

Cruise report:

Cruise ID: PHiXT2

Ship: RV Prince Madog

Master: Capt. Steve Duckworth

Location: Liverpool Bay, Eastern Irish Sea.

Cruise dates: 8th -11th May 2009

Scientific personnel:

Matthew Palmer (PSO, POL)

Emmer Litt (PML)

Jeff Polton (POL)

Anouska Bailey (UoLiverpool)

Shane Elipot (POL)

Anne Hammerstain (UoBangor)

Nicky Clargo (BODC)

Lucy Abram (UoLiverpool)

Clare Davis (UoLiverpool)

Project description:

PHiXT: nutrient PatHways from carbon fluX through the Trophic cascade

This cruise is the second of five multidisciplinary cruises during 2009/10 involving scientists from POL, PML and the Universities of Liverpool and Bangor. The majority of work is centered around water samples collected during 25 hour CTD stations at two sites; site A (53° 32' N 3° 21.8' W, 24m) which is the main mooring site of POL's Irish Sea Observatory, and an offshore site 30 (53° 37.2' N 3° 55.2' W, 44m). In addition, a single deployment of Liverpool's Stand Alone Pump System (SAPS) will be made at each station for ~30 minutes, deployed from the ships stern via the 'A' frame. During the May cruises the work will include 12.5 hour continuous profiling with POL's MSS turbulence profiler running concurrently with CTD, operated from the ship's stern. The preference is for work to be conducted whilst at anchor, thus permitting safe concurrent deployment of the MSS and CTD. Throughout the cruise period the ship's flowthrough system will be active. This system includes PML's autonomous pCO₂ measuring equipment and will contribute to a spatial and temporal picture on the behaviour of CO₂ surface fluxes in the Liverpool Bay region, which is a key part of this study.

The aims of the cruises are to provide data for a variety of individual projects;

1. "Temporal variability of CO₂ flux estimates in contrasting shelf sea regimes" and the "CARBON-OPS NERC KT Project" - Emmer Litt, CASIX PhD Project.
2. "How does pulsed stratification alter coastal primary and secondary production? A case study in Liverpool Bay". NERC SOFI PhD project – Anouska Bailey
3. "Phosphorus Dynamics in Liverpool Bay" – NERC PhD student Claire Davies

4. “Trophic dynamics and carbon flow in shelf seas”. Ocean Sciences PhD student Lucy Abram.

The combination of these individual studies with the inclusion of measurements of turbulent mixing rates provided by the POL MSS team and other measurements provided by POL’s Coastal Observatory will enable a greater understanding of nutrient and carbon pathways in the coastal environment.

Schedule:

To conduct 25 hour long surveys at,

1. A near-shore station, site A, 53° 32′ N, 3° 21.8′ W.
2. An off-shore station, site B, 53° 37.2′ N, 3° 55.2′ W.

Each survey to consist of

- Hourly CTD profiles and discrete water sample collection at a variety of depths.
- Conduct 12.5 hour long time series of turbulent microstructure using the MSS profiler.
- Conduct high volume filtering using SAPS (Stand Alone Pumping System).
- Conduct a short series of CTD profiles from 5NM west to 5NM east of site A with 5NM resolution.

Narrative (GMT):

8th May 2009:

All equipment was loaded onto the ship at Vittoria Dock, Birkenhead by 1800. The ship left Vittoria Dock at 2130, destination site A. At the Mersey radar tower the ship’s ADCP, flowthrough and pCO₂ systems were turned on. Due to mechanical failure atmospheric CO₂ is not being monitored. Wind was force 4-5 from the WSW with slight to moderate seas and moderate to low swell.

The ship was anchored close to site A at 2356 (53° 32.256′ N, 3° 21.859′ W) in 26.5m of water.

9th May 2009:

Weather generally improved, force 3-4 winds from the east, with slight seas.

The CTD survey commenced at 0000, following which 25 further CTD profiles were made on the hour until 10/05/09 0100.

During the CTD survey 351 profiles were made with the MSS between 0730 until 2000. Profiling was suspended during the turning tide to avoid entanglement with the ship as happened during PHiXT1.

SAPS was deployed from the ship’s stern at a depth of 20m for 30 minutes from 2035 and 2300.

10th May 2009:

Following recovery of the ship's anchor at 0106, the ship sailed to site B, anchoring at 0400 in 43.1m of water. The CTD survey commenced at 0403, following which 25 further CTD profiles were made on the hour until 11/05/09 0500.

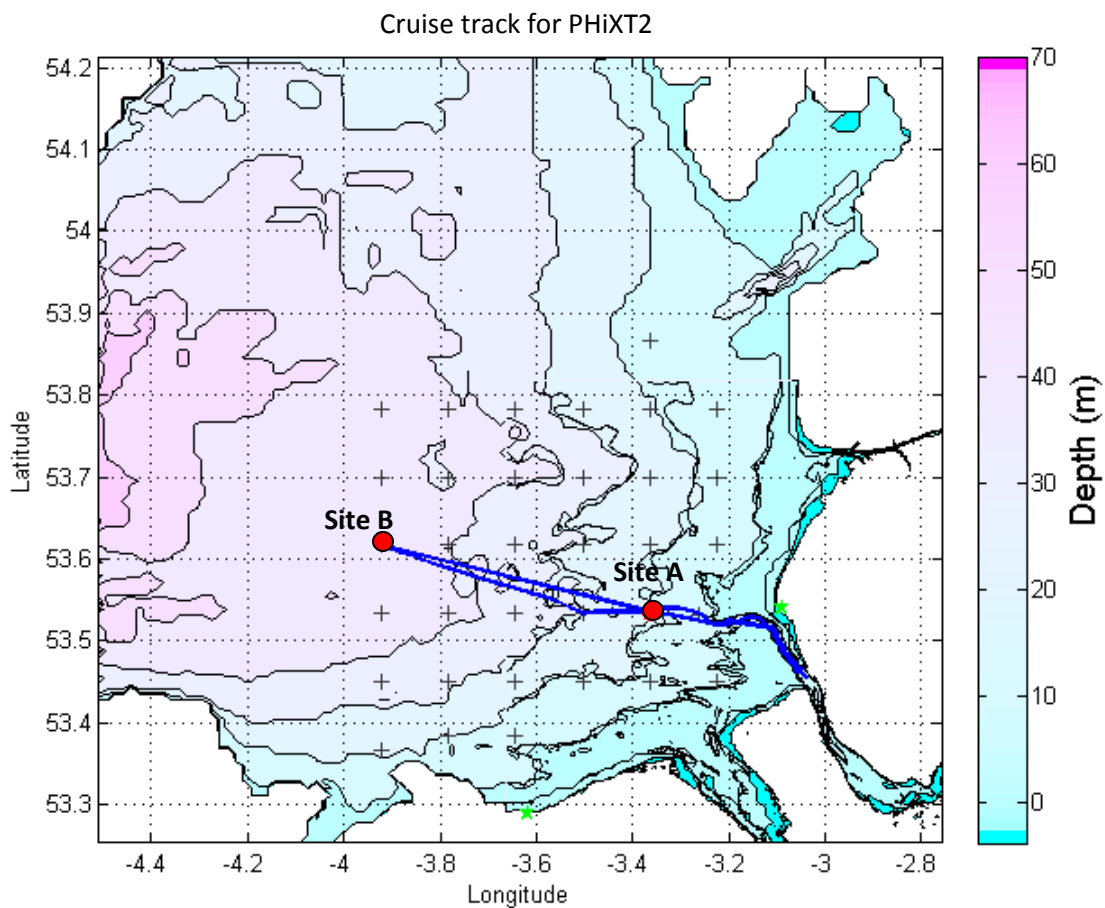
During the CTD survey 194 profiles were made with the MSS from 0701 until 1930.

SAPS was deployed from the ship's stern at a depth of 30m for 60 minutes from 2041 and 2243.

11th May 2009:

Following the 0500 CTD profile, the anchor was recovered and CTD profiles and water samples were taken at 53° 32.0' N, 3° 30.0' W, site A and 53° 31.95' N, 3° 15.6' W.

Following the short CTD transect the ship sailed for Birkenhead. ADCP, flowthrough and pCO₂ systems were turned off at the Mersey radar tower at 0937. The ship was unloaded at Vittoria Dock by 1000.



Samples collected and contact:

Appendix A: Total Alkalinity (TA) and dissolved inorganic carbon (DIC) – Emmer Litt (PML) emmta@pml.ac.uk

Appendix B: Stand Alone Pumping System filtration – Lucy Abram (UoLiverpool) L.Abram@liverpool.ac.uk

Appendix C: MSS turbulence profiles – Matthew Palmer (POL) rolm@pol.ac.uk

Appendix D: Nutrient, zooplankton and phytoplankton samples – Claire Mahaffey (UoLiverpool) Claire.Mahaffey@liverpool.ac.uk & Anouska Bailey (UoLiverpool) Anouska.Bailey@liverpool.ac.uk

Appendix E: Ships underway measurements – Matthew Palmer (POL) rolm@pol.ac.uk

Appendix F: CTD profiles – Matthew Palmer (POL) rolm@pol.ac.uk

Appendix A: Total Alkalinity (TA) and dissolved inorganic carbon (DIC)

Two 25 hour stations were selected; an offshore (53.617N, 3.914W) and inshore (53.537 N, 3.363 W) location. The aim was to parameterise the inorganic carbon dynamics over a diurnal period at the two stations, with a multidisciplinary approach of hydrodynamics and biogeochemistry to analyse the temporal variability and geographical extent of a known tidal signal in the pCO₂ data.

Water samples of TA and DIC were collected approximately every 3 hours from surface water at both the inshore and offshore location. pCO₂ was measured autonomously and continuously at the offshore and inshore location over the cruise length at each of the 25 hour stations.

TA and DIC water samples:

Inshore:

Date	Time	Station	CTD cast	Bottle no.	S/B	Depth (m)
09/05/2009	00:03	2 IN-1	001	101	S	2.07
	02:00	2 IN-3	003	102	S	2.34
	05:00	2 IN-6	006	103	S	2.00
	08:00	2 IN-9	009	104	S	3.40
	11:00	2 IN-12	012	105	S	2.45
	14:01	2 IN-15	015	107	S	3.77
	17:03	2 IN-18	018	106	S	3.07
	20:00	2 IN-21	021	108	S	1.97
	23:00	2 IN-24	024	109	S	2.11
10/05/2009	01:00	2 IN-26	026	114	S	1.45

Offshore:

Date	Time	Station	CTD cast	Bottle no.	S/B	Depth (m)
10/05/2009	04:03	2 OFF-1	001	110	S	2.60
	08:01	2 OFF-5	003	111	S	1.25
	11:01	2 OFF -8	006	112	S	1.37
	13:59	2 OFF -11	009	115	S	1.07
	15:00	2 OFF -12	012	113	S	0.99
	17:00	2 OFF -14	015	116	S	1.25
	20:00	2 OFF -17	018	117	S	1.96
11/05/2009	00:01	2 OFF -21	021	118	S	1.19
	03:00	2 OFF -24	024	119	S	1.57
	05:00	2 OFF -26	026	120	S	1.48

Appendix B:

The SAPS was deployed on 4 occasions. All deployments filtered near bed seawater:

1. 9/5/09 to 20m on the inshore site – deployment failed
2. 9/5/09 to 20m on the inshore site – deployment failed
3. 10/5/09 to 30m on the offshore site – deployment failed
4. 10/5/09 to 30m on the offshore site – successful

The filter from the successful deployment on the second cruise has been analysed for lipid extraction and analysis, C and N concentration, isotope analysis and pigment analysis.

Appendix C:

The MSS90L microstructure profiler is a free-falling instrument deployed from the stern of the vessel operated manually using a small electric hydrographic winch and neutrally buoyant conductive tether. The instrument collects data during descent measuring shear, temperature and conductivity microstructure, and temperature and conductivity profiles. Additional sensors measure pressure and lateral acceleration to determine fall speed, depth and verticality. During the cruise 351 near continuous profiles were made at the near-shore station between 0730 until 2000 on the 9th May and 194 profiles were made at the offshore station between 0701 until 1930 on the 10th May 2009.

Appendix D:

Nutrient and phyto/zooplankton samples:

- Size-fractionated chlorophyll *a* – fixed volumes of seawater are filtered through 0.2 μ m, 2 μ m, and 10 μ m polycarbonate filters under low vacuum pressures. The filters are stored frozen at -80°C until analysis in the laboratory where chlorophyll *a* is extracted from the filter by sonicating the filter in 5ml 90% acetone for 10 minutes. Fluorometric analysis of the raw extract as well as the extract post-acidification allows for correction for phaeopigments.
- Nutrients – sea water samples are stored in 125ml polycarbonate bottles (acid-washed and triple-rinsed with sample water) prior to analysis with Quattro nutrient analyser onboard.
- Dissolved organic carbon (DOC) – seawater samples are filtered through combusted GF/F filters in a glass filter assembly. 20ml of filtrate is pipette into an acid-washed, combusted glass vial pre-filled with 50 μ l 50% (v/v) hydrochloric acid. Samples are stored in laboratory refrigerator for analysis on Shimadzu TOC-V.
- Bacterial abundance – 50 ml of seawater from designated Niskin is emptied into a sterile centrifuge tube pre-filled with formaldehyde (final concentration 2%). Samples are stored in cold room before DAPI staining and enumeration under epifluorescence microscope.
- Phytoplankton and microzooplankton abundance – 100ml of seawater is measured into amber glass jar pre-filled with acid Lugol's solution (final concentration 2%) and stored in cold-room. Abundances, biovolumes, and community composition are measured under inverted microscope.
- Particulate organic nutrients – fixed volumes of seawater are filtered through combusted GF/F (PC/PN), combusted acid-washed GF/F (PP) or 0.8 μ m polycarbonate (PSi) and the filters frozen prior to analysis in laboratory.
- Net community production - estimated by determining the change in dissolved oxygen concentration in seawater samples in 125 ml glass bottles stored under a 16:8 hour light: dark cycle ('light') or in the dark over a 24-hour incubation period in comparison to a Tzero O₂ concentration. Net community production (μ mol O₂ l⁻¹ day⁻¹) is calculated by subtracting the mean Tzero oxygen concentration from the mean O₂ concentration in the 'light' bottles.

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Near-shore site A: 9th -10th May 2009:

Time	Chlorophyll a	Dissolved nutrients	DOC	Bacterial abundance	Phytoplankton abundance/ID	Microzooplankton abundance/ID	Particulate C/N	Particulate P	Particulate Si
00:03	Y	Y	Y						
01:02	Y	Y	Y						
02:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
03:00	Y	Y	Y						
04:00	Y	Y	Y						
05:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
06:00	Y	Y	Y						
07:00	Y	Y	Y						
08:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
09:00	Y	Y	Y						
10:00	Y	Y	Y						
11:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
12:00	Y	Y	Y						
13:00	Y	Y	Y						
14:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
15:00	Y	Y	Y						
16:00	Y	Y	Y						
17:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
18:00	Y	Y	Y						
19:00	Y	Y	Y						
20:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
21:00	Y	Y	Y						
22:00	Y	Y	Y						
23:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
00:00	Y	Y	Y						
01:00	Y	Y	Y						

NOTE 1: Shaded columns - samples taken at surface only. All others sampled at surface and bottom

Offshore site B: 10th-11th May 2009:

Time	Chlorophyll a	Dissolved nutrients	DOC	Bacterial abundance	Phytoplankton abundance/ID	Microzooplankton abundance/ID	Particulate C/N	Particulate P	Particulate Si
04:00	Y	Y	Y						
05:00	Y	Y	Y						
06:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
07:00	Y	Y	Y						
08:00	Y	Y	Y						
09:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
10:00	Y	Y	Y						
11:00	Y	Y	Y						
12:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
13:00	Y	Y	Y						
14:00	Y	Y	Y						
15:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
16:00	Y	Y	Y						
17:00	Y	Y	Y						
18:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
19:00	Y	Y	Y						
20:00	Y	Y	Y						
21:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
22:00	Y	Y	Y						
23:00	Y	Y	Y						
00:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
01:00	Y	Y	Y						
02:00	Y	Y	Y						
03:00	Y	Y	Y	Y	Y	Y	Y	Y	Y
04:00	Y	Y	Y						
05:00	Y	Y	Y						

NOTE 1: Shaded columns - samples taken at surface only. All others sampled at surface and bottom

NOTE 2: NCP oxygen incubations for 24 hours - light, dark, and Tzero.

Appendix E: Ship's underway measurements:

The intake for the surface sampling system is located underneath RV Prince Madog, at about 3 m below sea level. The parameters recorded every minute by the WS Oceans system are:

Date, Transmittance, Hull Temperature (°C), Barometric Pressure (mbar), Fluorescence, Oxygen concentration, Turbidity, Salinity, Conductivity sensor water temperature (°C). Sea surface temperature, salinity and transmittance were calibrated against the CTD by BODC. In addition a pCO₂ sensor is incorporated into the surface sampling system.

Met package measures and records Barometric pressure (mbar), Solar Radiation (W m⁻²), PAR (μmols / m²s), Air Temperature (°C), Relative Humidity, Relative Wind Speed (m s⁻¹), Relative Wind Direction (°) – zero indicates wind on the bow, Minimum Air Temp (°C), Maximum Air Temp (°C), Wind Gust (m s⁻¹).

Underway data, pCO₂ and ships ADCP data were recorded every minute. The ship was fitted with a 300 kHz ADCP set to record 50 x 1m bins, every 30 seconds with 29 pings / ensemble. The systems ran continually beyond Puffin Island up to the Mersey radio tower between 8/5/09 2218 and 11/5/09 0937.

Appendix F:

The Sea-Bird 911 CTD recorded downwelling PAR light levels, temperature, conductivity, oxygen concentration, transmittance and fluorescence at 24 Hz. The frame was fitted with an altimeter. The CTD temperature data was checked against a Sea-Bird SBE35 precision thermometer. Water samples were taken from a near bed (3mab) bottle for calibration of the CTD salinity data by Anne Forbes-Brook (University of Bangor). A LISST-100X particle sizer with internal logging was attached to the CTD frame. A LISST-25 particle sizer was fitted to the CTD and its data logged on the Sea-Bird data logging system.

CTD log:

cast sequence	cast ID	time	Latitude (N)	Longitude (W)
1	2in-1	May 09 2009	53deg 32.256'	03deg 21.842'
2	2in-2	May 09 2009	53deg 32.208'	03deg 21.936'
3	2in-3	May 09 2009	53deg 32.204'	03deg 21.935'
4	2in-4	May 09 2009	53deg 32.215'	03deg 21.940'
5	2in-5	May 09 2009	53deg 32.253'	03deg 21.885'
6	2in-6	May 09 2009	53deg 32.255'	03deg 21.818'
7	2in-7	May 09 2009	53deg 32.245'	03deg 21.785'
8	2in-8	May 09 2009	53deg 32.226'	03deg 21.750'
9	2in-9	May 09 2009	53deg 32.206'	03deg 21.737'
10	2in-10	May 09 2009	53deg 32.216'	03deg 21.744'
11	2in-11	May 09 2009	53deg 32.239'	03deg 21.765'
12	2in-12	May 09 2009	53deg 32.253'	03deg 21.793'
13	2in-13	May 09 2009	53deg 32.257'	03deg 21.796'

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14	2in-14	May 09 2009	53deg 32.250'	03deg 21.790'
15	2in-15	May 09 2009	53deg 32.201'	03deg 21.935'
16	2in-16	May 09 2009	53deg 32.183'	03deg 21.934'
17	2in-17	May 09 2009	53deg 32.180'	03deg 21.929'
18	2in-18	May 09 2009	53deg 32.216'	03deg 21.920'
19	2in-19	May 09 2009	53deg 32.231'	03deg 21.780'
20	2in-20	May 09 2009	53deg 32.221'	03deg 21.765'
21	2in-21	May 09 2009	53deg 32.193'	03deg 21.742'
22	2in-22	May 09 2009	53deg 32.195'	03deg 21.740'
23	2in-23	May 09 2009	53deg 32.204'	03deg 21.741'
24	2in-24	May 09 2009	53deg 32.215'	03deg 21.750'
25	2in-25	May 10 2009	53deg 32.225'	03deg 21.768'
26	2in-26	May 10 2009	53deg 32.228'	03deg 21.784'
27	2off-1	May 10 2009	53deg 37.043'	03deg 55.082'
28	2off-2	May 10 2009	53deg 37.102'	03deg 55.125'
29	2off-3	May 10 2009	53deg 37.100'	03deg 54.965'
30	2off-4	May 10 2009	53deg 37.059'	03deg 54.898'
31	2off-5	May 10 2009	53deg 36.977'	03deg 54.849'
32	2off-6	May 10 2009	53deg 37.032'	03deg 54.842'
33	2off-7	May 10 2009	53deg 37.021'	03deg 54.845'
34	2off-8	May 10 2009	53deg 37.016'	03deg 54.853'
35	2off-9	May 10 2009	53deg 36.989'	03deg 54.943'
36	2off-10	May 10 2009	53deg 36.993'	03deg 55.124'
37	2off-11	May 10 2009	53deg 37.008'	03deg 55.264'
38	2off-12	May 10 2009	53deg 37.045'	03deg 55.275'
39	2off-13	May 10 2009	53deg 37.030'	03deg 55.281'
40	2off-14	May 10 2009	53deg 37.027'	03deg 55.280'
41	2off-15	May 10 2009	53deg 37.006'	03deg 55.272'
42	2off-16	May 10 2009	53deg 36.924'	03deg 55.174'
43	2off-17	May 10 2009	53deg 37.038'	03deg 54.869'
44	2off-18	May 10 2009	53deg 37.067'	03deg 54.866'
45	2off-19	May 10 2009	53deg 37.066'	03deg 54.866'
46	2off-20	May 10 2009	53deg 37.076'	03deg 54.888'
47	2off-21	May 11 2009	53deg 37.016'	03deg 55.048'
48	2off-22	May 11 2009	53deg 36.997'	03deg 55.281'
49	2off-23	May 11 2009	53deg 36.994'	03deg 55.292'
50	2off-25	May 11 2009	53deg 37.011'	03deg 55.298'
51	2off-25	May 11 2009	53deg 36.999'	03deg 55.298'
52	2off-26	May 11 2009	53deg 36.978'	03deg 55.295'
53	TR1	May 11 2009	53deg 32.041'	03deg 30.017'
54	TR2	May 11 2009	53deg 32.253'	03deg 22.212'
55	TR3	May 11 2009	53deg 31.936'	03deg 15.566'

Acknowledgements:

This work was made possible by the hard work and expertise of the officers and crew of the RV Prince Madog led by Capt. Eric Lloyd. Assistance was also provided by the workshop engineers of Proudman Oceanographic Laboratory. I would like to thank both of these groups and all the science crew for making the cruise such a success in often demanding conditions.