Liverpool Bay gives us some understanding of the maximum potential phytoplankton growth in the region and thus potential for carbon sequestration. In addition, monitoring nutrient levels over the long term in Liverpool Bay may provide an early indicator of the risk of eutrophication in this region heavily influenced by river-inputs.

Water samples were taken at each site for determining concentrations of SPM as part of a long term Observatory requirement for total suspended sediment concentrations (now inorganic/organic as well). The data are also required for marine optics, and for comparisons of absorption and scattering with the ac-s instrument. Chlorophyll-*a* and CDOM samples are taken as part of the marine optics study.

Discrete samples for the determination of chlorophyll, SPM, dissolved oxygen, inorganic nutrients and salinity also provide calibration points for the CTD and mooring sensors.

1.4 Grab samples

Samples of the sea-bed sediment at each station are to be collected immediately after the CTD profile during the survey, using a Day Grab. The samples will be analysed for composition and particle size distributions.

1.5 Zooplankton net hauls

Ten vertical zooplankton net hauls are to be collected at Site A to determine species diversity and abundance.

2. Cruise narrative

(All times are in GMT throughout this report)

<u>Sunday, 17th April 2011</u>
Prince Madog berthed at Vittoria Wharf at 23:35, and some participants (from NOC and Plymouth) stayed on board.

<u>Monday, 18th April</u>
Loading started at 06:00 and was completed by 07:00. The ship left her berth at 07:38, with the remaining participants joining an hour before. Prince Madog entered the River Mersey (via Alfred Lock) at 08:09, three hours before high water; progress to Site A was against the incoming tide. The ship's surface monitoring and ADCP were switched on at 08:21 on passing the radar tower at Seaforth.

A pre-recovery CTD profile was completed at 10:23, during which the wind speed was less than 5 m s^{-1} from SE and the sea state was slight. The ADCP frame at Site A was recovered successfully by 10:47 and the new frame (see Figure 2) was released at 10:55. The Cefas SmartBuoy was released at 12:18 (there is a period of 15 minutes every two hours when deployment can not take place because of the nutrient analyser cycle). Recovery of the old buoy was completed by 12:33. All these mooring operations were completed without any problems, and followed by a post-deployment CTD at 12:38.

The 25-hour station with half-hourly CTD profiles began at 13:00; Prince Madog anchored 500 m SE of Site A at 13:29. On-the-hour CTDs included water bottle samples for SPM, chlorophyll and CDOM, nutrients, isotope analysis; water samples were also collected for Cefas to determine SPM, chlorophyll, nutrients and oxygen concentrations. This was followed with a deployment of a separate dipping frame (see Figure 3) with ac-s, CTD and sensors to measure scattering and fluorescence at near-surface, 5 m and 10 m below the surface, and near-bed; the first successful deployment was after the 17:01 CTD. Water samples were not taken during the on-the-half-hour CTD profiles. [The times of the two watches were switched to avoid the NOC engineers' working hours exceeding the limit – due to the late start and extended duration of mooring work, and the delay in setting up the profiling ac-s.] Zooplankton net hauls were carried out by Cefas after the CTD casts at 16:31 and 18:01. Wind speeds were between 2 and 5 m s^{-1} from SE. Strong flood currents prevented the CTD deployment at 20:30.

Tuesday, 19th April
Continuation of the 25-hour station. Wind speeds continued to be between 2 and 5 m s^{-1}; the direction changed from SE to NE after 09:00. No CTDs were carried out between 02:00 and 03:00 because of strong ebb currents. Similarly there were no CTD casts at 09:00 and 09:30 due to strong flood currents. The 25-hour station finished with the CTD profile at 14:00 (off anchor).

The CTD survey grid and grab sampling started from station 29 at 16:27, followed by east-west transects (stations 29, 28, 17, 16, 6, 4, 4a, 3a, 3, 7; omitting 5 and 5a). The wind speeds up to 19:00 were between 0.5 and 3 m s^{-1}; directions varied from north to west, and became more easterly later.

Wednesday, 20th April
CTD operations continued (stations 15, 18, 27, 30, 31, 26, 19, 14, 8, 2, 2a, 35, 1/9, 13, 20), during which the wind direction varied between east and south.

Site B (station 20, within the traffic separation zone) was reached at 11:11 and a CTD cast with water samples (pre-recovery) and grab sample were taken. The ADCP frame was recovered at 11:43 and the SmartBuoy retrieved at 12:00. A post-recovery CTD (without water sampling) was completed at 12:05. No moorings were deployed.

The ship's engineers reported an air leak in the engine room. After the Prince Madog had left the traffic separation area, the engines were stopped (12:35 to 12:48) to allow them to investigate the problem.

The CTD grid resumed at 13:10 (stations 25, 32, 22, 23, 34, 33, 24, 21, 12, 11, 10; omitting 11a and 12a). At station 22, the grab did not return a sample after two attempts. Between 17:00 and 20:00 the wind and sea conditions were calm. The survey finished at 21:34, and Prince Madog headed for port: entering Alfred Lock at 23:35 and alongside at Vittoria Wharf by 23:57. The ship's surface monitoring and ADCP were switched off at 22:52.

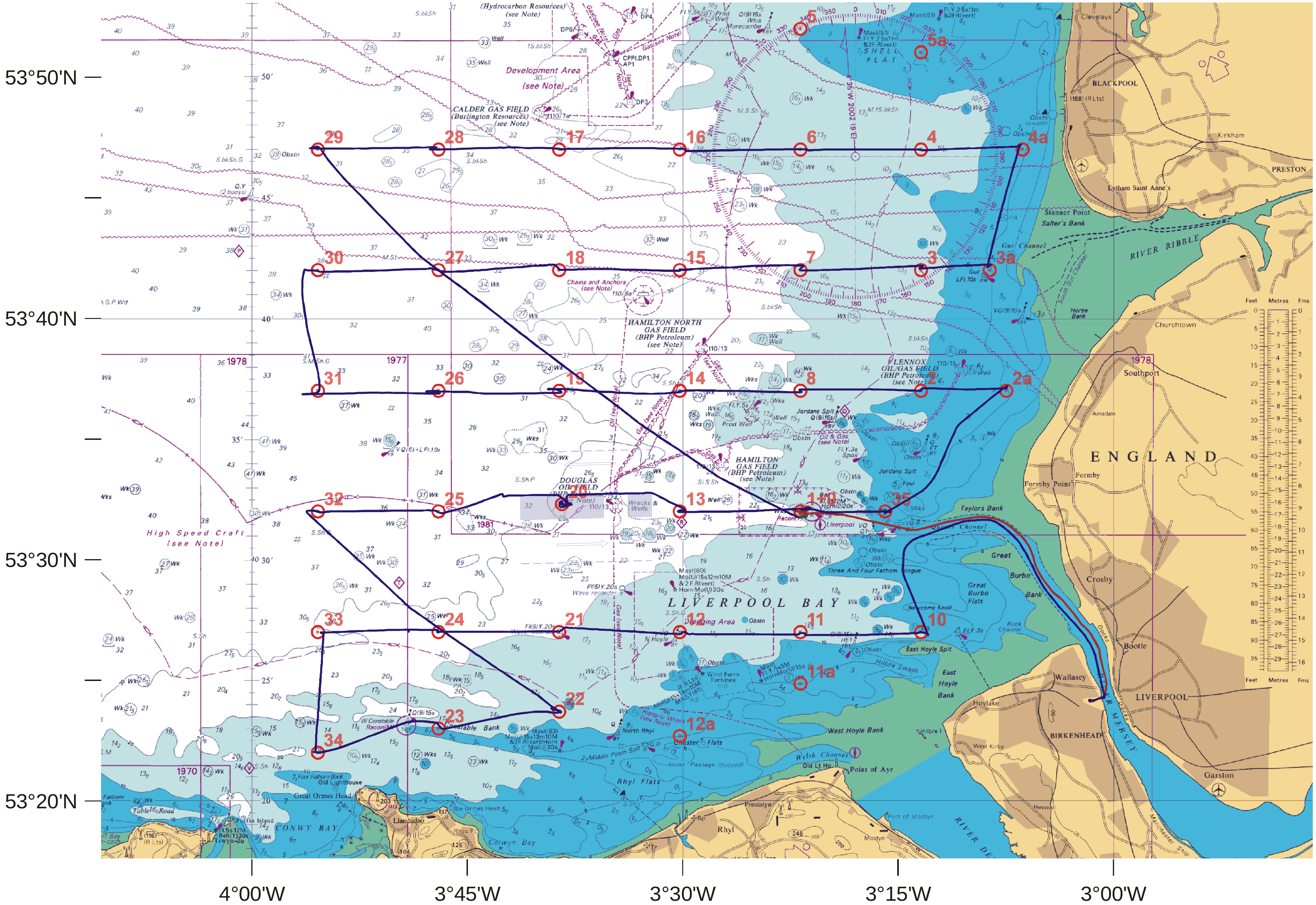
Maundy Thursday, 21st April
Unloading started at 07:00. Prince Madog departed for Menai Bridge at 14:30.

3. Moorings

3.1 Recovered Instrumentation

Table 1. Recovered mooring positions and times

	Latitude (N)	Longitude (W)	Water depth (m)	Date	Time (GMT)
ADCP frame (Site A)	53°32.015	3°21.448	27.7	18/04/2011	10:47
SmartBuoy (Site A)	53°32.001	3°21.766	26.1	18/04/2011	12:33
ADCP frame (Site B)	53°32.408	3°38.549	40.9	20/04/2011	11:43
SmartBuoy (Site B)	53°32.313	3°38.419	40.1	20/04/2011	12:00



© Crown Copyright/SeaZone Solutions Ltd [2011]. All Rights Reserved. Not to be used for navigation.

Figure 1. Irish Sea Observatory cruise 76 track, 18th–21st April 2011

Site A Bedframe

Table 2 lists the instruments mounted on the sea bed frame recovered from Site A. The frame was fitted with a fizz link, a spooler with 50 m of rope for recovery of the ballast weight and two Benthos releases: S/N 71919 (Rx=10.5 kHz, Tx=12.0 kHz, RC=C), S/N 72381 (Rx=11.0 kHz, Tx=12.0 kHz, RC=B).

Site A Mooring

Table 3 lists the instruments that were recovered from the SmartBuoy mooring at Site A. The Cefas SmartBuoy is fitted with sensors for conductivity, temperature and optical back scatter at 1 m below surface, light sensors at 1 m and 2 m below the surface, a fluorometer (SeaPoint), oxygen sensor (Aanderaa Optode), an in-situ NAS2E nutrient analyzer. A water sampler obtains samples every fourth day for laboratory analysis of total oxidisable nitrogen (TOxN) and silicate, and every eighth day for phytoplankton species, composition and abundance. The conductivity, temperature, optical back scatter and light data are transmitted back to Cefas via Orbcomm satellite.

Table 2. Instruments recovered from the Site A bedframe

Instrument	S/N	Notes	Clock set	Delayed start	Stopped logging	Clock drift (secs)
RDI 600 kHz ADCP *	12241	1 GB memory. Mode 1: 100 pings every 10 minutes 35 × 1 m bins (2.65–36.65 m above the bed, WNO 35). Beam coordinates – speeds, correlation, echo intensity, % good. Sound velocity calculated from temperature, depth and salinity of 32. Beam separation 20°.	16:34:30 14/03/2011	06:00:00 16/03/2011	10:08:00 20/04/2011	−19
SeaBird SBE 16*plus*	4848	Mounted on frame base with pumped conductivity sensor and SeaPoint turbidity sensor (see below). Sample interval 600 s; Digiquartz integration time 40 s, range 400; pump 0.5 s, 1 s delay.	09:03:00 15/03/2011	06:00:00 16/03/2011	18:32:30 20/04/2011	+8
SeaPoint turbidity sensor	10538	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper.	-	-	-	-
Teledyne Citadel CTD **	2277	Mounted with Aanderaa Optode (see below). Sample rate 4 Hz, interval 600 s, record time 40 s.	15:50:30 14/03/2011	06:00:00 16/03/2011	-	-
Aanderaa Optode **	670		-	-	-	-

To be investigated:

* ADCP S/N 12241: Suspect supply lead or battery connection making and breaking.

** CTD S/N 2277 & Optode S/N 670: Initially could not connect with internal battery. Memory almost empty.

Table 3. Instruments recovered from the Site A SmartBuoy mooring

Instrument	S/N	Notes	Instrument depth (m)	Clock set	Delayed start	Stopped logging	Clock drift (secs)
SeaBird MicroCAT	2010	Temperature and conductivity recorder. Mounted on frame with ac-s and fluorometer)	5	09:43:30 15/03/2011	06:00:00 16/03/2011	18:58:00 20/04/2011	+14
WET Labs ac-s	060	(DH4 data logger S/N 140)	5	16:05:00 10/03/2011	07:09:00 16/03/2011	15:51:00 19/04/2011	−2
WET Labs fluorometer	1513	Attached to ac-s frame	5	16:45:00 10/03/2011	07:30:00 16/03/2011	16:00:30 19/04/2011	+20
SeaBird MicroCAT	5434	Temperature and conductivity recorder	10	09:55:30 15/03/2011	06:00:00 16/03/2011	19:14:10 20/04/2011	+6
StarOddi Mini-logger	2840	Set to record at 600 s intervals	7.5	N/A	06:00:00 16/03/2011	19:45:30 20/04/2011	−6.5
StarOddi Mini-logger	2841	Set to record at 600 s intervals	15	N/A	06:00:00 16/03/2011	19:50:30 20/04/2011	−6.5

Table 4. Instruments recovered from the Site B bedframe

Instrument	S/N	Notes	Clock set	Delayed start	Stopped logging	Clock drift (secs)
RDI 600 kHz ADCP	2390	1.5 GB memory. Mode 1: 100 pings every 10 minutes 45 × 1 m bins (2.65–46.65 m above the bed, WNO 45). Beam coordinates – speeds, correlation, echo intensity, % good. Sound velocity calculated from temperature, depth and salinity of 32. Beam separation 20°.	16:44:30 14/03/2011	06:00:00 16/03/2011	18:25:50 20/04/2011	+56
SeaBird SBE 16*plus*	5310	Mounted frame base with pumped conductivity sensor and SeaPoint turbidity sensor (see below). Sample interval 600 s; Digiquartz integration time 40 s, range 400; pump 0.5 s, 1 s delay.	09:25:30 15/03/2011	06:00:00 16/03/2011	18:38:30 20/04/2011	+8
SeaPoint turbidity sensor	10320	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper.	-	-	-	-

Table 5. Instruments recovered from the Site B SmartBuoy mooring

Instrument	S/N	Notes	Instrument depth (m)	Clock set	Delayed start	Stopped logging	Clock drift (secs)
SeaBird MicroCAT	4966	Temperature and conductivity recorder	5	17:56:00 17/03/2011	06:00:00 18/03/2011	19:09:15 20/04/2011	+11
SeaBird MicroCAT	5790	Temperature and conductivity recorder	10	17:23:30 17/03/2011	06:00:00 18/03/2011	19:05:00 20/04/2011	+14
StarOddi Mini-logger	2842	Set to record at 600 s intervals	7.5	N/A	06:00:00 16/03/2011	19:54:00 20/04/2011	−6.5
StarOddi Mini-logger	2848	Set to record at 600 s intervals	15	N/A	06:00:00 16/03/2011	19:57:00 20/04/2011	−6.5
StarOddi Mini-logger	2851	Set to record at 600 s intervals	20	N/A	06:00:00 16/03/2011	20:00:15 20/04/2011	−6.5

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

A weather station attached to the SmartBuoy frame was also recovered.

Site B Bedframe
Details of instruments mounted on the sea bed frame recovered from Site B are in Table 4. The frame was fitted with a fizz link, a spooler with 50 m of rope for recovery of the ballast weight and two Benthos releases: S/N 72863 (Rx=13.5 kHz, Tx=12.0 kHz, RC=A), S/N 72381 (Rx=11.5 kHz, Tx=12.0 kHz, RC=C).

Site B Mooring
Table 5 lists the instruments that were recovered from the SmartBuoy mooring at Site B. The Cefas SmartBuoy is fitted with sensors for conductivity, temperature and optical back scatter and a fluorometer at 1 m 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.

3.2 Deployed Instrumentation

Table 6. Deployed mooring positions and times

	Latitude (N)	Longitude (W)	Water depth (m)	Date	Time (GMT)
ADCP frame (Site A)	53°32.042	3°21.486	27.8	18/04/2011	10:55
SmartBuoy (Site A)	53°32.049	3°21.716	26.4	18/04/2011	12:18
No deployments at Site B					

Table 7. Instruments deployed on the Site A bedframe

Instrument	S/N	Notes	Clock set	Delayed start
RDI 600 kHz ADCP	5807	1.0 GB memory. Mode 1: 100 pings every 10 minutes 35 × 1 m bins (2.65–36.65 m above the bed, WNO 35). Beam coordinates – speeds, correlation, echo intensity, % good. Sound velocity calculated from temperature, depth and salinity of 32. Beam separation 20°.	07:58:00 18/04/2011	10:00:00 18/04/2011
SeaBird SBE 16*plus*	4597	Mounted on frame base with pumped conductivity sensor and SeaPoint turbidity sensor (see below). Sample interval 600 s; Digiquartz integration time 40 s, range 400; pump 0.5 s, 1 s delay.	08:39:30 18/04/2011	10:00:00 18/04/2011
SeaPoint turbidity sensor	10471	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper	-	-
Teledyne Citadel CTD	2278	Mounted with Aanderaa Optode (see below). Sample rate 4 Hz, interval 600 s, record time 40 s.	08:15:00 18/04/2011	10:00:00 18/04/2011
Aanderaa Optode	669		-	-

Table 8. Instruments deployed on the Site A SmartBuoy mooring

Instrument	S/N	Notes	Instrument depth (m)	Clock set	Delayed start
SeaBird MicroCAT	5433	Temperature and conductivity recorder. Mounted on frame with ac-s and fluorometer)	5	09:41:30 18/04/2011	10:00:00 18/04/2011
WET Labs ac-s	095	(DH4 data logger S/N 161)	5	08:59:00 18/04/2011	09:05:00 18/04/2011
WET Labs fluorometer	1514	Attached to ac-s frame	5	09:24:00 18/24/2011	09:30:00 18/04/2011
SeaBird MicroCAT	4998	Temperature and conductivity recorder	10	09:47:30 on 18/04/2011	10:00:00 18/04/2011
StarOddi Mini-logger	2836	Set to record at 600 s intervals	7.5	N/A	10:00:00 18/04/2011
StarOddi Mini-logger	2837	Set to record at 600 s intervals	15	N/A	10:00:00 18/04/2011

<u>Site A Bedframe</u>

Table 7 lists the instruments on the new sea bed frame (Figure 2) deployed at Site A. The frame is fitted with a fizz link, a spooler with 50 m of rope for recovering the ballast weight and two Benthos releases: S/N 70355 (Rx=10.0 kHz, Tx=12.0 kHz, RC=B), S/N 70358 (Rx=11.0 kHz, Tx=12.0 kHz, RC=A).

<u>Site A Mooring</u>

Table 8 lists the instruments deployed on the SmartBuoy mooring at Site B. The Cefas SmartBuoy is fitted with sensors for conductivity, temperature and optical back scatter at 1 m below surface, light

Figure 2. First instrumented deployment of the new sea bed frame.

Figure 3. Dipping frame with ac-s, CTD and ECO triplet.

sensors at 1 m and 2 m below the surface, a fluorometer (SeaPoint), oxygen sensor (Aanderaa Optode) and an in-situ NAS2E nutrient analyzer. The NAS2E obtains water samples every fourth day (for laboratory analysis of TOxN and silicate) and every eighth day (phytoplankton species, composition and abundance). Conductivity, temperature, optical back scatter and light data are transmitted back to Cefas via Orbcomm satellite.

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.

4. CTD 25-hour station ac-s

In the absence of appropriate clamps for securing the WET Labs ac-s and ECO Triplet to the ship CTD's rosette frame, they were instead mounted on a dipping frame together with a SeaBird SBE 16*plus* CTD. The instruments (listed in Table 9) were deployed from the ship's A-frame using a rope marked at regular intervals (in metres) wound around a power-assisted capstan. At the start of each deployment, the frame was lowered to 10 m for four minutes while the ac-s flushed its intake tubes. This was followed by two minutes of measurements at each position: near-surface, 5 m and 10 m below the sea surface, and approximately 3 m above the sea bed.

Table 9. Instruments mounted on the ac-s dipping frame

Instrument	S/N	Notes
WET Labs ac-s	059	Set up in 'profile' mode, delay 1 minute, pre-warm up 0 s, warm up 2 minutes, flush 0 s, sample period 15 minutes at 4 Hz (DH4 logger S/N 119)
SeaBird SBE 16*plus*	4737	5 minute sampling. Clock set 13:54:00 18/04/2011 for delayed start at 14:00:00. Stopped logging at 18:46:30 on 20/04/2011 with zero clock drift.
WET Labs ECO Triplet	-	Sensors for multiple simultaneous measurements of fluorescence and scattering.

5. CTD and LISST survey

Instrumentation mounted on the rosette frame is listed in Table 10. Near-bed water samples were taken at 3 m above the sea bed to calibrate the CTD salinity. Analysis is by a Guildline Portasal 8410A at Bangor University.

Samples were taken from the following 5-litre Niskin bottles:

near-bed	bottle 3 – SPM, chlorophyll, CDOM
	bottle 4 – nutrients and salinity
	bottle 5 – Cefas
near-surface	bottle 9 – SPM, chlorophyll, CDOM
	bottle 10 – nutrients
	bottle 11 – Cefas

Table 10. Instruments mounted on the CTD rosette frame

Instrument	S/N	Notes
SeaBird temperature sensor (SBE 3)	P4100	
SeaBird conductivity sensor (SBE 4)	2543	
SeaBird 43 oxygen sensor	1491	
LI-COR LI 192SB (downwelling PAR/irradiance sensor)	26	
Turner SCUFAII fluorometer	262	
SeaTech T1000 transmissometer	T1021	0.2 m path
SeaBird SBE35 precision thermometer	0041	
Sequoia Scientific LISST-100X particle sizer	1291	Internal logging www.sequoiasci.com/products/part_LISST_100.aspx
Satlantic SUNA nitrate analyser – NOT PRESENT	-	Removed during cruise 74. Replaced for cruise 75 but did not record meaningful data.

6. SPM, chlorophyll and CDOM sampling (Irish Sea Observatory)

Water from near-surface (1 m) and near-bed (3 m above sea bed) were taken to determine SPM, chlorophyll-*a* and CDOM concentrations. Pre-processing, sample collection and post-processing steps are summarised below.

***6.1 Suspended particulate matter* (*SPM*)**

Pre-processing: Whatman 0.7 µm pore size 47 mm diameter glass fibre (GF/F) filters. Use tweezers to handle filters at edges. (a) Examine filters for damage, etc. Rinse to remove loose fibres and plasticiser; place in aluminium dishes and dry in the oven at 75°C for 2 hours. (b) Check filters do not stick to the dishes; transfer to muffle furnace and combust at 400°C for 4 hours. (Above 450°C may alter the filter matrix.) (c) Place in desiccator for half hour before weighing (5-figure balance in grams).

Sample collection: (d) Use clean buckets placed beneath Niskin bottles on the CTD frame, taking entire contents. (e) Stir sample before measuring out, typically 1 litre required, less (500 ml) if transmissometer on CTD indicates turbid conditions. (f) Place pre-weighed filter on to holder and assemble the funnel. Switch on vacuum pump, ensuring suction <0.4 bar (<0.2 bar if done at same time as chlorophyll

sample). Add sample in stages – do not allow filter to go dry. (g) Before final 50 ml goes through add 250 ml deionised water; repeat. (h) Put filter back in appropriate dish/bag and store in freezer at −18°C.
Post-processing: (i) Dry filters at 75°C for 3 hours before weighing as in c) above. (j) Dry again at 75°C for a further 1 hour before weighing again. (k) Repeat step j) if weights are not the same. Difference in weight from original filter weight divided by the sample volume gives concentration of total SPM. (l) Combust at 500°C for 3 hours to remove organic fraction, then weigh. Differences in weights from original divided by volume gives inorganic SPM concentration.

6.2 Chlorophyll-a

Pre-processing: (m) Clean test tubes with screw-caps, numbered and placed in rack.

Sample collection: Whatman 0.7 µm pore size 47 mm diameter GF/F filters (straight from box). Use tweezers to handle filters at edges. (n) Use the same water sample as for SPM d) to f), except measure out 500 ml (less if water is turbid) and filter through with vacuum <0.2 bar. Do not rinse. (o) Put filter in the test tube, replace cap, and wrap in aluminium foil with label, then store in freezer at −18°C.

Post-processing: (p) Fluorometric method: make the chlorophyll standard and calibrate the fluorometer (Turner Designs, USA). (q) Take test tubes from freezer, add 5 ml of cold 90% acetone, place foil-wrapped tubes in a polypropylene beaker with water and sonicate in the water bath for 15 minutes. Do not allow the samples to warm up, and avoid exposing them to high light levels. (r) Remove filters leaving the pigmented acetone, analyse in the fluorometer as soon as possible. Add one drop of 10% hydrochloric acid to convert chlorophyll to phaeophytin and analyse again.

6.3 Coloured dissolved organic matter (CDOM)

Pre-processing: (s) Start with a stock of clean glass bottles and caps. Rinse with 1-N hydrochloric acid and then rinse at least twice with Milli-Q water and air-dry before use.

Sample collection: (t) Collect seawater in a clean container, as in d) above. (u) Use tweezers to place a Whatman 0.2 µm pore size 25 mm diameter polycarbonate filter in a clean polypropylene filter holder, replace the sealing ring and screw-on section. Rinse and fill a clean glass beaker with the sample; rinse a 20 ml glass syringe by drawing and discarding some of the sample. Fill the syringe from the beaker and insert the luer tip carefully into the filter holder. Slowly filter enough water to rinse the sample storage bottles. Using the same filter, obtain further filtrate to fill the 50 ml Pyrex bottles. (v) Cap bottles, label and wrap in aluminium foil, then store in freezer at −18°C or refrigerate at 4°C if analysing on ship.

Post-processing: Samples should be analysed on ship, or transferred frozen to the laboratory and processed as soon as possible. Significant deterioration in quality can occur in hours or days. (w) Allow the sample and a bottle of Milli-Q water to reach room temperature (important). Switch on the spectrophotometer (Shimadzu, Japan) and allow it to warm up (takes about 1 hour). (x) Use clean glass syringes, filter the sample as in u) above; rinse twice and fill two 10 cm path length cuvettes ensuring no air bubbles on the inside, no scratches. Wipe smears/prints off the outside. (y) Obtain a baseline first: fill both cuvettes with Milli-Q water and place them in the appropriate light path in the spectrophotometer sample chamber. (z) Fill the cuvette with the sample and leave the other with Milli-Q water as a reference blank. Carry out optical density or ‘absorbance’ scans from 380 nm to 750 nm at 0.5 nm spacing (slit width 1 or 2 nm); repeat five times every 300 seconds for each of (three) samples per site.

7. Cefas sampling

Zooplankton hauls were made at Site A. At selected CTD stations (shown in Table 12), near-surface (~1 m) samples were taken for: chlorophyll, suspended particulate matter, dissolved inorganic nutrients, salinity and dissolved oxygen. Dissolved oxygen samples were also taken from near-bed at Site A.

7.1 Zooplankton vertical haul samples

Ten zooplankton samples were collected at Site A between 16:31 and 19:00 on 18/04/2011 using ring-nets hauled vertically through the water column from near-bed to the surface.

Two different ring-nets were used: a 0.5 m diameter ring net with 80 µm mesh and a 1 m diameter ring net with a 270 µm mesh. The volume of water passing through the net is calculated from the readings of a mechanical flow meter (GO, USA) mounted at the mouth of each net. Five repeat hauls are completed with each net and the replicate samples bulked for analysis. Samples are preserved with buffered formalin (4% final concentration). On return to the laboratory, samples are analysed by microscope to determine species diversity and abundances. For microscope analysis, each sample is washed into observation fluid (Steedman, 1976). Sub-samples (0.5 ml to 10 ml) are taken using a Stempel pipette and individual animals were counted.

7.2 Chlorophyll

Known volumes were filtered through GF/F filters (Whatman, UK). Filters are frozen at −18°C immediately after filtration then extracted in acetone and analysed on return to the laboratory. A fluorometer (Turner Designs, USA) is used to measure extracted pigment fluorescence, and phaeopigments after acidification with HCl, following the method described by Tett (1987). The fluorometer is calibrated using a solution of pure chlorophyll-*a* with concentration being determined spectrophotometrically. This method includes some chlorophyllides in the analysis therefore results are referred to as ‘chlorophyll’ rather than ‘chlorophyll-*a*’ (Tett, 1987).

7.3 Suspended particulate matter

For measurements of suspended particulate matter, known volumes of water collected by Niskin bottle are passed through pre-weighed 0.4 µm pore size polycarbonate filters and rinsed with 2 × 50 ml ultrapure water. Filters are then dried in a desiccator at room temperature and weighed until filter weight remains constant.

7.4 Salinity

A subsample is collected from the Niskin bottle into a 250 ml glass bottle and sealed. Salinity is using a Guildline portable autosalinometer (Guildline, Canada), which had been standardised with IAPSO standard seawater.

7.5 Dissolved oxygen

Water samples for oxygen determination are collected from the Niskin bottle and preserved in triplicate using the Winkler method (Winkler, 1888). Samples are analysed in the laboratory using an automatic titration system (Sensoren Instrumente Systeme, Germany) with a photometric endpoint according to Williams and Jenkinson (1982).

7.6 Dissolved inorganic nutrients

A subsample from the Niskin bottle is filtered under low vacuum through a GF/F filter (Whatman, UK), placed in a HDPE sample bottle and preserved with mercuric chloride (final concentration 0.02 g l^{-1}). Samples are refrigerated until analysis for concentration of TOxN, NO_2, Si, PO_4 and NH_4 using a Skalar continuous flow analyser (Skalar, Netherlands) according to Kirkwood (1996). Sample concentrations are compared to in-house standards prepared in natural seawater and commercial seawater standards (Ocean Scientific International Ltd, UK).

8. Nutrient sampling (Claire Mahaffey, University of Liverpool)

Water samples were taken from the near-surface (1 m) and near-bed (3 m above the sea bed) for the analyses of nitrate, nitrite, phosphate and silicate. Sampling locations are indicated in Table 12.

Samples are collected directly from the 5-litre Niskin bottles into acid-washed, deionised water rinsed 125 ml HDPE screw cap bottles. Bottles are rinsed three times and filled with ~100 ml of sample. Samples are capped, labelled and placed in a −18°C freezer and frozen upright. Samples are transported frozen to the University of Liverpool for analysis. Samples are defrosted overnight in the dark prior to analysis and analyzed within one week of collection using a Bran and Luebbe QuAAtro Pro 5-channel nutrient analyser (purchased by NOC).

9. Grab sampling (Andy Plater, University of Liverpool)

Samples were taken from the sea bed at each station using a Day Grab. A small handful (> ~100 g) of sediment was removed from the grab, sealed in a plastic bag and frozen at −18°C. The samples will be analysed for particle size distributions.

10. Groundwater – isotope analysis (Jim Marshall, University of Liverpool)

Water from coastal stations (Site A 25-hour station and at stations 6, 4, 4a, 3a, 3, 7, 8, 2, 2a, 35, 9, 22, 23, 34, 33, 24, 21, 12, 11, 10) were obtained for isotope analysis to determine groundwater content. Near-surface and near-bed water samples were collected as in Section 6.3 (t–v) above and used for rinsing and filling 25 ml HDPE bottles. They are stored at room temperature for later laboratory analysis.

11. Trace metals – determining concentrations of 'unstable species' As(III) & Sb(III) immediately after sampling (Pascal Salaun, University of Liverpool)

Apparatus: Potentiostat µAutolab III and interface IME663, nitrogen tank, sample vibrate device, fume hood, filtering apparatus (pump, tubing, Sartoban 300 filters), laptop computer, metal-free Niskin bottle.

Background: Oxo-anions of arsenic (As) and antimony (Sb) can be present under different valency states in seawater, in both dissolved and particulate fractions. In oxygenated seawater, only the penta-valent state is thermodynamically stable, although the presence of trivalent As(III) and Sb(III) has been reported. Found shortly before, during and after blooms, As(III) can be produced by: 1) biological uptake of As(V), reduction occurs within cell walls to As(III) which is then excreted; 2) an increase in bacterial activity following a bloom lowering the amount of dissolved As(V). The situation for Sb(III) is much less certain and its presence does not seem to be related to biological processes.

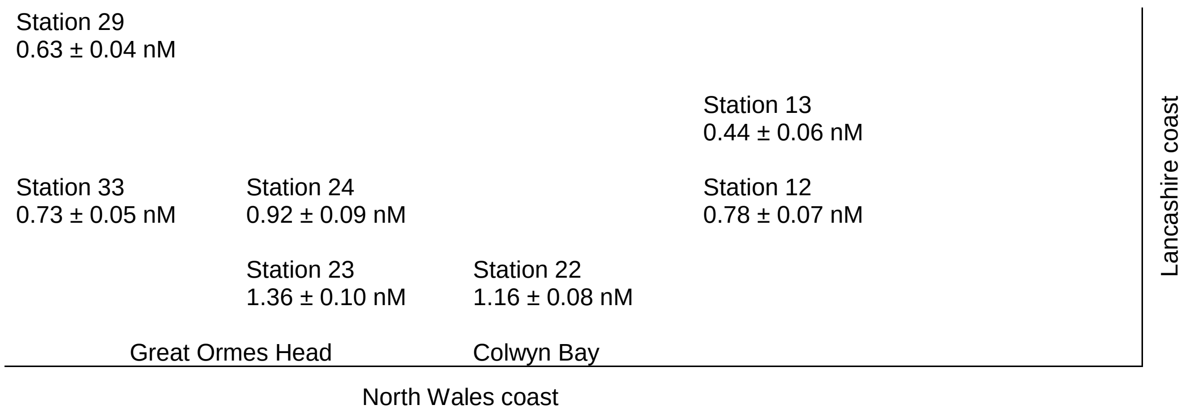
Detecting the trivalent species is not easy because of very low concentrations involved, typically nanomole levels for As(III) and sub-nanomole for Sb(III). The usual analytical technique involves acidifying the sample, but this may alter the original speciation, as acidifying a marine sample generates iodine, which oxidises any As(III)/Sb(III) to As(V)/Sb(V). A stabilising (reducing) agent, hydrazine N_2H_4, has to be added to prevent oxidation, and ideally, its reducing capability is sufficient to avoid oxidising As(III) to As(V) and too weak to reduce As(V) into As(III).

Salaun et al. (2007) developed a new electrochemical method applied at natural pH, without needing a reducing agent. However, in these conditions, sample stability is unknown. This study aims to:

- assess the method to measure natural As(III)/Sb(III) in unacidified seawater directly after sampling,
- assess the time-evolution of As(III)/Sb(III) in these samples for storage purposes,
- compare As(III)/Sb(III) concentrations in unacidified and in acidified samples.

Sampling: Using a metal-free 5-litre Niskin bottle, water is filtered immediately through Sartoban 300 cartridges (0.45 µm and 0.22 µm). At each location (stations 29, 28, 17, 6, 4a, 35, 13, 20, 25, 32, 22, 23, 34, 33, 24, 21, 12 and 11), a natural pH and an acidified sample (pH 2) were collected (~500 ml each).

Electrochemical analysis: Measurements were done onboard in de-aerated solutions. Straight after sampling, a 25 ml aliquot is placed in the voltammetric cell and the As(III) concentration determined as described by Salaun et al. (2007). During the 25-hour station, surface water samples were contaminated (probably oil/fuel compounds from the ship), interfering with the electrochemical analysis. Satisfactory response was only obtained for Wednesday 20th April: the following concentrations were found for As(III) using standard calibrations (two additions, two measurements per addition; calculation using least squares fit). Preliminary results show higher concentrations north of Colwyn Bay and Great Ormes Head.



12. Surface/underway sampling

Underway sea surface measurements, meteorological variables and ship's navigation were recorded between 08:21 on 18/04/2011 and 22:52 on 20/04/2011. The intake of the surface sampling system is located about 3 m below the water line of R.V. Prince Madog. The parameters recorded every minute by the WS Oceans system and found in the underway file are:

- time (GMT), latitude and longitude
- heading (°), track, ground speed (m s^{-1}), water speed (m s^{-1}) and depth (m)
- air temperature (°C), humidity and pressure (mbar)
- solar radiation (W m^{-2}) and PAR (photosynthetically active radiation, μmol m^{-2} s^{-1})
- current velocities components U, V
- relative wind speed (m s^{-1}), relative wind direction (° where zero indicates wind on the bow), true wind speed (m s^{-1}), true wind direction (°) and gusts (m s^{-1})
- sea temperature (°C) and salinity
- thermosalinograph (TSG) temperature (°C) and TSG conductivity
- transmissance
- oxygen
- turbidity
- fluorescence
- flow

The ship was fitted with a 300 kHz ADCP set to record current velocity 25 × 2 m bins (bin nearest the surface at 5.1 m depth), every 30 s with 29 pings per ensemble. Data were recorded between 08:21 on 18/04/2011 and 22:52 on 20/04/2011.

13. Data quality control (from John Howarth, NOC)

Preliminary assessment of moored data deployed in March and recovered in April 2011
Irish Sea Observatory cruises 75, 76; R.V. Prince Madog cruises 07/11, 11/11: duration 33 days

<u>Site A - Frame</u> NOCL rig ID 1121 (last deployment of old style frame)

600 kHz ADCP S/N 12241: The ADCP record is contained in ten files; the cable between the battery pack and the ADCP is suspected and has now been discarded. Fortunately all the in-water data, except for the first 3 hours is contained in one file, recording 5 minutes out of sync with the normal 0, 10, ... past the hour. These data look OK. The near surface layer mean currents were more westward than usual – not seen at site B.

SeaBird 16*plus* S/N 4848 with SeaPoint turbidity S/N 10538: The temperature and pressure data look OK. The salinity data appear to be a constant 0.07 too low throughout compared with the MicroCATs.

Teledyne Citadel CTD S/N 2277 with Optode S/N 670: No data were recorded because the default set-up within the instrument was incorrect for independent battery operation. This problem will also affect the next deployment.

Site A - Mooring NOCL rig ID 1120

MicroCATs S/Ns 2010 and 5434: Temperature and salinity data look OK; when the water column is well mixed agreeing to better than 0.005 for both temperature and salinity.

StarOddis S/Ns 2840 and 2841: Data look OK. Compared with the MicroCATs, S/N 2840 was reading 0.03°C too high and S/N 2841 0.01°C too low.

Met station (Package 2) – S/N [unknown]

The record was again short, with gaps appearing in last few hours of the deployment. After the last deployment it was agreed that the set up would be changed to conserve power – had this happened?

The air temperature record was low compared with that at Hilbre Island; the difference is correlated with temperature, consistent with the previous deployment. The mean difference was 4.9°C, and the maximum difference –10.4°C. If the temperature measurement is incorrect this will affect the wind speed measurement, by 0.18% per °C error.

The buoy's atmospheric pressure correlates very well with Hilbre Island; the mean offset was –0.9 mb. The maximum wind speeds at the buoy were weaker than at Hilbre Island (they were similar on the previous deployment) and there are significant wind direction differences between the two sites shown in the rose plots and histograms. (We will need several deployments to establish differences, if any between the two sites.)

Site B new site – Frame NOCL rig ID 1123 (old style frame) [This is last deployment at this site.]

600 kHz ADCP S/N 2390: The data look OK.

SeaBird 16*plus* S/N 5310 with SeaPoint turbidity S/N 10320: Temperature data look OK. Throughout the record there are constant small mean salinity differences with the MicroCATs, but not clear which is correct, see MicroCATs below.

Site B new site – Mooring: NOCL rig ID 1122 [This is the last deployment at this site.]

MicroCATs S/Ns 4966 and 5790: Temperature data look OK. There is one spike of one reading in the conductivity / salinity data recorded by S/N 5790. The table of mean salinity differences when the water column is well-mixed is

S/N 4966 – S/N 5790:	0.02
S/N 4966 – S/N 5310 (SBE 16+):	0.03
S/N 5790 – S/N 5310:	0.01

StarOddis S/Ns 2842, 2848 and 2851: Data look OK. Compared with the MicroCATs when the water column was well-mixed S/N 2842 was 0.01°C too high; S/N 2848 was 0.01°C too low and S/N 2851 was 0.02°C too low. Note that all the StarOddis are digitized in 0.012 / 0.013°C intervals.

14. Cruise participants and acknowledgements

The assistance of the master, officers and crew of the R.V. Prince Madog and all scientists is appreciated in ensuring the success of this cruise.

Scientific personnel
Andy Lane (NOC), Principal Scientist
Terry Doyle (NOC)
Emlyn Jones (NOC)
John Kenny (NOC)
Peter Hughes (Bangor Univ.)
Jeni Moore (Univ. Strathclyde)
Pascal Salaun (Univ. Liverpool)
Fred Wobus (Univ. Plymouth)
Jennie Keable (Cefas)
Chris Read (Cefas)

Ship's officers and crew
Steve Duckworth (Master)
David Shaw (Chief Officer)
Mick Callaghan (AB)
Phil Jones (AB)
Dave Leigh (AB)
Les Black (Chief Engineer)
Meikle Mackay (2nd Engineer)
Colin Hughes (Cook)

We are grateful to the Port of Liverpool (Mersey Docks and Harbour Company) for permission to undertake the 25-hour station while at anchor.

References

Kirkwood, D.S., 1996. Nutrients: practical notes on their determination in seawater. ICES Techniques in Marine Environmental Sciences. Report No. 17. ICES, Copenhagen. 25pp. ISSN 0903-2606

Salaun, P., Planer-Friedrich, B., van den Berg, C.M.G., 2007. Inorganic arsenic speciation in water and seawater by anodic stripping voltammetry with a gold microelectrode. Analytica Chimica Acta, 585(2), 312–322. doi:10.1016/j.aca.2006.12.048

Steedman, H.F. (Ed.), 1976. Zooplankton fixation and preservation. Monographs in oceanographic methodology. UNESCO Press, Paris. 350pp.

Tett, P.B., 1987. Plankton. pp280–341 in: Biological Surveys of Estuaries and Coasts. Baker, J.M., Wolff, J.W. (Eds.), Cambridge University Press, Cambridge. 472pp. ISBN 978-0521311915

Williams, P.J. le B., Jenkinson, N.W., 1982. A transportable microprocessor-controlled precise Winkler titration suitable for field station and shipboard use, Limnology and Oceanography, 27, 576–584.

Winkler, L.W., 1888. Die Bestimmung des in Wasser gelösten Sauerstoffes. Berichte der Deutschen Chemishen Gesellschaft, 21, 2843–2855. [The determination of dissolved oxygen in water.]

Glossary

ac-s	an instrument recording spectra of: *a*, absorption; *c*, attenuation
ADCP	acoustic Doppler current profiler
BODC	British Oceanographic Data Centre
CDOM	chromomorphic or coloured dissolved organic matter
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CTD	conductivity, temperature, depth
IAPSO	International Association for the Physical Sciences of the Oceans
LISST	laser in situ scattering transmissometry – particle size analyser
NOC	National Oceanography Centre
PAR	photosynthetically active radiation
SPM	suspended particulate matter
TSG	thermosalinograph
TOxN	total oxidisable nitrogen

Table 11. Nominal positions of CTD stations (near-shore stations added for cruise 75)

Station	Latitude (N)	Longitude (W)	Station	Latitude (N)	Longitude (W)
1 & 9 (A)	53° 32.0′	3° 21.8′	23	53° 23.0′	3° 47.0′
2	53° 37.0′	3° 13.4′	24	53° 27.0′	3° 47.0′
3	53° 42.0′	3° 13.4′	25	53° 32.0′	3° 47.0′
4	53° 47.0′	3° 13.4′	26	53° 37.0′	3° 47.0′
5	53° 52.0′	3° 21.8′	27	53° 42.0′	3° 47.0′
6	53° 47.0′	3° 21.8′	28	53° 47.0′	3° 47.0′
7	53° 42.0′	3° 21.8′	29	53° 47.0′	3° 55.4′
8	53° 37.0′	3° 21.8′	30	53° 42.0′	3° 55.4′
10	53° 27.0′	3° 13.4′	31	53° 37.0′	3° 55.4′
11	53° 27.0′	3° 21.8′	32	53° 32.0′	3° 55.4′
12	53° 27.0′	3° 30.2′	33	53° 27.0′	3° 55.4′
13	53° 32.0′	3° 30.2′	34	53° 22.0′	3° 55.4′
14	53° 37.0′	3° 30.2′	35	53° 32.0′	3° 15.9′
15	53° 42.0′	3° 30.2′			
16	53° 47.0′	3° 30.2′			
17	53° 47.0′	3° 38.6′	*2a*	*53° 37.0′*	*3° 07.5′*
18	53° 42.0′	3° 38.6′	*3a*	*53° 42.0′*	*3° 08.5′*
19	53° 37.0′	3° 38.6′	*4a*	*53° 47.0′*	*3° 06.0′*
20 (B)*	53° 32.3′	3° 38.4′	*5a*	*53° 50.9′*	*3° 13.4′*
21*	53° 27.0′	3° 38.6′	*11a*	*53° 24.9′*	*3° 21.8′*
22**	53° 23.7′	3° 38.6′	*12a*	*53° 22.7′*	*3° 30.2′*

* Before cruise 66 (26/01/2010), Station 21 was referred to as Site B and Station 20 was at 53° 32.0′ N 3° 38.6′ W.

** Before cruise 60 (01/04/2009), Station 22 was at 52°23.0′ N 3° 38.6′ W.

Table 12. Station log

Station	CTD #	Date & Time	Latitude (N)	Longitude (W)	Water depth (m)	SPM & Chl	CDOM	Nutrients srf & bot	Grab #	Cefas (srf chl, SPM, salinity & nutrients)
1 (A)	1	18/04/11 10:23	53° 31.952′	3° 21.476′	28.2					✓ + srf/bot O_2
1 (A)	2	18/04/11 12:38	53° 32.023′	3° 21.978′	26.6	✓				✓ + srf/bot O_2
A1	3	18/04/11 13:00	53° 31.848′	3° 21.425′	25.9	✓	✓	✓		✓
A2	4	18/04/11 13:33	53° 31.836′	3° 21.598′	24.3					
A3	5	18/04/11 14:00	53° 31.838′	3° 21.599′	24.1	✓	✓	✓ srf only		✓
A4	6	18/04/11 14:30	53° 31.840′	3° 21.599′	23.0					
A5	7	18/04/11 14:59	53° 31.842′	3° 21.599′	22.2	✓	✓	✓		✓
A6	8*	18/04/11 15:32	53° 31.846′	3° 21.598′	21.2					
A7	9	18/04/11 16:01	53° 31.848′	3° 21.597′	20.6	✓	✓	✓		✓
A8	10	18/04/11 16:31	53° 31.847′	3° 21.596′	20.1					
A9	11	18/04/11 17:01	53° 31.842′	3° 21.596′	19.9	✓	✓	✓		✓
A10	12	18/04/11 17:32	53° 31.848′	3° 21.589′	19.0					✓
A11	13	18/04/11 18:01	53° 31.843′	3° 21.580′	20.1	✓	✓	✓		✓
A12	14	18/04/11 18:31	53° 31.843′	3° 21.580′	20.1					
A13	15	18/04/11 19:01	53° 31.829′	3° 21.512′	21.5	✓	✓	✓		✓
A14	16	18/04/11 19:32	53° 31.823′	3° 21.431′	22.6					
A15	17	18/04/11 20:00	53° 31.827′	3° 21.395′	23.7	✓	✓	✓		✓
A16	18	18/04/11 21:02	53° 31.808′	3° 21.396′	26.5	✓	✓	✓		✓
A17	19	18/04/11 21:32	53° 31.825′	3° 21.390′	27.5					
A18	20	18/04/11 22:00	53° 31.816′	3° 21.395′	28.2	✓	✓	✓		✓
A19	21	18/04/11 22:31	53° 31.827′	3° 21.398′	28.6					
A20	22	18/04/11 23:04	53° 31.824′	3° 21.409′	28.9	✓	✓	✓		✓
A21	23	18/04/11 23:37	53° 31.830′	3° 21.448′	>26.7					
A22	24	19/04/11 00:04	53° 31.823′	3° 21.466′	>26.2	✓	✓	✓		✓
A23	25	19/04/11 00:33	53° 31.818′	3° 21.511′	27.7					
A24	26	19/04/11 01:00	53° 31.817′	3° 21.525′	27.0	✓	✓	✓		✓
A25	27*	19/04/11 01:31	53° 31.815′	3° 21.549′	26.0					
A26	28	19/04/11 02:00	-	-	-					
A27	29	19/04/11 02:30	-	-	-					
A28	30	19/04/11 03:00	-	-	-					
A29	31	19/04/11 03:30	53° 31.821′	3° 21.592′	21.9					
A30	32*	19/04/11 04:06	53° 31.823′	3° 21.590′	>20.2	✓	✓	✓		✓
A31	33	19/04/11 04:34	53° 31.825′	3° 21.588′	20.9					
A32	34	19/04/11 05:02	53° 31.823′	3° 21.587′	20.5	✓	✓	✓		✓
A33	35	19/04/11 05:31	53° 31.820′	3° 21.587′	20.3					
A34	36	19/04/11 06:00	53° 31.804′	3° 21.580′	20.4	✓	✓	✓		✓
A35	37	19/04/11 06:31	53° 31.804′	3° 21.575′	20.7					
A36	38	19/04/11 07:00	53° 31.801′	3° 21.522′	21.3	✓	✓	✓		✓
A37	39	19/04/11 07:31	53° 31.818′	3° 21.486′	22.1					
A38	40	19/04/11 08:00	53° 31.832′	3° 21.456′	23.1	✓	✓	✓		✓
A39	41	19/04/11 08:30	53° 31.833′	3° 21.422′	24.4					
A40	42	19/04/11 10:00	53° 31.831′	3° 21.390′	27.8	✓	✓	✓		✓
A41	43	19/04/11 10:30	53° 31.830′	3° 21.393′	28.4					

* CTD pump had problems during casts 8, 27, and 32

(continued)

Table 12. Station log (continued)

Station	CTD #	Date & Time	Latitude (N)	Longitude (W)	Water depth (m)	SPM & Chl	CDOM	Nutrients srf & bot	Grab #	Cefas (srf chl, SPM, salinity & nutrients)
A42	44	19/04/11 11:01	53° 31.832′	3° 21.395′	28.8	✓	✓	✓		✓
A43	45	19/04/11 11:33	53° 31.819′	3° 21.413′	28.8					
A44	46	19/04/11 12:03	53° 31.810′	3° 21.430′	28.8	✓	✓	✓		✓
A45	47	19/04/11 12:34	53° 31.810′	3° 21.430′	28.2					
A46	48	19/04/11 13:03	53° 31.828′	3° 21.516′	27.5	✓	✓	✓		✓
A47	49	19/04/11 13:33	53° 31.818′	3° 21.563′	26.7					
A48	50	19/04/11 14:00	53° 31.813′	3° 21.666′	26.2	✓	✓	✓		✓
29	51	19/04/11 16:27	53° 47.078′	3° 55.480′	39.4	✓		✓	1	
28	52	19/04/11 17:21	53° 49.019′	3° 47.240′	38.2	✓		✓	2	
17	53	19/04/11 18:12	53° 46.977′	3° 38.396′	31.4	✓		✓	3	✓
16	54	19/04/11 18:56	53° 46.981′	3° 29.912′	21.4	✓		✓	4	
6	55	19/04/11 19:37	53° 46.981′	3° 21.555′	17.0	✓		✓	5	
4	56	19/04/11 20:15	53° 46.963′	3° 13.576′	14.9	✓		✓	6	
4a	57	19/04/11 20:49	53° 47.114′	3° 06.593′	11.0	✓		✓	7	✓
3a	58	19/04/11 21:35	53° 42.121′	3° 08.798′	12.3	✓	✓	✓	8	✓
3	59	19/04/11 22:07	53° 42.078′	3° 13.514′	20.7	✓	✓	✓	9	
7	60	19/04/11 22:54	53° 42.037′	3° 21.836′	28.7	✓		✓	10	✓
15	61	19/04/11 23:42	53° 42.004′	3° 30.184′	41.9	✓		✓	11	
18	62	20/04/11 00:29	53° 42.096′	3° 38.680′	43.7	✓		✓	12	
27	63	20/04/11 01:14	53° 41.979′	3° 46.995′	44.2	✓		✓	13	
30	64	20/04/11 01:56	53° 41.972′	3° 55.517′	43.4	✓		✓	14	✓
31	65	20/04/11 02:45	53° 36.919′	3° 55.571′	46.0	✓		✓	15	
26	66	20/04/11 03:47	53° 37.015′	3° 47.211′	39.2	✓		✓	16	
19	67	20/04/11 04:43	53° 37.057′	3° 38.692′	32.9	✓		✓	17	✓
14	68	20/04/11 05:37	53° 36.978′	3° 30.113′	27.9	✓		✓	18	
8	69	20/04/11 06:21	53° 36.979′	3° 21.736′	20.5	✓		✓	19	
2	70	20/04/11 07:03	53° 37.048′	3° 13.368′	9.5	✓	✓	✓	20	✓
2a	71	20/04/11 07:38	53° 37.141′	3° 07.439′	5.5	✓	✓	✓	21	✓
35	72	20/04/11 08:41	53° 31.987′	3° 15.874′	12.0	✓	✓	✓	22	
9	73	20/04/11 09:20	53° 32.135′	3° 21.557′	23.8	✓	✓	✓	23	✓
13	74	20/04/11 10:17	53° 32.060′	3° 30.264′	33.8	✓	✓	✓	24	
20 (B)	75	20/04/11 11:11	53° 32.395′	3° 38.017′	40.1	✓	✓	✓	25	✓
20 (B)	76	20/04/11 12:04	53° 32.332′	3° 38.282′	39.3					
25	77	20/04/11 13:10	53° 32.043′	3° 47.165′	47.9	✓	✓	✓	26	
32	78	20/04/11 13:55	53° 32.044′	3° 55.478′	49.2	✓	✓	✓	27	✓
22	79	20/04/11 15:49	53° 23.768′	3° 38.597′	16.0	✓		✓	(28)	
23	80	20/04/11 16:38	53° 23.117′	3° 46.918′	12.3	✓		✓	29	
34	81	20/04/11 17:20	53° 22.037′	3° 55.473′	20.7	✓		✓	30	✓
33	82	20/04/11 18:01	53° 27.009′	3° 55.038′	34.1	✓		✓	31	
24	83	20/04/11 18:46	53° 27.098′	3° 47.041′	26.3	✓		✓	32	
21	84	20/04/11 19:28	53° 27.076′	3° 38.500′	21.5	✓		✓	33	✓
12	85	20/04/11 20:09	53° 27.042′	3° 29.996′	15.6	✓		✓	34	
11	86	20/04/11 20:48	53° 26.996′	3° 21.761′	15.9	✓		✓	35	
10	87	20/04/11 21:26	53° 27.031′	3° 13.409′	15.7	✓	✓	✓	36	✓