Irish Sea Observatory cruise 78

Dates: 25 -28 July 2011
Ship: R.V. Prince Madog (cruise 21/11)
Principal Scientist: John Howarth (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

Only one monitoring site is now maintained (Site A, marked Figure 1). At this site instruments are mounted in a sea bed frame, on a surface buoy and along its mooring chain. Site A is also instrumented with a Cefas WaveNet waverider.

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 in a single point mooring. A temperature mini-logger is attached to the mooring wire at 7.5 m below the surface and SeaBird MicroCAT temperature and conductivity loggers at 10 m and 15 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 (including a weather station system) in a single point mooring. SeaBird MicroCAT temperature and conductivity loggers are attached to the mooring wire at 10 m and 15 m below the

surface together with a mini-logger at 7.5m. In addition, a frame containing a WET Labs ac-s unit, WET Labs fluorometer and SeaBird MicroCAT is attached at 5 m below the surface.

1.2 CTD and LISST survey

The second cruise objective is to undertake a CTD survey of up to 34 stations every five nautical miles covering the eastern Irish Sea (see Figure 1 and Table 9). 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. Seven additional near-shore stations are 2a, 3a, 4a, 5a, 11a and 12a (introduced on Cruise 75) and 35a (introduced on Cruise 77).

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.

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

The third cruise objective is to complete a 25-hour station at site A 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. Following the on-the-half-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.

1.4 Trace metal analysis

Water samples were obtained during the CTD survey and 25-hour station for on-board determination of the electrochemically labile copper. Also at the 25-hour station an in situ sensor was deployed for analysis of electrochemically labile copper.

1.5 Recover a 5 beam ADCP

To recover a fast sample 5-beam ADCP which had been deployed at 53° 47.994′ N, 4° 00.291′ W, near to site 29, for a recent turbulence glider mission.

1.6 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)

Monday, 25 July 2011

Loading of RV Prince Madog at Vittoria Wharf, Birkenhead commenced at 14:00 and she left her berth at 15:30. Surface monitoring and the ship's ADCP were switched on at 16:23 on passing the Seaforth radar tower. On arrival at Site A, at 17:51, the first CTD was recorded. The ADCP frame was released at 18:04, the instruments were on the deck at 18:15 and the recovery was completed by 18:18. The new style replacement ADCP frame was deployed at 18:29 and the replacement SmartBuoy at 18:52. The existing SmartBuoy was hooked at 18:59 and its mooring completely recovered by 19:08. The second CTD was recorded followed by the zooplankton net hauls. The CTD survey began with sites along the North Wales coast – 10, 11, 11A, 12A, 22, 23, 34 – since this region was of greatest interest for the trace metal survey.

Tuesday, 26 July

Prince Madog now proceeded north along the western survey line (33, 32, 31, 30, 29) arriving at 29 at 06:19. The 5-beam ADCP near site 29, deployed for a turbulence glider mission, was released at 07:00 and was all on deck by 07:13. The CTD survey then recommenced along east-west lines from north to south – 28, 17, 16, 6, 4, 4A, 5A, 5, 3A, 3, 7, 15, 18, 27, 26, 19, 14, 8, 2, 2A, 35A, 35.

Wednesday, 27July

The CTD survey continued with 1, 13, 20, 25, 24, 21 and 12, finishing at site 1 at 05:20 where RV Prince Madog anchored and commenced the 25 hour station at 05:30.

Thursday, 28 July

The anchor was raised at 06:22 and the final CTD profile recorded at 06:30. The surface monitoring and ship's ADCP systems were switched off at 07:50, by the radar tower at Seaforth. At 08:45 RV Prince Madog was alongside at Vittoria Wharf, the equipment was unloaded and she left Birkenhead at 10:12.

All the cruise objectives were met, in part due to calm conditions throughout.

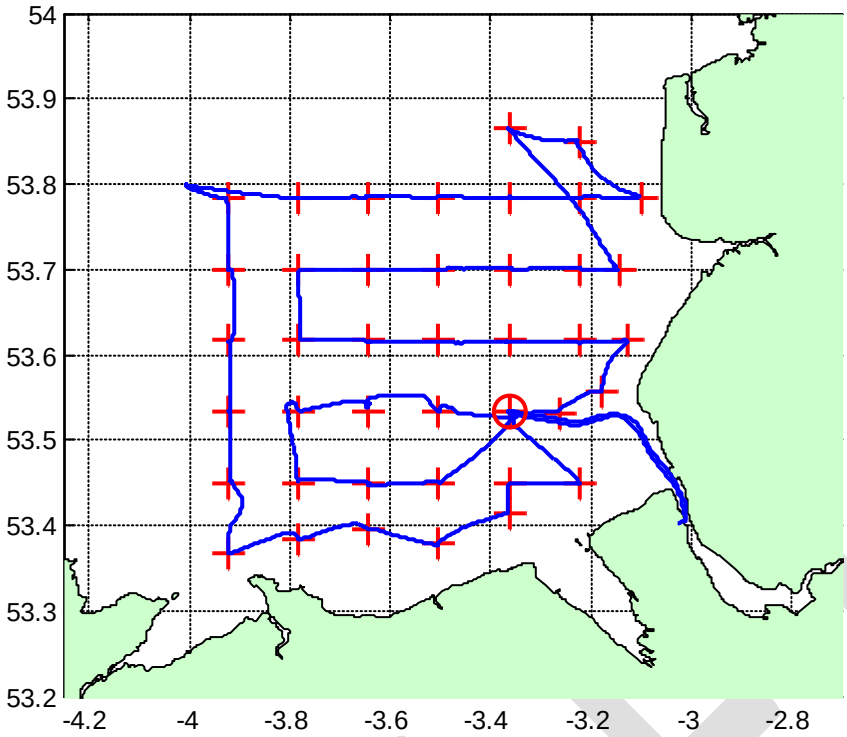


Figure 1. Irish Sea Observatory cruise 78 track. The nominal positions of the CTD stations are marked with red crosses and the main mooring site with an additional red circle.

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°31.985´	3°21.376´	25.2	25/07/2011	18:04
SmartBuoy (Site A)	53°31.955´	3°21.626´	25.3	25/07/2011	18:59
5 beam ADCP (near 29)	53°48.002´	4°00.361´	46.0	26/07/2011	07:00

Site A Bedframe

Table 2 lists the instruments on the old style sea bed frame. 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 71919 (Rx=10.5 kHz, Tx=12.0 kHz, RC=C), S/N 72858 (Rx=14.5 kHz, Tx=12.0 kHz, RC=A).

Table 2. Instruments recovered on the Site A 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 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°.	14:03:45 05/06/2011	06:00:00 06/06/2011	10:42:30 29/07/2011	106
SeaBird SBE 16*plus*	4736	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.	12:52:30 05/06/2011	06:00:00 06/06/2011	12:18:20 01/08/2011	5
SeaPoint turbidity sensor	10538	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper	-	-	-	-
SeaBird SBE 16*plus*	4738	Mounted with Aanderaa Optode (see below). Sample interval 600 s; Digiquartz integration time 40 s, range 400; pump 0.5 s, 1 s delay.	13:03:00 05/06/2011	06:00:00 06/06/2011	12:07:00 01/08/2011	6
Aanderaa Optode	674		-	-	-	-

Site A Mooring

Table 3 lists the instruments deployed on the SmartBuoy mooring. 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) 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 Orbcom satellite. A weather station was also attached to the SmartBuoy frame but was dislodged during deployment.

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.

Table 3. Instruments recovered on the Site A SmartBuoy mooring

Instrument	S/N	Notes	Instrument depth (m)	Clock set	Delayed start	Stopped logging	Clock Drift (secs)
SeaBird MicroCAT	2506	Temperature and conductivity recorder. Mounted on frame with ac-s and fluorometer)	5	‡ Not correct (see below) *14:40:00 05/06/2011*	06:00:00 06/06/2011	13:11:40 01/08.2011	9
WET Labs ac-s	060		5	06:06:30 06/06/2011	06:10:00 06/06/2011	15:08:15 26/07/2011	-2
WET Labs fluorometer	1513	Attached to ac-s frame	5	15:07:30 05/06/2011	06:05:00 06/06/2011	15:04:30 02/08/2011	50
StarOddi Mini-logger	2840	Set to record at 600 s intervals	7.5	N/A	06:00:00 06/06/2011	15:08:00 01/08/2011	9
SeaBird MicroCAT	5791	Temperature and conductivity recorder	10	‡ *14:18:00 05/06/2011*	06:00:00 06/06/2011	12:56:10 01/08/2011	-10
SeaBird MicroCAT	5792	Temperature and conductivity recorder	15	‡ *14:23:00 05/06/11*	06:00:00 06/06/2011	12:59:10 01/08/2011	47
StarOddi Mini-logger	2842	Set to record at 600 s intervals	By met. package	N/A		15:11:30 01/08/2011	9

‡ Microcat clocks incorrectly set – need to add 11 hours to their time stamps.

5 Beam ADCP

Table 4 lists the instruments on the old style sea bed frame. 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 69676 (Rx=11.5 kHz, Tx=12.0 kHz, RC=C), S/N 72863 (Rx=13.5 kHz, Tx=12.0 kHz, RC=A).

Table 4. Instruments recovered on the 5 beam ADCP bedframe

Instrument	S/N	Notes	Clock set	Delayed start	Stopped logging	Clock drift (secs)
RDI 600 kHz ADCP	10634	Beams 1-4 sn10634. Master and slave configured for 45 x 1 m bins.	16:05:00 27/06/2011	07:00:00 28/06/2011	13:26:50 29/07/2011 Battery flat	10
RDI 600 kHz ADCP	10705	Beam 5 sn 10705. Master and slave configured for 45 x 1 m bins.	16:05:00 27/06/2011	07:00:00 28/06/2011	13:31:00 29/07/2011 Battery flat	10
SeaBird SBE 16*plus*	5309	Mounted on frame base with pumped conductivity sensor . Sample interval 600 s; Digiquartz integration time 40 s, range 400; pump 0.5 s, 1 s delay.	16:00:00 27/06/2011	07:35:00 28/06/2011	12:25:00 01/08/2011	2

3.2 Deployed Instrumentation

Table 5. Deployed mooring positions and times

	Latitude (N)	Longitude (W)	Water depth (m)	Date	Time (GMT)
ADCP frame (Site A)	53°32.041´	3°21.437´	24.5	25/07/2011	18:29
SmartBuoy (Site A)	53°32.036´	3°21.887´	25.2	25/07/2011	18:52

Site A Bedframe

Table 6 lists the instruments on the new style frame. 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 71922 (Rx=11.5 kHz, Tx=12.0 kHz, RC=A), S/N 70356 (Rx=10.5 kHz, Tx=12.0 kHz, RC=D).

Table 6. 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°.	09:50:30 25/07/2011	17:00:00 25/07/2011
SeaBird SBE 16*plus*	4596	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.	10:04:30 25/07/2011	17:00:00 25/07/2011
SeaPoint turbidity sensor	10471	Taped to roll bar and setup for 0–125 FTU range and fitted with wiper	-	-
SeaBird SBE 16*plus*	4735	Mounted with Aanderaa Optode (see below). Sample interval 600 s; Digiquartz integration time 40 s, range 400; pump 0.5 s, 1 s delay.	10:12:00 25/07/2011	17:00:00 25/07/2011
Aanderaa Optode	675		-	-

Site A Mooring

Table 7 lists the instruments deployed on the SmartBuoy mooring. 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) 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. A weather station was also attached to the SmartBuoy frame.

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.

Table 7. Instruments deployed on the Site A SmartBuoy mooring

Instrument	S/N	Notes	Instrument depth (m)	Clock set	Delayed start
SeaBird MicroCAT	2991	Temperature and conductivity recorder. Mounted on frame with ac-s and fluorometer)	5	11:32:00 25/07/2011	17:00:00 25/07/2011
WET Labs ac-s	059	DM-4 logger sn 119	5	16:22:30 25/07/2011	16:30:00 25/07/2011
WET Labs fluorometer	1514	Attached to ac-s frame	5	13:11:20 25/07/2011	16:35:00 25/07/2011
StarOddi Mini-logger	2836	Set to record at 600 s intervals	7.5	N/A	17:00:00 25/07/2011
SeaBird MicroCAT	5433	Temperature and conductivity recorder	10	10:34:00 25/07/2011	17:00:00 25/07/2011
SeaBird MicroCAT	5790	Temperature and conductivity recorder	15	11:21:30 25/07/11	17:00:00 25/07/2011
StarOddi Mini-logger	2837	Set to record at 600 s intervals	On top of SmartBuoy beside met sensor	N/A	17:00:00 25/07/2011

4. CTD and LISST survey

Instrumentation mounted on the rosette frame is listed in Table 8. 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 – nutrients and salinity
bottle 4 – SPM, chlorophyll, CDOM
bottle 5 – Cefas

mid-water bottle 8 – trace metals

near-surface bottle 9 – nutrients
bottle 10 – SPM, chlorophyll, CDOM
bottle 11 – Cefas
bottle 12 – Cefas

Table 8. 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	26	Downwelling PAR/irradiance sensor
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

5. 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.

5.1 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.

5.2 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.

5.3 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.

6. 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.

6.1 Zooplankton vertical haul samples

Ten zooplankton samples were collected at Site A between 10:29 and 11:10 on 06/06/2011 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.

6.2 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).

6.3 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.

6.4 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.

6.5 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).

6.6 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).

7. 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 10.

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 -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).

8. Trace metal sampling

Aim:

The two main goals of the COBS78 cruise for trace metal analysis were:

- on-board determination of the electrochemically labile Cu determined and later comparison with total Cu concentration and Cu speciation determined in laboratory conditions;
- in-situ analysis of electrochemically labile copper during a 25 hours station; comparison with total Cu concentrations levels determined in hourly collected samples later in laboratory conditions.

Motivations:

Copper is one of the most common metal contaminants present in coastal waters and is of particular concern due to its high toxicity towards phytoplankton. Total concentration of Cu in Liverpool Bay ranges from 8 to 40 nM. These concentrations can be toxic, depending on the Cu chemical speciation. It is thought that concentration levels of free copper above 1 pM are sufficient to limit algal growth of some species.

Using an electrochemical technique, the signal obtained is of importance as it gives an estimation of the potentially bioavailable fraction, i.e. highly reactive Cu species (free Cu and small weak inorganic/organic complexes) complexes. Determination of natural levels of labile copper in sea water is still an analytical challenge and cannot be reliably achieve on the standard Hg drop electrode.

Experimental:

Samples collected with a 5 litres Niskin bottle (metal free). Samples are immediately filtered at 0.2 µm by connecting the Niskin bottle to a peristaltic pump through a Sartoban 300 filter (0.45 µm + 0.2 µm).

Electrochemical analysis was done using a Palmsens potentiostat using the software RS developed by Conrad Chapman. Measurements were done by square wave anodic stripping voltammetry (SWASV) using a deposition time of 5 min and background subtraction. The working electrode was a 5 µm gold wire, the reference electrode were a Ag/AgCl/KCl(3M)//NaNO3 (0.1 M) for on-board analysis and a Ag rod with electrodeposited solid AgCl at its surface for in-situ analysis. Typical voltammetric parameters were: 0.55 V (30s), -1.3 V (300s), 2s eq, stripping from -1.3 to 0.55 V.

Grid survey:

Sample were collected at the following stations by chronological order: 10, 12a, 22, 23, 32, 33, 34, 17, 6, 4a, 5a, 5, 3a, 3, 7, 15, 18, 27, 26, 19, 8, 2a, 35a, 35, 13, 20, 25, 23, 24, 21, 12.

At each stations, one filtered bottle (500 ml) was collected. Around 50 ml was used for on-board determination of electrochemically labile Cu at two deposition potentials (-0.3 V and -1.3 V). The rest was acidified to ~ pH 2.5 with HCl and stored in the fridge until further analysis.

25hours station:

Samples (500 ml bottle) were collected every hour if possible, acidified to pH 2.5 and stored in the fridge. The sampling depth was 5 meters. Every 3 hours, an additional 500 ml was collected for speciation analysis. This bottle is directly placed in the freezer without any treatment.

Concomitantly to this sampling procedure, the electrochemical system was placed directly in the water column at ~ 5 m depth (9 for the last few hours) and measurements were made continuously at a deposition potential of -1.3 V.

Preliminary results:

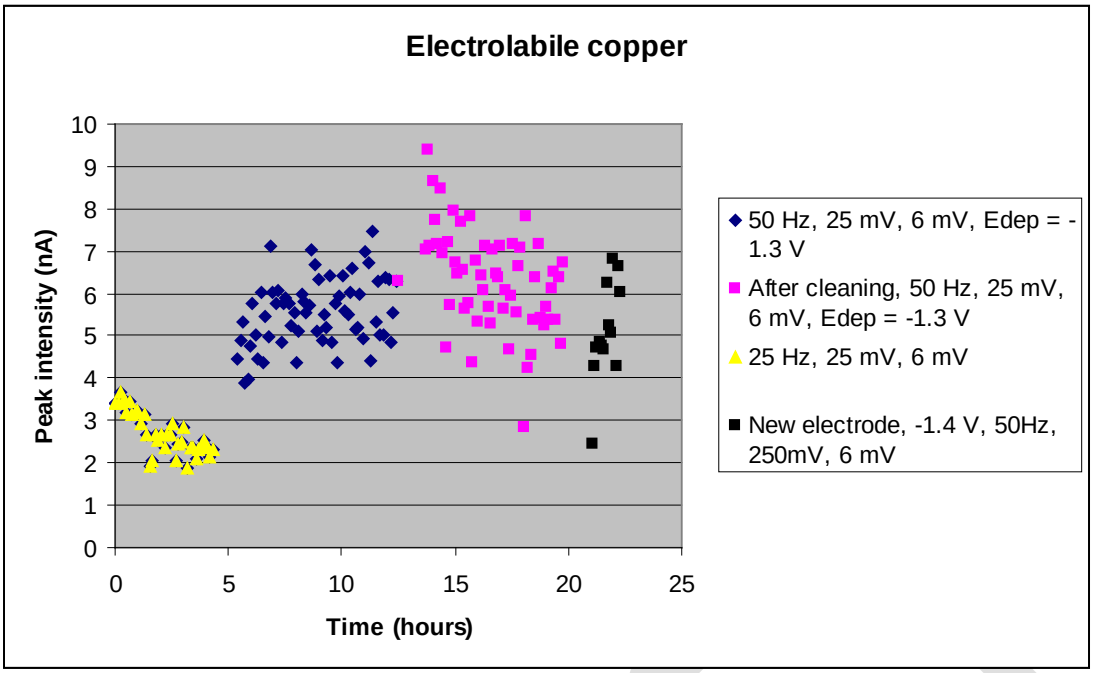
Grid survey:

Most stations did not show any Cu peaks when depositing at -0.3 V for a long deposition time of 300s, which is surprising in view of previous results where a Cu peak was always observed at any deposition potentials. This would indicate a very low labile fraction and therefore would be good for the biota. Measurements done at -1.3 V displayed a well define Cu peak but still relatively low when considering the long deposition time (300s).

In-situ analysis:

Measurements were done in-situ for almost 25 hours. Each cycle of measurement took around 7 min. The Cu peak intensities are displayed below as a function of time for different conditions of aalysis.

A relatively large variation in intensity is observed although the data will have to be treated to correct for misreading of the peak baseline. The first serie (yellow triangle) displayed a constant decrease with increase of the electrical noise. The electrode was cleaned in 0.5 M H_2SO_4 and placed again in-situ. The signal recorded for the next 20 hours is well shaped with stable background current which indicates that the electrochemical sensor is behaving as expected. At the end of the 25 hours station, the sensor was placed in a full bucket of unfiltered sea water and continuous measurement were made. The response was very stable indicating that the sensor was working well and that the variations observed for the in-situ analysis may be real.



9. Surface/underway sampling

Underway sea surface measurements, meteorological variables and ship's navigation were recorded between 16:23 on 25/07/2011 and 07:50 on 28/07/2011. 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 16:23 on 25/07/2011 and 07:50 on 28/07/2011. There were gaps due to ADCP crashing five times during the cruise. The problem is thought to lie with the computer which is due for replacement.

10. AC-S 25 hour station

A frame containing an AC-S (s/n 095, DM-4 logger s/n 161), eco-triplet (turbidity, chlorophyll-a fluorescence, CDOM: s/n 801) and a MicroCAT (s/n 4966, sampling every 5 minutes) was deployed every hour after the half past CTD profile.

The AC-S was set up in 'profile mode'
Delay 1 minute
Pre-warm 0 seconds
Warm up 2 minutes
Flush 0 seconds
Sample period 15 minutes @ 4 Hz.

The cast sequence was:
Start profile on AC-S.
Lower frame to 10 m for 4 minutes.
Raise frame to surface for 2 minutes.
Lower frame to 5 m for 2 minutes.
Lower frame to 10 m for 2 minutes.
Lower frame to 3m above the bed for 2 minutes.
Recover frame and switch off.

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

Site A – Frame: NOCL rig id 1127: (deployment in old style frame)

600 kHz ADCP sn 2390: The data look ok.

SeaBird 16+ sn 4736 with SeaPoint turbidity sn 10538; mounted horizontally with pumped conductivity sensor. The temperature, conductivity and pressure data look ok.

SeaBird 16+ sn 4738 with Aanderaa Optode sn 674; mounted horizontally with pumped conductivity sensor. The temperature and conductivity data look ok. The pressure data are wrong for last 13 days of the record.
The Optode sensor outputs two channels but only one was recorded – the internal temperature channel was missing. Oxygen values have been calculated with SeaBird temperatures but this will not be as accurate. In addition oxygen data are suspect for the last 9 days.

Temperature differences: mean 0.001°C; standard deviation 0.005°C.
Salinity differences: mean -0.01; standard deviation 0.01. The difference drifts with time at a rate of 0.0007 per day, from 0.005 to -0.035 (sn 4736 – sn 4738); sn 4738 may be close to the Microcat at -15 m. Salinity records agree with Microcats when water column well mixed to ~0.04.

Site A – Mooring: NOCL rig id 1126

Microcats sns 2506, 5791and 5792 nominally at 5, 10 and 15 m below surface (actual depth ranges 4.9-5.8 m, 10.0-11.5 m and 13.7-16.8 m respectively.
The clocks of all three Microcats were incorrectly set: 11 hours needs adding to their time stamps. Hence 7 hours 20 minutes of data are missing at the start. Temperature and salinity data look ok; when the water column is well mixed agreeing to ~0.001°C for temperature and ~0.005 for salinity.

Star Oddi sns 2840 at 7.5 m below surface. Data look ok, by comparison with the Microcats.

Met package
The package was knocked off the buoy during deployment.

Star Oddis sns 2842. The mean difference with the air temperature at Hilbre was 1.2°C, cooler at the buoy, with a standard deviation of 1.0°C. The difference is believable and was not correlated with temperature.

Near site 29 – Frame: NOCL rig id 1128
5-beam ADCP. No checks.

SeaBird 16+ sn 5309. Data look ok but not checked against other measurements.

12. 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	*Ship's officers and crew*
John Howarth (NOC), Principal Scientist	Steve Duckworth (Master)
Terry Doyle (NOC)	Robert Bassi (Chief Officer)
Ray Edun (NOC)	Tommy Roberts (A/Bosun)
Andy Lane (NOC)	Phil Jones (Bosun)
Jennie Keable (Cefas)	Dave Leigh (AB)
Chris Read (Cefas)	Les Black (Chief Engineer)
Jenni Moore (Strathclyde)	Meikle Mackay (2nd Engineer)
Anne Forbes-Brook(Bangor Uni.)	Colin Hughes (Cook)
Pascal Salaun (Liverpool)	
Joanna Skorupa (Liverpool)	

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 9. Nominal positions of CTD stations

Station	Latitude (N)	Longitude (W)
1 & 9 (A)	53° 32.0′	3° 21.8′
2	53° 37.0′	3° 13.4′
3	53° 42.0′	3° 13.4′
4	53° 47.0′	3° 13.4′
5	53° 52.0′	3° 21.8′
6	53° 47.0′	3° 21.8′
7	53° 42.0′	3° 21.8′
8	53° 37.0′	3° 21.8′
10	53° 27.0′	3° 13.4′
11	53° 27.0′	3° 21.8′
12	53° 27.0′	3° 30.2′
13	53° 32.0′	3° 30.2′
14	53° 37.0′	3° 30.2′
15	53° 42.0′	3° 30.2′
16	53° 47.0′	3° 30.2′
17	53° 47.0′	3° 38.6′
18	53° 42.0′	3° 38.6′
19	53° 37.0′	3° 38.6′
20 (B)*	53° 32.3′	3° 38.4′
21*	53° 27.0′	3° 38.6′
22**	53° 23.7′	3° 38.6′

Station	Latitude (N)	Longitude (W)
23	53° 23.0′	3° 47.0′
24	53° 27.0′	3° 47.0′
25	53° 32.0′	3° 47.0′
26	53° 37.0′	3° 47.0′
27	53° 42.0′	3° 47.0′
28	53° 47.0′	3° 47.0′
29	53° 47.0′	3° 55.4′
30	53° 42.0′	3° 55.4′
31	53° 37.0′	3° 55.4′
32	53° 32.0′	3° 55.4′
33	53° 27.0′	3° 55.4′
34	53° 22.0′	3° 55.4′
35	53° 32.0′	3° 15.9′
35a	53° 33.4′	3° 10.7′
2a	*53° 37.0′*	*3° 07.5′*
3a	*53° 42.0′*	*3° 08.5′*
4a	*53° 47.0′*	*3° 06.0′*
5a	*53° 50.9′*	*3° 13.4′*
11a	*53° 24.9′*	*3° 21.8′*
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 10. Station log

Station	CTD #	Date & Time	Latitude (N)	Longitude (W)	Water depth (m)	SPM & Chl	CDOM	Nutrients srf & bot	Cefas (srf chl, SPM, salinity & nutrients)	Trace metal
1	1	25/07/11 17:51	53° 31.886´	3° 21.353´	25.5				✓ + srf/bot O_2	
1	2	25/07/11 19:22	53° 31.772´	3° 21.476´	26.2	✓		✓	✓ + srf/bot O_2	
10	3	25/07/11 21:32	53° 26.965´	3° 13.353´	16.5	✓	✓	✓	✓	✓
11	4	25/07/11 22:13	53° 27.013´	3° 21.787´	17.6	✓		✓		
11A	5	25/07/11 22:38	53° 24.833´	3° 21.994´	10.4	✓	✓	✓	✓	
12A	6	25/07/11 23:29	53° 22.730´	3° 30.285´	10.6	✓	✓	✓	✓	✓
22	7	26/07/11 00:23	53° 23.688´	3° 38.371´	14.9	✓	✓	✓		✓
23	8	26/07/11 01:15	53° 22.991´	3° 46.921´	12.0	✓	✓	✓		✓
34	9	26/07/11 02:11	53° 21.995´	3° 55.288´	22.0	✓	✓	✓	✓	✓
33	10	26/07/11 03:09	53° 27.022´	3° 55.348´	37.0	✓	✓	✓		✓
32	11	26/07/11 03:58	53° 32.000´	3° 55.274´	46.7	✓	✓	✓		✓
31	12	26/07/11 04:47	53° 36.987´	3° 55.289´	46.1	✓		✓		
30	13	26/07/11 05:36	53° 41.992´	3° 55.253´	42.9	✓		✓	✓	
29	14	26/07/11 06:19	53° 46.963´	3° 55.609´	44.2	✓		✓		
28	15	26/07/11 08:13	53° 46.998´	3° 47.035´	42.7	✓		✓		
17	16	26/07/11 08:55	53° 47.080´	3° 38.645´	36.1	✓		✓	✓	✓
16	17	26/07/11 09:38	53° 47.016´	3° 30.299´	26.2	✓		✓		
6	18	26/07/11 10:22	53° 47.017´	3° 21.774´	20.1	✓		✓		✓
4	19	26/07/11 11:01	53° 47.021´	3° 13.270´	16.1	✓		✓		
4A	20	26/07/11 11:41	53° 47.078´	3° 06.364´	9.1	✓	✓	✓	✓	✓
5A	21	26/07/11 12:34	53° 51.030´	3° 13.664´	9.1	✓		✓	✓	✓
5	22	26/07/11 13:17	53° 51.986´	3° 21.859´	14.0	✓		✓		✓
3A	23	26/07/11 14:40	53° 42.046´	3° 08.785´	9.1	✓	✓	✓	✓	✓
3	24	26/07/11 15:11	53° 42.030´	3° 13.335´	16.4	✓		✓		✓
7	25	26/07/11 15:56	53° 42.062´	3° 21.699´	24.2	✓		✓		✓
15	26	26/07/11 16:41	53° 42.037´	3° 30.156´	37.5	✓		✓		✓
18	27	26/07/11 17:28	53° 41.988´	3° 38.543´	39.6	✓		✓		✓
27	28	26/07/11 18:06	53° 41.981´	3° 46.981´	42.3	✓		✓		✓
26	29	26/07/11 18:47	53° 37.109´	3° 46.750´	41.8	✓		✓		✓
19	30	26/07/11 19:29	53° 37.004´	3° 38.543´	32.3	✓		✓	✓	✓
14	31	26/07/11 20:12	53° 36.898´	3° 30.106´	32.9	✓		✓		
8	32	26/07/11 20:55	53° 36.929´	3° 21.964´	24.3	✓		✓		✓
2	33	26/07/11 21:38	53° 36.903´	3° 13.442´	14.1	✓		✓		
2A	34	26/07/11 22:09	53° 36.954´	3° 07.527´	10.2	✓	✓	✓	✓	✓
35A	35	26/07/11 22:44	53° 33.359´	3° 10.933´	9.1	✓	✓	✓		✓
35	36	26/07/11 23:14	53° 31.967´	3° 15.970´	13.3	✓	✓	✓		✓
1	37	26/07/11 23:46	53° 31.718´	3° 20.830´	22.6	✓				
13	38	27/07/11 00:47	53° 32.023´	3° 30.332´	29.5	✓	✓	✓		✓
20	39	27/07/11 01:37	53° 32.372´	3° 38.360´	31.0	✓	✓	✓		✓
25	40	27/07/11 02:20	53° 32.075´	3° 47.060´	40.8	✓	✓	✓		✓
24	41	27/07/11 03:15	53° 27.025´	3° 47.025´	28.5	✓		✓		✓
21	42	27/07/11 03:55	53° 26.971´	3° 38.566´	24.2	✓		✓		✓

Station	CTD #	Date & Time	Latitude (N)	Longitude (W)	Water depth (m)	SPM & Chl	CDOM	Nutrient srf & bot	Cefas (srf chl, SPM, salinity & nutrients)	Trace metal
12	43	27/07/11 04:34	53° 27.031´	3° 30.089´	17.7			✓		✓
25/1	44	27/07/11 05:36	53° 31.850´	3° 21.496´	24.7					
25/2	45	27/07/11 06:05	53° 31.839´	3° 21.497´	25.1	✓‡	✓	✓	✓ + srf/bot O_2	✓
25/3	46	27/07/11 06:43	53° 31.829´	3° 21.515´	25.8					
25/4	47	27/07/11 07:03	53° 31.845´	3° 21.492´	25.8	✓	✓	✓	✓	
25/5	48	27/07/11 07:31	53° 31.862´	3° 21.505´	25.8					
25/6	49	27/07/11 08:02	53° 31.856´	3° 21.566´	26.1	✓‡	✓	✓	✓	✓
25/7	50	27/07/11 08:31	53° 31.849´	3° 21.579´	26.0					
25/8	51	27/07/11 09:02	53° 31.854´	3° 21.583´	26.0	✓	✓	✓	✓	
25/9	52	27/07/11 09:31	53° 31.854´	3° 21.582´	25.6					
25/10	53	27/07/11 10:01	53° 31.851´	3° 21.581´	25.1	✓‡	✓	✓	✓	✓
25/11	54	27/07/11 10:30	53° 31.847´	3° 21.579´	24.7					
25/12	55	27/07/11 11:00	53° 31.849´	3° 21.583´	24.2	✓	✓	✓	✓	✓
25/13	56	27/07/11 11:30	53° 31.843´	3° 21.578´	23.7					
25/14	57	27/07/11 12:00	53° 31.848´	3° 21.583´	23.3	✓‡	✓	✓	✓	✓
25/15	58	27/07/11 12:30	53° 31.856´	3° 21.579´	22.9					
25/16	59	27/07/11 13:00	53° 31.857´	3° 21.580´	22.5	✓	✓	✓	✓	✓
25/17	60	27/07/11 13:30	53° 31.859´	3° 21.578´	22.2					
25/18	61	27/07/11 14:00	53° 31.859´	3° 21.577´	22.0	✓‡	✓	✓	✓ + srf/bot O_2	✓
25/19	62	27/07/11 14:30	53° 31.842´	3° 21.576´	21.9					
25/20	63	27/07/11 15:00	53° 31.848´	3° 21.571´	22.0	✓	✓	✓	✓	✓
25/21	64	27/07/11 15:30	53° 31.851´	3° 21.518´	22.2					
25/22	65	27/07/11 16:00	53° 31.851´	3° 21.519´	22.4	✓‡	✓	✓	✓	✓
25/23	66	27/07/11 16:30	53° 31.855´	3° 21.516´	23.0					
25/24	67	27/07/11 17:01	53° 31.864´	3° 21.498´	23.3	✓	✓	✓	✓	✓
25/25	68	27/07/11 17:31	53° 31.862´	3° 21.496´	23.9					
25/26	69	27/07/11 18:01	53° 31.859´	3° 21.494´	24.5	✓‡	✓	✓	✓	✓
25/27	70	27/07/11 18:30	53° 31.856´	3° 21.495´	25.1					
25/28	71	27/07/11 19:01	53° 31.857´	3° 21.496´	25.6	✓	✓	✓	✓	✓
25/29	72	27/07/11 19:30	53° 31.855´	3° 21.499´	26.0					
25/30	73	27/07/11 20:01	53° 31.854´	3° 21.501´	26.2	✓‡	✓	✓	✓	✓
25/31	74	27/07/11 20:30	53° 31.847´	3° 21.510´	26.5					
25/32	75	27/07/11 21:01	53° 31.846´	3° 21.513´	26.4	✓	✓	✓	✓	✓
25/33	76	27/07/11 21:31	53° 31.841´	3° 21.532´	26.2					
25/34	77	27/07/11 22:00	53° 31.849´	3° 21.547´	26.0	✓‡	✓	✓	✓ + srf/bot O_2	✓
25/35	78	27/07/11 22:30	53° 31.854´	3° 21.554´	25.5					
25/36	79	27/07/11 23:00	53° 31.853´	3° 21.564´	25.0	✓	✓	✓	✓	✓
25/37	80	27/07/11 23:30	53° 31.856´	3° 21.568´	24.6					
25/38	81	28/07/11 00:00	53° 31.858´	3° 21.569´	23.8	✓	✓	✓	✓	✓
25/39	82	28/07/11 00:30	53° 31.861´	3° 21.568´	23.3					
25/40	83	28/07/11 01:00	53° 31.865´	3° 21.566´	22.8	✓‡	✓	✓	✓	✓
25/41	84	28/07/11 01:30	53° 31.869´	3° 21.560´	22.3					
25/42	85	28/07/11 02:00	53° 31.867´	3° 21.561´	22.0	✓‡	✓	✓	✓	✓

25/43	86	28/07/11 02:30	53° 31.862´	3° 21.562´	21.7					
Station	**CTD #**	**Date & Time**	**Latitude (N)**	**Longitude (W)**	**Water depth (m)**	**SPM & Chl**	**CDOM**	**Nutrient srf & bot**	**Cefas (srf chl, SPM, salinity & nutrients)**	**Trace metal**
25/44	87	28/07/11 03:00	53° 31.868´	3° 21.549´	21.5	✓	✓	✓	✓	✓
25/45	88	28/07/11 03:30	53° 31.875´	3° 21.534´	21.6					
25/46	89	28/07/11 04:00	53° 31.868´	3° 21.512´	21.7	✓‡	✓	✓	✓	✓
25/47	90	28/07/11 04:30	53° 31.863´	3° 21.507´	22.0					
25/48	91	28/07/11 05:00	53° 31.865´	3° 21.497´	22.5	✓	✓	✓	✓	✓
25/49	92	28/07/11 05:30	53° 31.865´	3° 21.495´	23.2					
25/50	93	28/07/11 06:02	53° 31.854´	3° 21.483´	23.8	✓	✓	✓	✓ + srf/bot O_2	✓
25/51	94	28/07/11 06:29	53° 31.866´	3° 21.616´	24.7					

‡ No surface SPM