Irish Sea Observatory cruise 75

PI: Andy Lane (leg 1) & Matthew Palmer (leg 2)
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Ship: Prince Madog (cruise 07/11)

(All times in GMT throughout report)

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 measurements with coupled models into a pre-operational coastal prediction system whose results are displayed online at http://cobs.pol.ac.uk/. Further details about the Observatory may be found at this website.

1. Cruise and Scientific Objectives

This cruise was split into two sections to accommodate a visit to the ship and participation by Andrew Miller MP, accompanied by Prof. Jonathan Sharples (NOC/UoLiverpool) and Robert Smith (NOC). The first leg of this cruise was overseen by Andy Lane and the second leg by Dr. Matthew Palmer.

1.1 Mooring deployment and recovery

Leg 1:

Two permanent monitoring sites are maintained at the locations marked in Figure 1. At each of these sites instrumentation is mounted in a sea bed frame, on a surface buoy and along its mooring chain. Maintaining a long time series of observations will ultimately help to discriminate between natural and anthropogenic variability within Liverpool Bay. The primary aim of the cruise was 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 (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 Aanderra oxygen Optode.

b) CEFAS SmartBuoy (including a 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 10m below the surface. A frame containing a WetLabs ACS unit, Wetlabs fluorometer and SeaBird MicroCat is attached at 5m below the surface.

c) A new design sea bed lander frame for short term trial of the deployment and recovery systems. To be deployed and recovered during this cruise.

To deploy:

d) 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 Aanderra oxygen Optode.

e) 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 10m below the surface. A frame containing a WetLabs ACS unit, Wetlabs fluorometer and SeaBird MicoCat is attached at 5m below the surface.

Leg 2:
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 miniloggers at 7.5 m, 15 m and 20 m below the surface.

To deploy:

c) 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).

d) 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 miniloggers at 7.5 m, 15 m and 20 m below the surface.

1.2 CTD and LISST survey

The second objective of the cruise was to complete a survey covering 34 sites which form the standard ISO CTD grid with additional stations along the Sefton coastline to investigate near coast gradients. The station positions are shown in Figure 1. The regular survey grid covers the area from the coast of North Wales to a line extending westwards from Blackpool, and from the Lancashire coast to a line extending northwards from Great Orme Head. The grid and sampling are designed to determine the effects of the Dee, Mersey and Ribble on the dynamics and biogeochemistry of Liverpool Bay.

At each fixed station samples are taken for the analysis of nutrient concentrations. 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.

Suspended Particulate Matter Samples (SPM) are taken at each site as part of a long term observatory requirement for total suspended sediment concentrations (now inorganic/organic as well). The samples are

also required for marine optics, and for comparisons of absorption and scattering with the ACS instrument. Chlorophyll-a and Coloured Dissolved Organic Matter (CDOM) samples are taken as part of a 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.

1.3 Grab samples

The third objective was to collected grab samples of the seabed sediment at each station.

1.4 Zooplankton net hauls

The fourth objective was to collect 10 vertical zooplankton net hauls at Site A to determine species diversity and abundance.

2. Cruise Narrative

The RV Prince Madog berthed at Vittoria Wharf (Birkenhead, UK) at 18:00 on 15/03/2011. Loading was completed by 18:45.

Leg 1: The ship entered the River Mersey via Alfred Lock at 06:58 on 16/03/2011. The ship's surface monitoring and ADCP were switched on at 07:57 on passing the radar tower at Crosby. Weather was fine to calm throughout the cruise.

Zooplankton net hauls were completed by CEFAS at site A between 09:04 and 09:30.

A CTD profile was made prior to recovery of the site A moorings at 10:02. The Site A ADCP frame was recovered successfully by 10:34. The replacement frame was released at 10:51. The CEFAS SmartBuoy was released at 11:16 and recovery of the old buoy complete by 11:32. All mooring operations were successfully completed although it was identified that the AC-S frame had become entangled in the mooring cable (most likely during deployment in Jan 2011) leading to wear on the AC-S protective frame and cable. The cable was disposed of and the problem noted for future deployments. A post-deployment CTD profile was made at 11:46.

The CTD grid and grab sampling was started from station 5 at 14:02 followed by east-west transects (figure 1). At 12:00 17/03/2011 the trial lander frame was deployed close to site A. The spatial survey continued until 19:50 17/03/2011 when all required stations were successfully visited and all required samples collected.

The ship anchored overnight at close to the Mersey to await leg 2 which required a changeover of personnel. The ship left anchor at 05:48 and proceeded to the Mersey cruise liner terminal to collect new personnel (Matthew Palmer, Jonathan Sharples, Robert Smith) and drop-off persons to meet the maximum passenger requirements of the vessel (Andy Lane and Alex Ewan).

Leg 2: The ship arrived at Site B (Station 20) was reached at 10:27 18/03/2011. The weather was fine and the sea calm. A pre-mooring recovery CTD profile was made at 10:34. The lander frame was fully recovered by 10:57 and the replacement lander frame deployed at 11:12. The CEFAS SmartBuoy was deployed at 11:32 and the old buoy recovered by 11:42. A post-recovery CTD was made at site B at 11:55 and a day grab made at 12:30.

The new lander frame under trial was successfully recovered from site A by 16:15. The recovery line was trapped under the frame body which hindered recovery however the calm sea-state reduced any risk to minimal. The ineffective recovery line was reported to the NOC workshop for redesign prior to the next deployment. An extra CTD profile was taken at site A at 1628.

The ships surface monitoring and ADCP were switched off at 18:41 on 18/01/2011. The ship entered Alfred Lock at 19:25. Unloading was completed by 21:00.

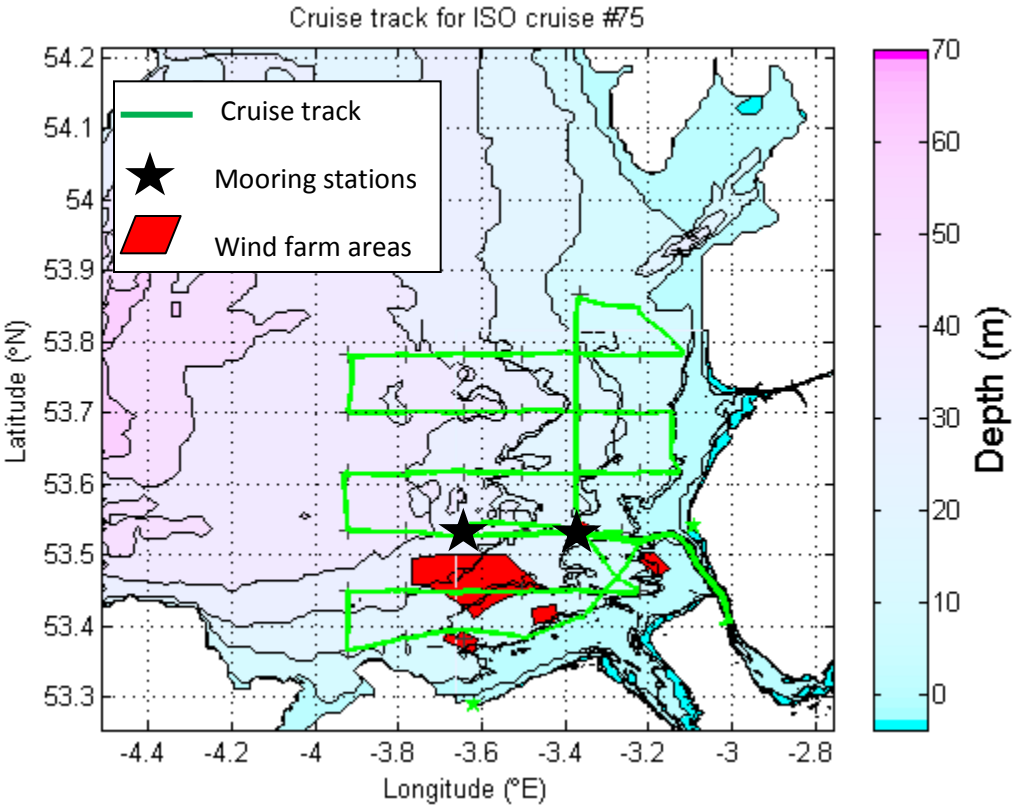

Figure 1. Coastal Observatory Cruise Track #75 with bathymetry (OD)

3. Moorings

3.1 Recovered Instrumentation

N.B. the site A lander fame under trial was not fitted with any instrumentation other than an acoustic release for recovery so is not reported in this section.

Table 1: Recovered mooring positions and times

	Latitude (N)	Longitude (W)	Depth (m)	Date	Time (GMT)
ADCP frame (Site A)	53°32.058	3°21.420	24.1	16/03/2011	10:34
SmartBuoy (Site A)	53°32.083	3°21.658	23.3	16/03/2011	11:21
ADCP frame (Site B)	53°32.420	3°38.631	39.4	18/03/2011	10:57
SmartBuoy (Site B)	53°32.414	3°38.484	38.6	18/03/2011	11:42

Site A Bedframe NOC rig id 1117

The following instrumentation was mounted on the seabed frame deployed at Site A.

Instrument	S/N	Notes	Clock set	Delayed start	Stopped logging	Clock drift (s)
RDI 600 kHz ADCP	3644	1.5 GB memory. Mode 1: 100 pings every 10 minutes 35 × 1 m bins (2.65–36.65 m above the bed, WN035). Beam coordinates – speeds, correlation, echo intensity, % good. Sound velocity calculated from temperature, depth and salinity of 32. 20° beam separation.	11:18 11/1/2011	06:00 12/01/2011	10:53 22/3/2011	+10
SeaBird SBE 16plus	4597	Mounted on base of frame 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.	12:07:00 11/01/2011	06:00:00 12/01/2011	10:45 29/3/2011	+9
SeaPoint turbidity sensor	10471	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper	-	-	As above	-
SeaBird SBE 16 plus	4741	Mounted with Aanderra Optode (see below). Sample interval 600s.	12:31:00 11/01/2011	06:00:00 12/01/2011	10:36 29/3/2011	+9
Aanderra Optode	675		-	-	As above	-

Site A Mooring: NOCL Rig ID 1116

The following instrumentation was recovered from the SmartBuoy mooring at Site A

Instrument	S/N	Notes	Nominal Depth (m)	Clock set	Delayed start	Stopped logging	Clock drift (s)
SeaBird Microcat	4966	Temperature and conductivity recorder. Mounted on frame with AC-S and fluorometer)	5	13:12:30 11/01/2011	06:00:00 12/01/2011	16:45 17/03/2011	+11
AC-S	59	(DH4 data logger S/N 119)	5	18:31:00 11/01/2011	08:50:00 12/01/2011	16:04 16/01/2011	+2
Wetlabs fluorometer	1514	Attached to AC-S frame	5	19:08:00 11/01/2011	07:40:00 12/01/2011	15:29 29/03/2011	90
SeaBird Microcat	5790	Temperature and conductivity recorder	10	12:56:00 on 11/01/2011	06:00:00 12/01/2011	16:49	17

						17/03/2011	
StarOddi Mini-logger	2836	Set to record at 600s intervals	7.5	N/A	06:00:00 12/01/2011	13:05 29/03/2011	-6.65
Staroddi Mini-logger	2837	Set to record at 600s intervals	15	N/A	06:00:00 12/01/2011	13:11 29/03/2011	-6.65
Weather Station		Set to record at 600s intervals	Surface				

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 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 satellite. An NOC weather station is attached to the SmartBuoy recording wind speed and direction, air temperature, atmospheric pressure and position (GPS).

The single point mooring was composed of 1½" long link chain, marked by a 1.8 m diameter toroid and anchored by a half tonne clump of scrap chain.

Site B Bedframe: NOCL Rig ID 1118

The table below details the recovered instruments mounted on the seabed frame at Site B

Instrument	S/N	Notes	Clock set	Delayed start	Stopped logging	Clock drift (secs)
RDI 600 kHz ADCP	5807	1 GB memory. Mode 1: 100 pings every 10 minutes 45 × 1 m bins (2.65–46.65 m above the bed, WN045). Beam coordinates – speeds, correlation, echo intensity, % good. Sound velocity calculated from temperature, depth and salinity of 32. 20° beam separation.	11:49:10 11/01/2011	06:00:00 12/01/2011	10:58 22/03/2011	+7
SeaBird SBE 16plus	4737	Mounted on base of frame 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.	12:17:30 11/01/2011	06:00:00 12/01/2011	12:08 29/03/2011	+6
SeaPoint turbidity sensor	10537	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper	-	-	As above	-

Site B Mooring: NOCL Rig ID 1119

The following instrumentation was recovered from the SmartBuoy mooring at Site B

Instrument	S/N	Notes	Nominal Depth (m)	Clock set	Delayed start	Stopped logging	Clock drift (s)
SeaBird Microcat	4998	Temperature and conductivity recorder.	5	13:07:00 11/01/2011	06:00:00 12/01/2011	12:42 29/03/2011	+11
SeaBird Microcat	5433	Temperature and conductivity recorder	10	13:02:00 11/01/2011	06:00:00 12/01/2011	12:46 29/03/2011	+16
StarOddi Mini-logger	2838	Set to record at 600s intervals	7.5	N/A	06:00:00 12/01/2011	13:16 29/03/2011	-6.65
Staroddi Mini-logger	2849	Set to record at 600s intervals	15	N/A	06:00:00 12/01/2011	13:21 29/03/2011	-6.65
Staroddi Mini-logger	2852	Set to record at 600s intervals	20	N/A	06:00:00 12/01/2011	13:24 29/03/2011	-6.65

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 2: Deployed mooring positions and times

	Latitude (N)	Longitude (W)	Depth (m)	Date	Time (GMT)
ADCP frame (Site A)	53°32.023	3°21.437	24.1	16/03/2011	10:51
SmartBuoy (Site A)	53°31.998	3°21.744	23.8	16/03/2011	11:16
ADCP frame (Site B)	53°32.394	3°38.540	38.9	18/03/2011	11:12
SmartBuoy (Site B)	53°32.308	3°38.411	38.9	18/03/2011	11:33

Site A Bedframe

The following instrumentation was mounted on the seabed frame deployed at Site A.

Instrument	S/N	Notes	Clock set	Delayed start
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, WN035). Beam coordinates – speeds, correlation, echo intensity, % good. Sound velocity calculated from temperature, depth and salinity of 32. 20° beam separation.	16:34:30 14/03/2011	06:00:00 16/03/2011
SeaBird SBE 16plus	4848	Mounted on base of frame 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 11/01/2011	06:00:00 16/01/2011

SeaPoint turbidity sensor	10538	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper	As above-	-
Teledyne Citadel CT	2277	Mounted with Aanderra Optode (see below). Sample interval 600s.	15:15:30 14/03/2011	06:00:00 16/03/2011
Aanderra Optode	670		As above	-

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 70358 (Rx= 11.0 kHz, Tx=12.0 kHz, RC=B)

Site A Mooring

The following instrumentation was deployed from the SmartBuoy mooring at Site A

Instrument	S/N	Notes	Nominal Depth (m)	Clock set	Delayed start
Weather Station??					
SeaBird Microcat	2010	Temperature and conductivity recorder. Mounted on frame with AC-S and fluorometer)	5	19:43:30 15/03/2011	06:00:00 16/01/2011
AC-S	060	(DH4 data logger S/N 119)	5	16:05:00 10/03/2011	07:30:00 16/03/2011
Wetlabs fluorometer	1513	Attached to AC-S frame	5	16:45:00 10/03/2011	07:30:00 16/03/2011
SeaBird Microcat	5434	Temperature and conductivity recorder	10	09:55:30 15/03/2011	06:00:00 16/03/2011
StarOddi Mini-logger	2840	Set to record at 600s intervals	7.5	N/A	06:00:00 16/03/2011
Staroddi Mini-logger	2841	Set to record at 600s intervals	15	N/A	06:00:00 16/03/2011

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 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 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.

Site B Bedframe

The following instrumentation was mounted on the seabed frame deployed at Site B.

Instrument	S/N	Notes	Clock set	Delayed start

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, WN045). Beam coordinates – speeds, correlation, echo intensity, % good. Sound velocity calculated from temperature, depth and salinity of 32. 20° beam separation.	16:44:30 14/03/2011	06:00:00 16/03/2011
SeaBird SBE 16plus	5310	Mounted on base of frame 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
SeaPoint turbidity sensor	10320	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper	As above	-

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=10.5 kHz, Tx=12.0 kHz, RC=C)
S/N 70356 (Rx=11.0 kHz, Tx= 12.0 kHz, RC=B)

Site B SmartBuoy

The following instrumentation was deployed from the SmartBuoy mooring at Site B

Instrument	S/N	Notes	Nominal Depth (m)	Clock set	Delayed start
SeaBird Microcat	4966	Temperature and conductivity recorder.	5	17:56:00 17/03/2011	06:00:00 18/03/2011
SeaBird Microcat	5790	Temperature and conductivity recorder	10	17:23:30 17/03/2011	06:00:00 18/03/2011
StarOddi Mini-logger	2842	Set to record at 600s intervals	7.5	N/A	06:00:00 12/01/2011
Staroddi Mini-logger	2848	Set to record at 600s intervals	15	N/A	06:00:00 12/01/2011
Staroddi Mini-logger	2851	Set to record at 600s intervals	20	N/A	06:00:00 12/01/2011

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

4. CTD and LISST survey

The following instrumentation was 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	0.2m path
SeaBird SBE35 precision thermometer	0041	
Satlantic SUNA nitrate analyser	??	
Sequoia Scientific LISST-100X particle sizer	1291	Internal logging http://www.sequoiasci.com/products/part_LISST_100.aspx

Water samples were taken near the sea bed (~3m above bottom) for calibration of the CTD salinity. Samples were analysed on a Guildline Portasal 8410A at the University of Bangor.

During the survey grid the water samples were taken from the following 5L Niskin bottles on the CTD rosette for the specified analysis:

Near bed:

Bottle 3 – SPM/chlorophyll/CDOM
Bottle 4 – Nutrients and salinity
Bottle 5 – CEFAS

Near surface:

Bottle 8 – Nutrients
Bottle 9 – SPM/chlorophyll/CDOM;
Bottle 10 & 11 – CEFAS

5. Nutrient sampling (for Claire Mahaffey, UoL)

Nutrient samples were taken from the near surface (~1m) and near bed (~3m above) for the analysis to determine the concentration of nitrate (plus nitrite), phosphate and silicate.

Samples are collected directly from 5L Niskin bottles into acid-washed, deionised water rinsed 125ml HDPE screw cap bottles. Bottles are rinsed 3 times and filled with ~ 100ml of sample. Samples are capped, labeled and placed in a -20°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 typically analysed within 1 week of collection using a Bran and Luebbe QuAAtro Pro 5-channel nutrient analyser.

The location of samples collected are detailed in Table 3.

6. SPM, Chlorophyll and CDOM sampling (for Andy Lane, NOC-L)

Water from the near surface (1m) and near bed (3 mab) was taken for the determination of SPM, chlorophyll-a and CDOM. The following sections detail the pre-processing, sample collection and post-processing steps.

6.1 Suspended Particulate Matter (SPM)

Pre-processing: Whatman GF/F 0.7µm poresize 47mm diameter 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 don't 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) and take entire contents. (e) Stir sample before measuring out, typically 1L required, less (500ml) if transmissometer on CTD indicates turbid conditions. (f) Place filter on to holder and assemble the funnel. Switch on vacuum pump, ensuring suction <0.4bar (<0.2 bar if done at same time as chlorophyll sample). Add sample in stages - don't allow paper to go dry. (g) Before final 50ml goes through add 100ml of deionised water; repeat once. (h) Put filter back in to appropriate dish/bag. Store in freezer at -18°C.

Post-processing: (i) Dry filters at 75°C for 3 hours before weighing as in (c). (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 Chorophyll-a

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

Sample collection: (n) Use the same water sample as for SPM d) to f), except measure out 500ml and filter through Whatman GF/F 0.7µm poresize 47mm diameter filters (straight from box) with vacuum <0.2bar. Do not rinse. (o) Put filter in the test tube, replace cap, and wrap in aluminium foil with label. Store in freezer.

Post-processing: (p) Fluorometric method: make the chlorophyll standard and calibrate the fluorometer. (q) Take test tubes from freezer, add 5ml 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 filter papers 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 new stock of clean glass bottles and caps. Rinse with 1-N hydrochloric acid and then Milli-Q water and air-dry before use.

Sample collection: (t) Collect seawater in a clean container. (u) Place Whatman polycarbonate 0.2µm poresize 47mm diameter filter in the holder on glass funnel support and secure funnel with spring clamp; insert this into the flask and attach side arm to vacuum pump tubing (<0.2bar). Filter 150 ml of sampled water into flask, and use this to rinse glassware and sample storage bottles. Using same filter, obtain further filtrate to fill the 50 ml Pyrex bottles. (v) Cap bottles, label and refrigerate at 4°C in dark.

Post-processing: Samples should be analysed on ship, or transferred under refrigeration to the lab and processed as soon as possible.
Significant deterioration in quality can occur in hours or days. (w)
Spectrophotometry: switch on instrument and allow it to warm up (takes about 1 hour); allow sample and a bottle of Milli-Q water to reach room temperature (important). (x) Use clean glass syringes, rinse twice and fill

two 10 cm path length cuvettes; make sure there are no air bubbles inside, no scratches, wipe smears / prints off 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 nm); repeat five times every 300 seconds for each of three samples per site.

7. Sediment grab sampling (for Andy Plater, UoL)

Grab samples of sediment 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 in a -18°C freezer for analysis at the University of Liverpool.

8. Zooplankton vertical haul samples (CEFAS)

Ten zooplankton samples were collected at site A between 09:04 and 10:02 on 16/03/2011 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.

9. CEFAS sampling

The following near surface (1m) samples were taken for CEFAS: chlorophyll, suspended particulate matter, dissolved inorganic nutrients, salinity and dissolved oxygen. Sites sampled are detailed in Table 3. Dissolved oxygen samples were taken from the near bed at Site A to assist with calibration of the bedframe mounted Anderra oxygen sensor.

9.1 Chlorophyll

Known volumes were filtered through glass fibre (GF/F, What man, UK) filters. Filters are frozen at -20^{o}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).

9.2 Suspended particulate matter

For measurements of suspended particulate matter (SPM), known volumes of water collected by Niskin bottle are passed through pre-weighed 0.4 µm polycarbonate filters and rinsed with 250 ml ultrapure water. Filters are then dried in a desiccator at room temperature and weighed until filter weight remains constant.

9.3 Salinity

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

9.4 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).

9.5 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, NO2, Si, PO4 and NH4 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 (OSIL), UK).

10. Surface/Underway sampling

Underway sea surface measurements, meteorological variables and ship's navigation were recorded between 07:57 on 16/03/2011 and 18:41 on 18/03/2011 with a gap between 20:44 on 17/03/2011 and 07:56 18/03/2011 while the ship entered the River Mersey to change over science crew. The intake of the surface sampling system is located about 3m below the water line of RV Prince Madog. The parameters recorded every minute by the WS Oceans system and found in the underway file are:

- Time (GMT), Latitude, Longitude
- Heading (°), Track, Ground Speed (m/s), Water Speed (m/s), Depth (m)
- Air Temperature (°C), Humidity, Pressure (mbar)
- Solar Radiation (W m^{-2}), PAR (photosynthetically active radiation, µmol m^{-2} s^{-1})
- U, V
- Relative wind speed (m/s), Relative wind direction (° where zero indicates wind on the bow), True wind speed (m/s), True wind direction (°), Gusts (m/s)
- Sea Temperature (°C), Salinity
- TGS Temperature (°C), TGS Conductivity
- Transmissance
- Oxygen
- Turbidity
- Fluorescence
- Flow rate

Simultaneous measurements of current velocity were recorded using a hull mounted 300 kHz RDI 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.

11. Preliminary quality control comments (supplied by John Howarth, NOC)

Site A – Frame: NOCL rig id 1117

- 600 kHz ADCP sn 3644: The data look ok, except for the pressure record. The mean value is too small, by 9.5 decibars, and the range is about 0.9 of the SeaBird digiquartz's. As a consequence the wave data have not been reliably processed (since the fast sample orbital velocities were recorded lower in the water column heights than desirable). Wave data were recovered from the surface detected from the back-scattered signal for the previous deployment at site B when the pressure record was zero. For the present deployment the surface detection algorithm appears not to have worked.
- SeaBird 16+ sn 4597 with SeaPoint turbidity sn 10471.
- The temperature and pressure data look ok. The conductivity and salinity data are wrong throughout – salinity is about 0.2 too low at start and 5.2 too low at end.
- SeaBird 16+ sn 4741 with Optode sn 675. The temperature data look ok; salinity as expected are not. The temperatures from sn 4597 and salinities from the Microcat at -8m (sn 5790) were used to calculate oxygen values. (Using incorrect salinity values affects the oxygen concentration calculation but not the per cent solubility.) The oxygen data appear to be low, between 75 and 85% saturation (the start value is 17% below the end value of the previous deployment).

Site A – Mooring: NOCL rig id 1116

- Microcats sns 4966 and 5790. Temperature and salinity data look ok. (The salinity difference sn 4966 – sn 5790 is 0.02). The depth of sn 5790 was about 8.1m (not 10 m and about 3.5 m below sn 4966).
- Star Oddis sns 2836 and 2837. Data look ok but both temperatures were too low: 2836 by 0.075°C and 2837 by 0.05°C, in comparison with the Microcats. Since the depth of lower Microcat was about 2 m higher than expected, the depths of the Star Oddis are uncertain.

Site B– Frame: NOCL rig id 1119

- 600 kHz ADCP sn 5807. The data look ok.
- The frame heading changed by 2 degrees and its tilt by 7.5 degrees during the deployment; the changes occurring at spring tides.
- SeaBird 16+ sn4737 with SeaPoint turbidity sn 10537. Temperature data look ok. Throughout the record there are constant mean salinity differences with the Microcats. On previous deployments sn 4737 recorded about 0.07 too low which is consistent with the differences observed here.

Site B – Mooring: NOCL rig id 1118

- Microcats sns 4998 and 5433. Temperature data look ok, to within 0.01°C. The salinity difference (sn 4998 – sn 5433) is small (-0.008).

- Star Oddis sns 2838, 2849 and 2852. Data look ok but were too low: 2838 by 0.08°C; 2849 by 0.045°C and 2852 by 0.045°C, in comparison with the Microcats. Note that all the Star Oddis are digitized in 0.012 / 0.013°C intervals.

12. Cruise participants and acknowledgements

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

Scientific personnel	*Ship's officers and crew*
Andy Lane (NOC), PSO *Leg 1 only*	Steve Duckworth (Master)
Alexandra Ewan (NOC) Leg 1 only	David Shaw (Chief officer)
Matthew Palmer (NOC) PSO Leg 2 only	Les Black (Chief engineer)
Jonathan Sharples (NOC) Leg 2 only	Meikle Mackay (2nd Eng.)
Andrew Miller MP Leg 2 only	Phil Jones
Robert Smith (NOC) leg 2 only	Dave Leigh
Manon Francis (UoBangor)	Tom Roberts
Pablo Reche (UoBangor)	Colin Hughes
Ray Edun (NOC)	
Darryn Gaudie (NOC)	
Terry Doyle (NOC)	
Dave Pearce (CEFAS)	
Neil Needham (CEFAS)	
Anne Forbes-Brook (Bangor University)	

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Table 3. CTD positions, stations visited and samples taken. Times in GMT.

Cast	station	time	Latitude	Longitude	Depth (m)	SPM & chl	CDOM	Nutr-ients	Sediment grab	CEFAS samples

1	1 pre mooring	Mar 16 2011 10:03	53º31.84'	03 º21.11'	24.9	Yes	No	Yes	Yes	Yes
2	1 post mooring	Mar 16 2011 11:46	53º32.13'	03 º21.57'	23	Yes	No	Yes	Yes	Yes
3	5	Mar 16 2011 14:01	53º51.87'	03 º21.78'	13.3	Yes	No	Yes	Yes	Yes
4	5A	Mar 16 2011 14:49	53º50.92'	03 º13.41'	8.12	Yes	No	Yes	Yes	Yes
5	4A	Mar 16 2011 15:34	53º47.12'	03 º06.92'	9.66	Yes	Yes	Yes	Yes	no
6	4	Mar 16 2011 16:08	53º47.00'	03 º13.42'	15.1	Yes	Yes	Yes	Yes	yes
7	6	Mar 16 2011 16:53	53º47.06'	03 º21.63'	19.4	Yes	No	Yes	Yes	no
8	16	Mar 16 2011 17:39	53º47.01'	03 º30.27'	26.2	Yes	No	Yes	Yes	no
9	17	Mar 16 2011 18:25	53º47.06'	03 º38.73'	37	Yes	No	Yes	Yes	Yes
10	28	Mar 16 2011 19:15	53º46.94'	03 º46.98'	43.6	Yes	No	Yes	Yes	no
11	29	Mar 16 2011 20:05	53º46.85'	03 º55.36'	43.2	Yes	No	Yes	Yes	no
12	30	Mar 16 2011 20:52	53º42.02'	03 º55.27'	44.3	Yes	No	Yes	Yes	Yes
13	27	Mar 16 2011 21:39	53º42.05'	03 º46.96'	43.4	Yes	No	Yes	Yes	no
14	18	Mar 16 2011 22:28	53º42.00'	03 º38.52'	41	Yes	No	Yes	Yes	no
15	15	Mar 16 2011 23:18	53º42.04'	03 º30.12'	38.5	Yes	No	Yes	Yes	no
16	7	Mar 17 2011	53º41.97'	03 º21.79'	24.4	Yes	No	Yes	Yes	Yes

		00:08								
17	3	Mar 17 2011 00:55	53º41.90'	03 º13.39'	16.7	Yes	Yes	Yes	Yes	no
18	3A	Mar 17 2011 01:27	53º42.04'	03 º08.69'	8.5	Yes	Yes	Yes	Yes	Yes
19	2A	Mar 17 2011 02:11	53º37.15'	03 º07.46'	7	Yes	Yes	Yes	Yes	yes
20	2	Mar 17 2011 02:43	53º36.97'	03 º13.42'	10.5	Yes	Yes	Yes	Yes	Yes
21	8	Mar 17 2011 03:25	53º37.00'	03 º21.82'	22.8	Yes	No	Yes	Yes	no
22	14	Mar 17 2011 04:10	53º37.05'	03 º30.26'	30.9	Yes	No	Yes	Yes	no
23	19	Mar 17 2011 04:56	53º37.08'	03 º38.49'	31.9	Yes	No	Yes	Yes	Yes
24	26	Mar 17 2011 05:44	53º36.92'	03 º46.81'	40.9	Yes	No	Yes	Yes	no
25	31	Mar 17 2011 06:37	53º36.92'	03 º55.50'	47	Yes	No	Yes	Yes	no
26	32	Mar 17 2011 07:27	53º32.03'	03 º55.18'	48.3	Yes	Yes	Yes	Yes	Yes
27	25	Mar 17 2011 08:09	53º31.95'	03 º47.17'	47.3	Yes	Yes	Yes	Yes	no
28	20	Mar 17 2011 08:59	53º32.29'	03 º38.45'	40.2	Yes	Yes	Yes	Yes	Yes
29	13	Mar 17 2011 09:47	53º31.85'	03 º30.09'	33.7	Yes	Yes	Yes	Yes	no
30	9	Mar 17 2011 10:41	53º31.82'	03 º21.89'	27.8	Yes	Yes	Yes	Yes	Yes
31	35	Mar 17 2011 11:21	53º31.92'	03 º15.91'	14.8	Yes	Yes	Yes	Yes	no

32	10	Mar 17 2011 12:54	53º26.94'	03 º13.52'	24.1	Yes	Yes	Yes	Yes	Yes
33	11	Mar 17 2011 13:35	53º27.03'	03 º21.88'	15.7	Yes	Yes	Yes	Yes	no
34	12	Mar 17 2011 14:13	53º26.94'	03 º30.09'	15.4	Yes	No	Yes	Yes	no
35	21	Mar 17 2011 14:53	53º26.98'	03 º38.59'	22.1	Yes	No	Yes	Yes	Yes
36	24	Mar 17 2011 15:37	53º26.98'	03 º46.98'	29.9	Yes	No	Yes	Yes	no
37	33	Mar 17 2011 16:22	53º26.95'	03 º55.46'	35.4	Yes	No	Yes	Yes	no
38	34	Mar 17 2011 17:03	53º21.97'	03 º55.45'	21	Yes	No	Yes	Yes	Yes
39	23	Mar 17 2011 17:41	53º22.95'	03 º46.90'	12.6	Yes	No	Yes	Yes	no
40	22	Mar 17 2011 18:16	53º23.71'	03 º38.66'	16.6	Yes	No	Yes	no	no
41	12a	Mar 17 2011 19:04	53º23.10'	03 º30.38'	14.6	Yes	No	Yes	no	no
42	11a	Mar 17 2011 19:50	53º24.75'	03 º21.75'	14	Yes	Yes	Yes	Yes	no
43	20 pre mooring	Mar 18 2011 10:34	53º32.50'	03 º38.40'	40.2	Yes	No	Yes	Yes	Yes
44	20 post mooring	Mar 18 2011 11:55	53º32.41'	03 º38.45'	38.8	Yes	No	No	Yes	no
45	1	Mar 18 2011 16:29	53º31.95'	03 º21.65'	20.1	Yes	No	No	Yes	Yes