National Oceanography Centre, Southampton

Cruise Report No. 9

RRS *Discovery* Cruise 306

23 JUN - 9 JUL 2006

Pelagic biogeochemistry of the PAP Site

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2006

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ABSTRACT

The aim of this cruise was to develop a better understanding of carbon cycling in the pelagic waters of the Porcupine Abyssal Plain (PAP). There were three objectives

1) Turnaround moorings at the PAP Observatory;

2) Conduct a 1-D time series on the central station of a wide range of biogeochemical processes and to back this up with a mesoscale survey of key variables;

3) To trial the use of Autosub for mesoscale surveys in conjunction with the ship.

All objectives were met, although the tops of the moorings were found to be missing probably due to fishing activity and the Autosub trials were incomplete due to vehicle failure. A full mesoscale survey was carried out using the ship and an eleven day time series at the central station was achieved.

KEYWORDS

Autosub, bacterioplankton, biogeochemistry, circulation, cruise 306 2006, CTD, currents, *Discovery*, hydrography, moorings, NE Atlantic, nutrients, oxygen, PAP, phytoplankton, primary production, protozooplankton, SAPS, turbulence, zooplankton

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CONTENTS

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2. SHIPS PERSONNEL

Person	**Responsibility**
Antonio Gatti	Master
Philip Oldfield	Chief Officer
Mike Hood	2nd Officer
Darcy White	Third Officer
George Parkinson	Chief Engineer
John Clarke	2nd Engineer
Chris Carey	3rd Engineer
James Bills	3rd Engineer
Dennis Jakobaufderstroht	ETO
Andrew McNair	Eng Cadet
Robert Masters	ETO (port call only)
Iain Thomson	CPO (Deck)
Stephen Smith	CPO (Sci)
Stephen Day	POD
John Dale	SG1A
David Anderson	SG1A
Mark Moore	SG1A
Ian Cantlie	SG1B
Carl Moore	ERPO
Keith Curtis	SCM
Peter Lynch	Chef
Lloyd Sutton	Asst. Chef
Peter Robinson	Steward

3. ITINERARY

Sailed Falmouth	18:00	23rd June 2006
Arrived PAP station	20:50	25th June 2006
Departed PAP station	12:00	7th July 2006
Docked Cork	09:00	9th July 2006

Change of itinerary: We sailed a day later than originally planned. This was due to illness of a member of the ship's crew that required the change of personnel.

4. OBJECTIVES

This cruise was undertaken as part of the NERC Core Strategic Programme of the NOC Biophysical Interactions and Controls on Export Processes (BICEP) Interactions.

The aim of the cruise was to develop a better understanding of the pelagic biogeochemistry of the Porcupine Abyssal Plain (PAP), through three objectives:

- Turnaround moorings at the PAP Observatory;
- Conduct a 1-D time series on the central station of a wide range of biogeochemical processes and to back this up with a mesoscale survey of key variables;
- To trial the use of Autosub for mesoscale surveys in conjunction with the ship.

5. NARRATIVE

5.1 Daily Diary

Friday 23 June [JD174]
Scientific party met at 13:00 to agree work plans. The Master gave welcome & safety talk at 15:00. We sailed at 18:00 after a series of delays. The Chief Officer was discharged off sick and a replacement was travelling from Lincolnshire. On reaching Plymouth, the railway shut due to a suicide on the track. The replacement mate required taxi from Plymouth to Falmouth. One of the ship's cranes broken, compromising our ability to handling moorings. The ship's engineers worked flat out yesterday and today and managed to cannibalise parts from other cranes. On sailing we moved into the lee of Falmouth Bay to carry out ship's compass check and then deployed Autosub briefly to check its sensors were working. The sea-state was surprisingly benevolent considering how hard the wind had been blowing for previous 3 days. The skies were still very cloudy.

Saturday 24 June [JD175]
We made an easy passage with winds BF 3-4. The scientists were finding their sea-legs, with no major problems. An Emergency muster & life boat drill was run at 10:30. We had a discussion about Autosub mission and decide to work the central box at PAP for the first deployment. We changed course to make to 49°15'N 16°11'W for the Autosub deployment.

Sunday 25 June [JD 176]
The winds moderated to BF 5 to 3 and back to 4. The clocks were put back 1-h during th night to get shipboard operations onto GMT. This brings scientific clocks, ship's clocks and local biological time into synchrony and should minimise confusion. The morning was bright with wind moderating down from BF 5 overnight. White horses skated across the ocean. The

ship remained stable despite the broken stabilisation system. A CTD trial dip showed that some bottles were not closing since their lanyards were too short – fortunately this will be easy to rectify. The Autosub trial ended disappointingly with recovery required after a 2 hour search. Recovery of Autosub is obviously not easy with the ship requiring forward motion and so creating prop wash that affects Autosub. We later found out it had been set up to navigate using the underside of ice – no wonder Autosub was confused. We eventually reached PAP at 20:45 and carried out deep CTD to characterise water column and test mooring releases.

Monday 26 June [JD 177]

A lovely sunny day with light breezes (BF 2-3). There was a lot of syrene floating on water surface with *Lepas* attached. Work began at 02:30 with plankton netting, followed by a shallow CTD cast to get water for biological production measurements. One of the advantages of starting predawn, is that with the ship's lights, animals appear from the depths. This morning found Sunfish (*Mola mola*) - a strangely large creature with a peculiarly shortened tail. The Sunfish is one of the few organisms that eats jellyfish and it was perhaps unsurprising that our plankton nets were full of jellies. Our work continued at 05:00 with deployment of a free-fall turbulence profiling system to measure how much deepwater containing nutrients mixes into the surface nutrient depleted layer. By 07:30 breakfast was a serious necessity! A deeper CTD cast to 1000m was made after breakfast to measure the physics, chemistry and biology of the twilight zone (an interface between the sunlight warm surface water and the cold dark deep ocean). Apstein netting was carried out after breakfast to catch phytoplankton to determine what plants we have in the water. We hope to be able to culture them to determine their propensity for sinking out of the surface waters. Around midday, another CTD cast was made to check the time of day that cells multiply and to relate this to light cycle. After lunch more turbulence measurements were made, followed by deployment of Autosub, our 7-m long autonomous underwater vehicle. Off on its first mission to support our work, it was programmed to steam a course around the ship to assess the variability of the physical, chemical and biological content of water around the ship. Our plan was to meet up with it in 3 days time. Much of our work on this cruise concerned the deep water moorings that were put in a year ago. These have been collecting information over the past year and we were eager to recover them to find out, for instance, how sedimentation of biological production into the oceans interior, compares with previous years. But our deck is so full of gear that first we have to create some space. So today, we laid a new mooring to be retrieved next year before we recover moorings tomorrow. Our work for the day ended in the evening with the deployment of some new free floating traps called PELAGRA. These will be tested overnight for recovery tomorrow. Turned in at 22:00, the 02:00 alarm call is not too far off!

Tuesday 27 June [JD178]

A morning of grey manky wet weather with BF 3-4. It brightening later with wind dropping to BF 3-2 but remained overcast until afternoon. It then became sunny! The early morning net casts had too many jellies to be good. Our first and second CTD's were fine. The PAP mooring 1 recovery proved very slow because the surface line had to be grappled for. In the end, the mooring was popped up and recovered from bottom. The kevlar line had parted partway and the top part of the mooring was missing completely. How many sensors had been lost? It was a similar story for mooring 2. The top part of the mooring was lost with no floatation buoy. This was disappointing. The recovery of Pelagras later in the day was also a problem. The first was fine but remaining two could not be located. Trouble comes in threes they say!

Wednesday 28 June [JD179]

A Grey overcast drizzly morning and overcast later (BF 4)

I was woken at 02:00 to be asked whether we should go back to PAP or sample at the Pelagra search site. No option really as they were 16 miles apart and not enough time to get there. Netting was completed, CTD and turbulence drops made and we then resumed our search for Pelagras. Trap 2 was located at 08:00 and was very low in water with just its flag showing. It took a great deal of skill to recover. Trap 3 was even lower in water with almost no buoyancy. It was a devil of a job to spot and even trickier to get onboard. Our first attempt caused it to pass under the ship's hull. It then submerged completely and took an hour to surface. Everyone was grateful when we eventually got it on board. Moorings were recovered but again the top part was missing and the bits recovered had long-line hooks embedded in the Kevlar. It is unlikely that we will redeploy moorings with close to surface parts since these would invite further losses of sensors – an expensive and fruitless exercise. Our intention to carry out SAPS overnight could not be carried out as they had not been charged.

Thursday 29 June [JD 180]

A sunny dawn should have heralded a good day. BF 4-5 with some white horses skitting across the sea. Autosub due to RV with us at PAP, so we moved off station to avoid collision. We recovered moorings 2 and 4. More tops missing with tuna hooks attached.

Friday 30 June [JD 181]

Woken up by ship's motion during the night. I wondered what the state of labs was in? Thinking through my walk around before turning in, I decided that gear was tied down. On getting up, the forecast in this general region for BF 6-7 but achieved BF 5-6. A long low swell came in against swell causing a lively ships motion. We recovered mooring 3 to find top missing. Seems long-lining activity was to blame. We agreed not to deploy other moorings. The old bathysnap mooring recovered; it was fine and the new one was deployed.

Saturday 1 July [JD 182]

A sunny beginning to the day with cloud later (BF 4). Our last full day at PAP before we began the mesoscale survey; we had a lot to pack in. The Autosub team wanted as much time as possible before deploying their vehicle so this was scheduled just before mid-night. Pelagra was also rescheduled for deployment after midnight to maximise the number of instruments in the water. We carried out deep SAPS to 3000m depth. England departed from the World Cup to Portugal on penalties. We cheered ourselves though with John Allen's "official" 42nd birthday celebration in bar.

Sunday 2 July [JD 183]

Three Pelagras were deployed successfully just after midnight. Our early-morning activity moved forward by half-an-hour to accommodate leaving at 06:00 to fit in all requirements in our 4 day survey. It was a gloriously bright sunny day with BF 4 earlier rising to BF 5 later. The survey was going well and returned to "home base" on schedule.

Monday 3 July [JD 184]

We deployed our fourth and final sediment trap. We enjoyed bright sunshine for most of day with BF 5 winds that moderated later. This gave us good working conditions and everyone seemed to be in excellent form. In the water, the diatoms seemed to have disappeared and large quantities of ciliates appeared. The jellyfish still persist.

Tuesday 4 July [JD 185]
A bright sunny start to the day but overcast latterly. The seas were calmer that yesterday with BF 2-3. Ideal conditions for working in. Today we had the first serious suggestion of a DCM forming at PAP and all are excited by this prospect. Unfortunately Autosub aborted in the night but it did so in the NW sector that we intend to survey. We decided to do the grid backwards (so to speak) so we could retrieve Autosub as soon as possible. Fortunately this was achieved quickly although the landing line was fouled around the propeller. This did not delay our work too badly. It is now time to start thinking about end of cruise preparations

Wednesday 5 July [JD 186]
We returned to PAP at 02:30. Another bright sunny day with BF 2-3 – excellent. CTDs showed further suggestion of a DCM forming with higher O_2 associated with the high deep fluorescence. This suggests it's a production as well as biomass peak. The wind speed increased during the night.

Thursday 6 July [JD 187]
We endured sou-westerly BF 6 overnight wondering what the implications were for the Autosub and Pelagra recoveries. Dawn heralded a grey overcast wet morning that brightened later. Our DCM is now less pronounced and has sunk down to 60m. The O_2 peaks at 40m depth. Could it be that the biomass is mixed downwards but production rates are faster than the mixing? This needs some thought. The Pelagra traps moved further to SW requiring much longer to collect them. We did not return to "home base" until close to midnight. The wind moderated in the afternoon to BF 4. We had some problems retrieving the Autosub with lazy line that was in danger of fouling the propeller. The Captain oversaw operations on the deck

Friday 7 July [JD 188]
Wind had picked up again to BF 6 but at least it was sunny. We completed our work at PAP at 11:30. It was a good feeling to head for Cork with an easy ship's motion of slow corkscrews through the water.

5.2 Acknowledgements

The PSO thanks the following for their collective help to ensure the success of D306: Captain and crew of RRS *Discovery* for their fullest support, Pam Talbot for scientists' logistics, Andy Louch and the NOCS UKORS staff for equipment and ship's logistics in NOCS, and the scientists and technicians onboard who ensured the cruise was a tremendously successful, friendly and pleasant experience.

6. SCIENTIFIC LOG

Date & Julian Day	Time	Event	Position	Station No.	*Discovery* Stn No.
21/06/06 172	1200	Mobilisation			
22/06/06 173		Mobilisation			
23/06/06 174	1800	Vessel sails			
	1948	Autosub deployed in Falmouth Bay	50°06.7'N 05°01.9'W		
	2030	Autosub recovered onboard. Sails for PAP area	50°06.3'N 05°01.6'W		

24/06/06		0900	Pre-cruise scientific and safety brief			
	175	1030	Emergency boat muster			
25/06/06		0200	Clocks retarded 1 hour to GMT			
	176	1056	CTD deployed to 1000m for test	49°15.0'N 16°11.1'N	176001	15861
		1209	CTD recovered onboard			
		1217-1319	Turbulence probe	49°15.0'N 16°11.8'N	176002	15862
		1320-1328	Apstein net deployed	49°16.7'N 16°12.0'N	176003	15863
		1354	Acoustic fish deployed	49°15.0'N 16°11.0'N	176004	15864
		1406	Autosub deployed	49°15.0'N 16°11.1'N	176005	15865
		1700	Acoustic fish inboard			
		1736	Autosub recovered inboard			
		1740	Vessel proceeding to PAP location			
		1751	MVP fish deployed	49°14.6'N 16°12.4'N	176006	15866
		2037	MVP fish onboard			
		2050	Vessel hove on PAP station	48°50.0'N 16°30.0'N		
		2100	CTD deployed	48°50.1'N 16°30.1'N	176007	15867
26/06/06		0010	CTD inboard			
	177	0236-0317	WP2 net deployments	48°50.1'N 16°29.9'N	177001	15868
		0324 - 0331	Apstein net deployment	48°50.0'N 16°30.0'N	177002	15869
		0357-0438	CTD deployment	48°50.1'N 16°30.0'N	177003	15870
		0510-0726	Turbulence profiler deployed	48°50.1'N 16°30.0'N	177004	15871
		0820-0930	CTD deployed	48°50.2'N 16°30.1'N	177005	15872
		0955-1000	Apstein net deployment	48°50.0'N 16°30.1'N	177006	15873
		1005-1007	Apstein net deployment	48°50.0'N 16°30.1'N	177007	15874
		1058	PES fish recovered onboard			
		1157-1237	CTD deployed	48°50.2'N 16°29.9'N	177008	15875
		1308-1400	Turbulence profiler deployed	48°50.2'N 16°29.9'N	177009	15876
		1403	Acoustic and PES fish deployed			
		1410	Autosub launched	48°50.9'N 16°29.6'N	177010	15877
		1448	Acoustic fish inboard			
		1600	On station mooring deployment			
		1605	Commence mooring deployment			

	1744	Mooring deployed	48°59.15'N 16°25.66'W	177011	15878
	1845	Vessel on station for Pelagra float deployment			
	2105	Pelagra No. 1 deployed	48°52.7'N 16°18.9'N	177012	15879
	2110	Pelagra No. 2 deployed	48°52.7'N 16°18.9'N	177013	15880
	2113	Pelagra No. 3 deployed	48°52.7'N 16°18.8'N	177014	15881
	2130	Vessel return to PAP station			
	2330	Vessel on station at PAP	48°50.0'N 16°30.0'N		
27/06/06	0230-0256	Plankton net deployments	48°50.0'N 16°30.0'N	178001	15882
178	0315-0321	Plankton net deployments	48°50.2'N 16°29.3'W	178002	15883
	0354-0430	CTD deployed	48°49.9'N 16°29.8'W	178003	15884
	0536-0610	CTD deployed	48°50.1'N 16°30.0'W	178004	15885
	0620-0801	Turbulence profiler deployed, proceed to mooring recovery	48°50.2'W 16°29.3'W	178005	15886
	0945	Mooring released	49°02.6'N 16°37.1'W		
	1135	Mooring grappled			
	1242	Buoyancy inboard			
	1300	Complete recovery			
	1414-1522	Turbulence profiler deployed	49°01.8'N 16°26.3'W	178006	15887
	1755	Mooring grappled	49°02.0'N 16°26.4'W	178007	15888
	1858	Buoyancy package inboard			
	1932	Mooring recovered onboard			
	2120	Pelagra float recovered, continue search for remaining floats	49°01.3'N 16°11.1'W	178008	15889
28/06/06		Cease search for Pelagra floats			
179	0234-0256	Plankton net deployments	49°02.0'N 16°09.1'W	179001	15890
	0306-0313	Plankton net deployments	49°02.1'N 16°08.9'W	179002	15891
	0343-0423	CTD deployed	49°02.0'N 16°08.7'W	179003	15892
	0450-0604	Turbulence profiler deployed	49°02.0'N 16°08.7'W	179004	15893
	0605	Resume search for Pelagra deployments			
	0818	Pelagra No. 2 recovered onboard. Searching for No.3	49°01.6'N 16°08.2'W	179005	15894
	1130	Pelagra No. 3 recovered	49°04.3'N 16°06.8'W	179006	15895
	1258	Vessel hove to on station	49°59.1'N 16°25.6'W	179007	15896

	1307-1330	Apstein net deployed			
	1435	Vessel hove to awaiting mooring release	48°58.5'N 16°37.3'W	179008	15897
	1439	Mooring released			
	1508	Buoyancy sighted			
	1544	2nd buoyancy sighted			
	1619	Buoyancy grappled alongside			
	1835	Mooring recovered onboard			
	1909-1955	CTD deployed	48°59.6'N 16°40.5'W	179009	15898
	2110	Vessel hove to on PAP station			
	2120	SAPS deployed	48°50.1'N 16°29.7'W	179010	15899
29/06/06	0103	SAPS recovered onboard			
180	0228-0249	Plankton net deployments	48°50.0'N 16°30.0'W	180001	15900
	0254-0302	Plankton net deployments	48°50.1'N 16°29.8'W	180002	15901
	0305	Acoustic fish deployed			
	0345-0429	CTD deployed	48°50.2'N 16°29.7'W	180003	15902
	0436-0635	Turbulence profiler deployed. Acoustic fish recovered	48°50.2'N 16°29.7'W	180004	15903
	0644-0808	CTD deployed. Acoustic fish deployed	48°30.3'N 16°31.9'W	180005	15904
	0830-0909	Snowcatcher deployed	48°50.2'N 16°30.9'W	180006	15905
	1105-1140	CTD deployed	48°50.0'N 16°29.7'W	180007	15906
	1145	Acoustic fish recovered			
	1241	Vessel re-positioning for Autosub recovery			
	1527	Autosub grappled			
	1540	Autosub recovered onboard	48°26.1'N 16°23.2'W	180008	15907
	1545	Reposition for Pelagra deployment			
	1902	1st Pelagra deployed	48°41.5'N 16°42.6	180009	15908
	1910	2nd Pelagra deployed – proceed to PAP station	48°41.4'N 16°42.5'W	180010	15909
	2032	Vessel on station at PAP			
	2043	SAPS deployed	48°50.0'N 16°29.7'W	180011	15910
30/06/06	0022	SAPS recovered onboard	48°49.3'N 16°27.8'W	180012	15910
181	0220-0240	Plankton net deployments	48°50.0'N 16°30.0'W	181001	15911
	0244-0253	Plankton net deployments	48°50.0'N 16°29.7'W	181002	15912
	0343-0427	CTD deployed	48°50.0'N 16°30.0'W	181003	15913
	0436-0630	Turbulence profiler deployed	48°50.0'N 16°29.2'W	181004	15914

	0703-0740	CTD deployed	48°50.0'N 16°29.7'W	181005	15915
	0815-0852	Apstein net deployments	48°49.9'N 16°29.6'W	18106	15916
	0900	Proceed to mooring recovery			
	1020	Hove to on station awaiting release	49°00.2'N 16°26.5'W	181007	15917
	1219	Mooring grappled			
	1233	Mooring recovered			
	1306-1501	Turbulence profiler deployed	49°00.3'N 16°27.3'W	181008	15918
	1610	Commence roughsnap deployment	49°00.1'N 16°27.3'W	181009	15919
	1624	Roughsnap deployed			
	1630	Vessel relocating for Pelagra recovery			
	1900	1st Pelagra recovered onboard	48°50.8'N 16°36.6'W	181010	15920
	1956	2nd Pelagra recovered onboard	48°49.8'N 16°37.4'W	181011	15921
	2000	Vessel relocating to PAP station			
01/07/06	0228-0248	Plankton net deployments	48°50.0'N 16°29.9'W	182001	15922
182	0253-0300	Plankton net deployments	48°50.1'N 16°29.9'W	182002	15923
	0340-0421	CTD deployed	48°50.0'N 16°30.0'W	182003	15924
	0438-0632	Turbulence profiler deployed	48°50.1'N 16°30.0'W	182004	15925
	0705-0823	CTD deployed	48°50.1'N 16°30.0'W	182005	15926
	0834-0916	Apstein net deployments	48°51.0'N 16°30.6'W	182006	15927
	1000-1015	Snow profiler deployed	48°50.2'N 16°29.9'W	182007	15928
	1045-1115	Turbo CTD deployed	48°50.9'N 16°30.3'W	182008	15929
	1140-1541	Turbulence profiler deployed	48°51.6'N 16°30.5'W	182009	15930
	1545	Relocate to PAP station			
	1746-1822	CTD deployed	48°50.0'N 16°30.0'W	182010	15931
	1905-2330	SAPS deployed	48°50.0'N 16°30.1'W	182011	15932
	2335	Acoustic fish deployed			
02/07/06	0005	Autosub launched	48°51.6'N 16°32.6'W	183001	15933
183	0018-0025	Hydrophone deployed			
	0034	Acoustic fish deployed			
	0159	Pelagra No.1 deployed	48°51.7'N 16°31.o'W	183002	15934
	0204	Pelagra No.2 deployed	48°51.7'N 16°31.0'W	183003	15935

	0210	Pelagra No.3 deployed	48°51.7'N 16°31.0'W	183004	15936
	0238- 0258	Plankton net deployments	48°50.1'N 16°30.1'W	183005	15937
	0301- 0308	Plankton net deployments	48°50.2'N 16°30.2'W	183006	15938
	0323- 0403	CTD deployed	48°50.3'N 16°30.1'W	183007	15939
	0423- 0524	Turbulence profiler deployed	48°49.9'N 16°29.9'W	183008	15940
	0525- 0552	Apstein net deployments	48°50.3'N 16°28.9'W	183009	15941
	0606	MVP deployed			
	0619	Set Co. 090˚ commence NW survey leg			
	0726	CTD deployed	48°53.6'N 16°11.1'W	183010	15942
	0738	PES fish deployed			
	0802	CTD recovered continue with survey			
	0947- 1020	CTD deployed	48°57.0'N 15°52.0'W	183011	15943
	0943	MVP recovered. Vessel hove to for mooring recovery			
	1234	Mooring released	49°01.7'N 16°21.8'W	183012	15944
	1329	Mooring sighted			
	1334	Mooring grappled			
	1504	Sediment trap mooring recovered onboard			
	1526	Resume MVP survey			
	1628- 1658	CTD deployed	49°07.9'N 16°11.0'W	183015	15945
	1839- 1910	CTD deployed	49°11.5'N 15°52.0'W	183016	15946
	2047- 2200	CTD deployed	49°15.0'N 16°10.9'W	183017	15947
03/07/06	0006- 0038	CTD deployed	49°02.4'N 16°11.0'W	184001	15948
184	0206	MVP recovered			
	0232- 0250	Plankton net deployments	48°50.5'N 16°29.7'W	184002	15949
	0251- 0258	Plankton net deployments	48°50.5'N 16°29.8'W	184003	15950
	0304	Pelagra No.4 deployed	48°50.6'N 16°29.9'W	184004	15951
	0320- 0354	CTD deployed	48°50.7'N 16°30.1'W	184005	15952
	0400- 0524	Turbulence profiler deployed	48°51.2'N 16°30.5'W	184006	15953
	0527- 0551	Apstein net deployments	48°52.4'N 16°30.3'W	184007	15954
	0603	MVP deployed			
	0627	Commence SE survey leg			
	0748- 0820	CTD deployed	48°46.4'N 16°11.1'W	184008	15954

	1005-1035	CTD deployed	48°42.8'N 15°51.9'W	184009	15955
	1456-1528	CTD deployed	48°32.2'N 16°11.0'W	184010	15956
	1708-1737	CTD deployed	48°28.6'N 15°51.9'W	184011	15957
	1915-1944	CTD deployed	48°25.0'N 16°11.0'W	184012	15958
	2228-2300	CTD deployed	48°37.5'N 16°11.2'W	184013	15959
04/07/06	0045	Complete SE survey leg			
185	0049	MVP recovered			
	0208-0228	Plankton net deployments	48°50.0'N 16°30.3'W	185001	15960
	0232-0235	Plankton net deployments	48°50.1'N 16°30.4'W	185002	15961
	0304-0341	CTD deployed	48°50.0'N 16°30.0'W	185003	15962
	0352-0518	Turbulence profiler deployed	48°50.2'N 16°30.8'W	185004	15963
	0524-0557	Apstein net deployments	48°51.1'N 16°32.3'W	185005	15963
	0608	MVP deployed. Commence NW survey leg			
	0736-0810	CTD deployed	49°02.5'N 16°49.3'W	185006	15964
	0810	Break off survey to search for problematic autosub			
	0935	Autosub recovered onboard. Resume survey	49°03.9'N 16°54.7'W	185007	15965
	1243-1315	CTD deployed	49°15.0'N 16°49.2'W	185008	15966
	1449	MVP inboard			
	1500-1531	CTD deployed	49°11.2'N 17°07.9'W	185009	15967
	1712-1742	CTD deployed	49°07.8'N 16°49.2'W	185010	15968
	2204-2235	CTD deployed	48°56.9'N 17°08.2'W	185011	15969
05/07/06	0023-0033	CTD deployed	48°53.6'N 16°49.0'W	186001	15970
186	0233-0253	Plankton net deployments	48°50.0'N 16°30.0'W	186002	15971
	0257-0301	Plankton net deployments	48°50.1'N 16°30.0'W	186003	15972
	0318-0352	CTD deployed	48°50.1'N 16°30.1'W	186004	15973
	0400-0523	Turbulence profiler deployed	48°50.2'N 16°30.4'W	186005	15974
	0525-0545	Apstein net deployments	48°50.7'N 16°32.2'W	186006	15974
	0606	MVP deployed. Commence SW survey leg			

	0735-0808	CTD deployed	48°46.4'N 16°49.0'W	186007	15975
	0954-1023	CTD deployed	48°42.7'N 17°07.9'W	186008	15976
	1446-1515	CTD deployed	48°32.1'N 16°48.8'W	186009	15977
	1705-1733	CTD deployed	48°28.4'N 17°07.8'W	186010	15978
	1911-1941	CTD deployed	48°24.8'N 16°48.8'W	186011	15979
	1949	Autosub deployed	48°24.5 16°48.4'W	186012	15780*
	2244-2315	CTD deployed	48°37.4'N 16°48.8'W	186013	15781
06/07/06	0124	MVP recovered at PAP site			
187	0230-0251	Plankton net deployments	48°50.0'N 16°30.0'W	187001	15782
	0253-0312	Plankton net deployments	48°50.0'N 16°29.9'W	187002	15783
	0315-0319	Plankton net deployments	48°50.0'N 16°30.0'W	187003	15784
	0337-0409	CTD deployed	48°50.0'N 16°30.0'W	187004	15785
	0427-0627	Turbulence profiler	48°50.0'N 16°30.0'W	187005	15786
	0631-0702	Apstein net deployments	48°49.3'N 16°31.6'W	187006	15787
	0726-0836	CTD deployed	48°50.0'N 16°29.9'W	187007	15788
	0845-1015	Turbulence profiler deployed	48°50.0'N 16°30.4'W	187008	15789
	1045-1115	CTD deployed. Relocate for Pelagra recovery	48°50.2'N 16°29.9'W	187009	15790
	1405	Pelagra No.4 recovered	48°53.2'N 17°00.4'W	187010	15791
	1719	Pelagra No.5 recovered	48°30.2'N 17°10.2'W	187011	15792
	1839	Pelagra No.2 recovered	48°28.1'N 17°03.0'W	187012	15793
	1916	Pelagra No.1 recovered	48°26.6'N 17°02.8'W	187013	15794
	2155	Commence search for autosub			
	2225	Autosub grappled	48°51.9'N 16°34.1'W	187014	15795
	2240	Autosub recovery lines fouled on rudder			
	2335	Autosub lifted onboard			
	2345	Recovery lines hauled free			
07/07/06	0230-0249	Plankton net deployments	48°50.0'N 16°30.0'W		
188	0253-0257	Plankton net deployments	48°50.0'N 16°30.0'N	188002	15797
	0322-0358	CTD deployment	48°50.0'N 16°30.0'W	188003	15798

0427- 0636	Turbulence profiler deployed	48°50.0'N 16°30.0'W	188004	15799
0703- 0730	Apstein net deployments	48°50.0'N 16°30.0'W	18805	15800
0748	SAPS deployed	48°49.9'N 16°30.6'W	18006	15801
0925	PES fish deployed			
1025	SAPS recovered onboard			
1050- 1115	Snow catcher deployed	48°49.6'N 16°32.3'W	188007	15802
1150	MVP deployed for test			
1200	End of science. Set Co. for Cork			
1214	MVP recovered onboard			

7 SCIENTIFIC REPORTS

7.1 Vessel mounted ADCP, navigation, heading & gyro *(Roz Pidcock, John Allen and Adrian Martin)*

Introduction

Since the FISHES, D253, cruise in May/June 2001, two RDI Vessel-Mounted Acoustic Doppler Current Profilers (VM-ADCPs) have been in operation on RRS *Discovery*; the narrowband 150kHz VM-ADCP and a 75 kHz Phased Array instrument (Ocean Surveyor). The vast majority of this report duplicates that of Penny Holliday and Helen Johnson for D253.

The 150 kHz ADCP is mounted in the hull 1.75 m to port of the keel, 33 m aft of the bow at the waterline and at an approximate depth of 5 m. The 75 kHz ADCP is also mounted in a in the hull, but in a second well 4.15 m forward and 2.5 m to starboard of the 150 kHz well.

This section describes the operation and data processing paths for both ADCPs. The navigation data processing is described first since it is key to the accuracy of the ADCP current data.

Navigation

The ship's primary position instruments were the GPS Trimble 4000 system and the Ashtech G12 system. The GPS 4000 system had been determined to be the most accurate system on a number of preceding cruises, and D306 was no exception. An examination of positional accuracy, whilst tied up alongside in Falmouth at the beginning of the cruise, showed that the corrected GPS 4000 system provided slightly higher positional accuracy than the Ashtech G12 system. As with preceding cruises, this accuracy was ~1.0m for the GPS4000 system and ~ 2.0 m for the G12 system.

The RVS "Bestnav" failed to produce anything sensible on D306. Thus a master navigation file will need to be created back at NOC in the near future, both the GPS4000 and the G12 data streams contained periods of duplicate times and positions, occasionally for prolonged periods of an hour or more.

Both of these systems had sufficient precision to enable a calculation of ship's velocities to better than 1 cms^{-1}, and therefore below the instrumental limits of the RDI ADCP systems.

Data were transferred daily from the GPS Trimble 4000 stream to the pstar navigation file, GP430601. The G12 and gyro (gyronmea) data streams were also transferred daily. Early on in the cruise, the gyronmea data stream suffered a gap of approximately 12 hours, during which time the gyro heading data was obtained from the corresponding 75kHz Ocean Surveyor ADCP raw data input file.

Scripts:

gyroexec0: transferred data from the RVS gyronmea stream to Pstar, a nominal edit was made for directions between 0-360° before the file was appended to a master file.

gp4exec0: transferred data from the RVS gps_4000 stream to Pstar, edited out pdop (position dilution of precision) greater than 5 and appended the new 24 hour file to a master file.

gpsg12exec0: this was identical to gp4exec0 but transferred the RVS gps_g12 data stream to Pstar.

Gpsglosexec0: as above to transfer the Glonass GPS stream

Heading

The ships attitude was determined every second with the ultra short baseline 3D GPS Ashtech ADU2 navigation system. Four antennae, 2 on the boat deck, two on the bridge top, measured the phase difference between incoming satellite signals from which the ship's heading, pitch and roll were determined. Configuration settings from previous calibrations (Trials cruise in April 2001) were used throughout the cruise, these were:

	X(R)	Y(F)	Z(U)
1-2 Vector	0.000	6.492	0.167
1-3 Vector	-10.162	0.135	-4.337
1-4 Vector	-10.113	6.431	-4.193

Table 7.1.1 Adjusted Relative Antenna Positions (m) requiring no pitch or roll offset angle

The Ashtech data were used to calibrate the gyro heading information as follows:

ashexec0: transferred data from the RVS gps_ash stream to pstar.

ashexec1: merged the ashtech data from ashexec0 with the gyro data from gyroexec0 and calculated the difference in headings (hdg and gyroHdg); ashtech-gyro (a-ghdg).

ashexec2: edited the data from ashexec1 using the following criteria:

heading	0 < hdg < 360 (degrees)
pitch	-5 < pitch < 5 (degrees)
roll	-7 < roll < 7 (degrees)
attitude flag	-0.5 < attf < 0.5
measurement RMS error	0.00001 < mrms < 0.01
baseline RMS error	0.00001 < brms < 0.1
ashtech-gyro heading	-7 < a-ghdg < 7 (degrees)

The heading difference (a-ghdg) was then filtered with a running mean based on 5 data cycles and a maximum difference between median and data of 1 degree. The data were then averaged to 2 minutes and further edited for

-2 < pitch <2

0 < mrms < 0.004

The 2 minute averages were merged with the gyro data files to obtain spot gyro values. The ships velocity was calculated from position and time, and converted to speed and direction. The resulting a-ghdg should be a smoothly varying trace that can be merged with ADCP data to correct the gyro heading. Diagnostic plots were produced to check this. During ship manoeuvres, bad weather or around data gaps, there were spikes which were edited out manually (plxyed).

Ashtech 3D GPS coverage was generally good. Gaps over 1 minute in the data stream are listed below.

time gap : 06 176 22:08:33 to 06 176 22:09:45 (1.2 mins)

time gap : 06 178 10:52:13 to 06 178 11:02:01 (9.8 mins)

time gap : 06 181 08:42:15 to 06 181 08:52:14 (10.0 mins)

time gap : 06 182 20:22:25 to 06 182 20:23:28 (1.1 mins)

time gap : 06 187 01:14:45 to 06 187 01:16:53 (2.1 mins)

time gap : 06 187 08:02:11 to 06 187 08:03:44 (1.6 mins)

150 kHz ADCP

The 150kHz RDI ADCP was logged using RDI Data Acquisition Software (DAS) version 2.48 with profiler firmware 17.20. The instrument was configured to sample over 120 second intervals with 96 bins of 4 m thickness, pulse length 4 m and a blank beyond transmit of 4m. The high vertical resolution was chosen to support the remote detection of zooplankton patchiness. At the beginning and end of the cruise, the ADCP was switched to bottom track mode over the continental slope to enable calibration of the instrument. Spot gyro heading data were fed into the transducer deck unit where they were incorporated into the individual ping profiles to correct the velocities to earth co-ordinates before being reduced to a 2 minute ensemble.

The 150 KHz ADCP on RRS *Discovery* had been refitted in dry dock to a heading offset of ~45°. This offset was accounted for in the DAS software configuration on D306. On some previous cruises the ADCP PC clock had been synchronised with the ship's master clock, so removing the tedious need for logging the drift of the PC clock and correcting for it in the processing (old adpexec1). Sadly this was not available on D306 and adpexec1 was resurrected again.

The ADCP data were logged continually by the level C computer. From there they were transferred once a day to the Pstar data structure and processed using standard processing scripts in Pstar. These are presented below, where "##" indicates the daily file number.

Data processing:

adpexec0: transferred data from the RVS level C "adcp" data stream to Pstar. The data were split into two; "gridded" depth dependent data were placed into "adp" files while "non-gridded" depth independent data were placed into "bot" files. Velocities were scaled to cm/s and amplitude by 0.42 to db. Nominal edits were made on all the velocity data to remove both bad data and to change the DAS defined absent data value to the Pstar value. The depth of each bin was determined from the user supplied information. Output files: adp306##, bot306##

adpexec1: Clock correction applied to both, gridded and non-gridded files. The PC clock was found to have a fairly steady drift, ~ 4 seconds per day, so time checks were made every 24 hours and these offset values were used in adpexec1 to create a clock correction file for calibrating adcp time. Output files: adp306##.corr, bot306.corr

adpexec2: this merged the adcp data (both files) with the ashtech a-ghdg created by ashexec2. The adcp velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables. Output files: adp306##.true, bot306##.true.

adpexec3: applied the misalignment angle, ø, and scaling factor, A, to both adcp files. The adcp data were edited to delete all velocities where the percent good variable was 25% or less. Again, variables were renamed and re-ordered to preserve the original raw data. Output Files: adp306##.cal, bot306##.cal.

adpexec4: merged the adcp data (both files) with the GPS 4000 navigation file (gp430601) created by gps4exec0. Ship's velocity was calculated from spot positions taken from the gp430601 file and applied to the adcp velocities. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 2 minute ensemble by subtracting 60 seconds and new positions were taken from gp430601. Output Files: adp306##.abs, bot306##.abs.

A calibration of the 150 kHz ADCP was achieved using bottom tracking data available from our departure from Falmouth across the continental shelf. Using long, straight, steady speed sections of standard two minute ensemble profiles we obtained a calibration of $\tan\phi = 0.0078(\pm s.d. = 0.0057), \therefore \phi = 0.4481°$ and $A = 1.0023(\pm s.d. = 0.0052)$. These values followed a complete re-fit of the ADCP instruments in April 2005.

75 kHz ADCP

The RDI Ocean Surveyor 75 kHz Phased Array ADCP was configured to sample over 120 second intervals with 60 bins of 16m depth, pulse length 16m and a blank beyond transmit of 8m. The instrument is a narrow band phased array ADCP with 76.8 kHz frequency and a 30° beam angle. The PC was running RDI software VmDAS v1.3. Gyro heading, and GPS Ashtech heading, location and time were fed as NMEA messages into the software which was configured to use the Gyro heading for co-ordinate transformation. The software logs the PC clock time, stamps the data (start of each ensemble) with that time, and records the offset of the PC clock from GPS time. This offset was applied to the data in the processing path before merging with navigation. The ADCP was fitted in the forward well as previously noted. It was known to have a heading alignment offset of 60°, this offset was fed into the RDI software configuration, although the software appeared to ignore it. Bottom tracking was switched at the beginning and at the end of the cruise for calibration purposes.

The 2 minute averaged data were written to the PC hard disk in files with a .STA extension, e.g. D306005_000000.STA, D306006_00000.STA etc. Sequentially numbered files were created whenever data logging was stopped and re-started. The software was set to close the file once it reached 100MB in size, though on D306 files were closed after ~24 hours, so they never became that large. All files were transferred to the Unix directory /data32/os75. Broadly speaking the processing path followed the steps outlined for the 150 kHz ADCP. In the following script description, "##" indicates the daily file number.

In parallel with the 150 KHz ADCP, a calibration of the 75 kHz ADCP was achieved using bottom tracking data available from our departure across the continental shelf from Falmouth. Using long, straight, steady speed sections of standard two minute ensemble profiles (.STA files) we obtained a calibration of $\tan\phi = -1.7078(\pm s.d. = 0.0111), \therefore \phi = -59.6479°$ and

$A = 1.0036(\pm s.d. = 0.0049)$. As with the 150kHz ADCP, these values follow a complete re-fit of the instruments in April 2005.

surexec0: data read into Pstar format from RDI binary file (psurvey, new program written on D253 by S. Alderson). Water track velocities written into "sur" file, bottom track into "sbt" files if in bottom track mode. Velocities were scaled to cm/s and amplitude by 0.45 to db. The time variable was corrected to GPS time by combining the PC clock time and the PC-GPS offset. The depth of each bin was determined from the user supplied information. Output Files: sur306##.raw, sbt306##.raw.

surexec1: data edited according to status flags (flag of 1 indicated bad data). Velocity data replaced with absent data if variable "2+bmbad" was greater than 25% (% of pings where >1 beam bad therefore no velocity computed). Three extra steps were necessary on D306 to deal with spikes in the PC-GPS time offset, deltatim. Using pedita and peditc, data was set to absent where deltatim lay outside of the range -10 to 10 seconds and the absent data points were interpolated over. Time of ensemble moved to the end of the ensemble period (120 secs added with pcalib). Output files: sur306##, sbt306##.

surexec2: this merged the adcp data (both files) with the ashtech a-ghdg created by ashexec2. The adcp velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables. Output files: sur306##.true, sbt306##.true.

surexec3: applied the misalignment angle, ø, and scaling factor, A, to both files. Variables were renamed and re-ordered to preserve the original raw data. Output Files: sur306##.cal, sbt306##.cal.

surexec4: merged the adcp data (both files) with the GPS 4000 navigation file (gp430601) created by gps4exec0. Ship's velocity was calculated from spot positions taken from the gp430601 file and applied to the adcp velocities. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 2 minute ensemble by subtracting 60 seconds and new positions were taken from gp430601. Output Files: sur306##.abs, sbt306##.abs.

7.2 Lowered CTD sampling, processing & calibration *(Adrian Martin, John Allen, Peter Keen, Roz Pidcock, Jason Scott, John Short & Dave Teare)*

Introduction

In total 50 CTD stations were completed on cruise D306. Of these 23 were completed at the central PAP site: 48^o 50'N 16^o 30'W. Depths of the profiles varied from 200m to 4000m. The 4 day mesoscale survey involved 24 casts away from the PAP site all to a depth of 500m with bottles being fired "on-the-fly" for speed. Niskin bottles were typically fired at 12 depths with two bottles per depth at the PAP site for the dawn cast with depths chosen according to requirements e.g. light level, presence of DCM and at 12 fixed depths (5, 20, 40, 60, 80, 100, 150, 200, 250, 300, 400, 500m) on the mesoscale survey with number of bottles at each depth dictated by requirements. Other casts at the PAP site were to depths suiting particular sampling requirements (flow cytometry, thorium etc) and bottle-firing depths varied accordingly.

Sampling

Samples were taken from all CTDs in the following order; oxygen, nanomolar nutrients, flow cytometry, salinities, nutrients, HPLC, primary production, thorium. Chlorophyll samples were not collected for calibrating the CTD's fluorometer on board.

Processing

The processing of SeaBird CTD data closely followed that of P314 (Read et al., 2004). That in turn was a modified version of the protocol adopted on D258, Marine Productivity I (Pollard and Hay, 2002). Details can be found below.

Note that 5-digit CTD station numbers were used throughout the cruise – 306nn. In addition, each CTD cast received a D306 deployment number. All processed CTD files are named according to CTD station number but also contain in the header the corresponding D306 deployment number. Table 7.2.1 shows the pairings of CTD station and D306 deployment numbers:\bold entries are mesoscale survey casts and italic entries are other casts away from the central PAP site. A number in brackets denotes where a different number was used on CTD log sheet to that recorded by the bridge. In such cases the number in brackets is the CTD sheet number.

CTD stn.	D306 number	time	CTD stn.	D306 number	time
ctd30601	176001	1055	ctd30626	184005	0320
ctd30602	176007	2100	ctd30627	184008(184006)	0747
ctd30603	177003	0356	ctd30628	184009	1005
ctd30604	177005	0821	ctd30629	184010	1459
ctd30605	177008	1157	ctd30630	184011	1708
ctd30606	178003	0353	ctd30631	184012	1915
ctd30607	178004	0537	ctd30632	184013	2229
ctd30608	179003	0343	ctd30633	185003	0300
ctd30609	179009	1913	ctd30634	185006	0735
ctd30610	180003	0346	ctd30635	185008	1242
ctd30611	180005	0645	ctd30636	185009	1459
ctd30612	180007	1106	ctd30637	185010	1713
ctd30613	181003	0344	ctd30638	185011	2204
ctd30614	181005	0705	ctd30639	186001	0024
ctd30615	182003	0340	ctd30640	186004	0318
ctd30616	182005	0700	ctd30641	186007	0740
ctd30617	182008	1045	ctd30642	186008	0955
ctd30618	182010	1747	ctd30643	186009	1446
ctd30619	183007	0326	ctd30644	186010	1705
ctd30620	183010	0730	ctd30645	186011	1912
ctd30621	183011	0947	ctd30646	186012	2244
ctd30622	183015	1628	ctd30647	187004	0337
ctd30623	183016	1839	ctd30648	187007	0728
ctd30624	183017	2048	ctd30649	187009	1045
ctd30625	184001(183018)	0007	ctd30650	188003	0320

Table 7.2.1: CTD sampling

1. SeaBird Software processing (SBEDataProcessing-Win32)

All processing was carried out in \\Discovery2ng\d306\D306\ctd. Full pathnames were used throughout, though from now on \ctd\raw and \ctd are used here as shorthand for convenience.

The following steps were run on the binary 24Hz data. The input files were NNNNNN.dat, NNNNNN.BL, NNNNNN.CON and NNNNNN.HDR where NNNNNN is the D306 deployment number. All input files were kept in \raw with processed data being stored in \ctd. A batchfile (D306Batch.txt) was created to process each raw file:

```
Datcnv /i%1\%2.DAT /c%1\%2.CON /p%1\DatCnv.psu /o%1
Wildedit /i%1\%2.CNV /p%1\WildEdit.psu /o%1
Filter /i%1\%2.cnv /p%1\Filter.psu /o%1
Alignctd /i%1\%2.CNV /p%1\AlignCTD.psu /o%1
Celltm /i%1\%2.CNV /p%1\CellTM.psu /o%1
Bottlesum /i%1\%2.ROS /c%1\%2.CON /p%1\BottleSum.psu /o%1
Trans /i%1\%2.CNV /p%1\Trans.psu /o%1
BinAvg /i%1\%2.cnv /p%1\BinAvg.psu /o%1
AsciiOut /i%1\%2.1Hz.cnv /p%1\Ascii_Out.psu /o%1
```

e.g to process raw file 176001.dat, execute

```
sbebatch \\Discovery2ng\d306\D306\ctd\raw\D306Batch.txt
\\Discovery2ng\d306\D306\ctd\raw 176001
```

The steps carried out by the batch file were set up in the following manner:

<u>Data conversion</u>

This generates .cnv and .ros file

- File setup
  - Program setup file DatCnv.psu was created in \raw
  - Instrument config file set to \raw\176001.CON (note: immaterial as overridden by batch file)
  - Config. file matched to input file.
  - Input dir: \raw
  - Input file: \raw\176001.dat (immaterial as overridden by batch file)
  - Output dir: \raw
  - Name append: left blank (will automatically append .cnv)
  - Output file: left blank
- Data setup
  - Process scans to end of file: yes
  - Scans to skip over: 0
  - Ouput format: ascii
  - Convert data from: upcast and downcast
  - Create file types: both bottle and data
  - Source of scan range data: .BL file
  - Scan range offset: 0sec
  - Scan range duration:
    - 5sec for standard casts (chosen after discussion with Dave Teare – CTD exceedingly unlikely to move on again within 5sec of bottle firing)
    - 1.5sec for mesoscale survey casts as bottles fired “on the fly” and 1.5 secs corresponds to roughly 1m travel.
  - Merge separate header file: No

Select output variables:

Note: temp2 and cond2 are the preferred sensors on the vane. The others (temp and cond) have a considerable lag (~5-10dbar) due to entrainment by the CTD frame. The names are swapped by ctd0 such that temp2 in the binary data becomes temp in the pstar version and vice versa (ditto for cond). Preliminary analysis however suggests that the vane-mounted instruments may experience ~6s or 4dbar oscillations on the mesoscale survey upcasts in the top 100m. This is under investigation.

1	pressure (digiquartz) – dbar	11	fluor (Chelsea Aqua 3 Chl Con) – □g/l
2	temp 2 (ITS-90) – deg C	12	user poly (BBRTD)
3	cond 2– mS/cm	13	Beam transmission (Chelsea/Seatech/Wetlab)
4	temp (ITS-90) – deg C	14	time elapsed - seconds
5	cond – mS/cm	15	jday
6	altimeter – m	16	latitude – deg
7	oxygen (SBE43) – □mol/kg	17	longitude – deg
8	temp difference, 2-1 (ITS-90) – deg C	18	voltage 5 (PAR) – volts
9	cond difference, 2-1 – mS/cm	19	voltage 4 (UPAR – upwelling irradiance i.e. sensor faces downwards) – volts
10	pot. temp (ITS-90) – deg C		

Table 7.2.2: Variables measured

WildEdit

Details as suggested in P314 report (Read et al., 2004)

File setup

Program setup file WildEdit.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

standard deviations for pass 1: 1

standard deviations for pass 2: 2

scans per block: 10

keep data within this distance of mean: 0

Exclude scans marked bad: yes

Select WildEdit variables:

select all

Filter

Details as suggested in P314 report (Read et al., 2004)

File setup

Program setup file Filter.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

Low pass filter A: 0.03

Low pass filter B: 0.15

A should be applied to conductivity (1,2 and 1-2)

B should be applied to pressure

AlignCTD

Details as suggested in P314 report (Read et al.,2004)

File setup

Program setup file AlignCTD.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

Enter advance values

oxygen advanced 10sec, all others unaffected

CellTM

Details as suggested in P314 report (Read et al., 2004)

File setup

Program setup file CellTM.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

α=0.03

1/β=7

both applied to both temperature sensors

BottleSum (has been renamed from RosSum since P314)

Generates a .btl file

Details as suggested in P314 report (JTA)

File setup

Program setup file BottleSum.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Config. filename doesn't matter as over-ridden by batch file

Match to input file: yes

Data setup

Output min and max for averages variables: yes

All variables EXCEPT TIME to be averaged (also exclude scan count if it appears)

Derived variables to average:

none

Translate

Details as suggested in P314 report (Read et al., 2004)

Note the output file (.cnv) has an extra variable to that chosen in Data Conversion. It is a flag of some type though haven't tracked down what yet. In ctd0 it is just referred to as "flag"

File setup

Program setup file Trans.psu was created in \raw

I/p dir and file, o/p name, dir and "appendation" as DataConversion

Data setup

Bin->ascii

BinAvg

Generates .1Hz.cnv file

Details as suggested in P314 report (JTA)

File setup

Program setup file BinAvg.psu was created in \raw
I/p dir and file, o/p name, dir and "appendation" as DataConversion
Name append: .1Hz

Data setup
Bin type: time (seconds)
Bin size: 1 sec
Include no. scans per bin: no
Exclude scans marked bad: yes
Scans to skip over: 0
Cast to process: up and down

<u>AsciiOut</u>

Generates .1hz.asc file

File setup
Program setup file ASCII_Out.psu was created in \raw
I/p dir and file, o/p name, dir and "appendation" as DataConversion
Data setup
Output header: yes
Lines/page: 60
Output data: yes
Exclude bad scans: yes
Columns labelled at top of file
Column separator: space
Julian days format: Julian days
Replace bad flag: -999.0

2. Pstar processing

Note that execs ctd0, ctd1, ctd2 and sam0 are slightly modified versions of those used on Poseidon 314. They appear to differ considerably from those used on previous *Discovery* cruises so care should be exercised in ensuring the correct exec version is used for any subsequent reanalysis..

ctd0 – translates the 24Hz SeaBird ctd306nn.cnv file into pstar format. Requires the latitude and longitude of the bottom of each cast. These are manually entered from details on the CTD logsheet but can be automatically checked and corrected later on. Output ctd306nn.24hz.

ctd1 – after checking output of ctd0 with plxyed for spikes that may need to be removed before proceeding, ctd1 averages 24Hz data into 1Hz and derives salinity, potential temperature and density. Output ctd306nn.1hz.

ctd2 – requires user to obtain datacycle numbers of 1^{st} good, deepest and last good data using plxyed and mlist prior to use. This exec then extracts data corresponding to the full up and down cast (ctd306nn.ctu) and purely the downcast (ctd306nn.2db which is averaged into 2db bins.

printexec – can be used to generate plots of potential temperature and salinity versus depth for the output of ctd2. For simplicity of use, pdf files have been created for 250m (ctd250.pdf) and 1000m (ctd1000.pdf) only so far. They are easily modified for other depths ranges though *sam0* – converts the ascii .btl file generated by SeaBird processing into a pstar file that contains the CTD variables corresponding to the bottle firing times. Output fir306nn in directory ctd/fir/

Due to the short duration of the cruise it was not possible to proceed further in the processing and calibration of the CTD data while at sea.

7.3 Salinometry *(Adrian Martin, John Allen, Roz Pidcock, Dave Teare)*

A Guildline Autosal salinometer (model 8400B, serial no. 60839) was installed in the controlled temperature laboratory (maintained at 20^{o}C). According to the manual, the 8400B can operate successfully at lab temperatures between 4°C below and 2°C above the bath temperature, the preferred temperature being in the middle of this range. The bath temperature was set at 21°C. A thermometer was used to measure the temperature of the CT lab, which varied little (between 20^{o}C and 21°C) throughout the cruise. Salinity samples were stored in the CT lab for at least 24hours prior to analysis. Generally the salinometer behaved well though it developed a leak on 5th July (184) when processing crate 1 for file D30609.dat. While attempting to rectify this by adjusting the seal on the intake pipe from the peristaltic pump it was realised that this seal had obviously been problematic before as it was wound with wire. The whole peristaltic pump component of the salinometer was therefore replaced by Dave Teare.

OSIL's Autosal software, SoftSal, was used throughout. On multidisciplinary cruises this expedites the entry of determined salinities into excel spreadsheets for merging with instrument data files. The software and the Autosal worked well and the stability of measurements, determined by monitoring the standard deviation of salinity measurements, was good. With few exceptions, the bottle samples were determined to a precision greater than 0.001. There are a couple of points worth noting about using this software however; firstly the software encourages the operator to re-trim the salinometer after each standardisation to standard seawater. This is almost certainly because the measured salinity standard is not recorded in the output file (the second point to note), so no post measurement offset can be made. OSIL's latest software (advertised in the standard seawater boxes), looks as though it overcomes this limitation, furthermore it is designed to be directly compatible with spreadsheet software like MS Excel. Standard seawater samples were analysed after every crate as a quality check.

Salinity values were copied in to an Excel spreadsheet, then transferred to the Unix system in the form of a tab-delimited ASCII file. Data from the ASCII files will be incorporated into the sam files using the Pstar script passam. There was insufficient time on the cruise to do this or to take the calibration of CTD or TSG data further while at sea.

Crate number	Bottle numbers	Date crate completed	jday	Time crate completed	Date sals. calculated	Salinities file
1	1-24	26/6	177	09:30	30/6	D306001.dat
6	121-144	28/6	179	04:00	30/6	D306002.dat
10	217-240	30/6	181	04:30	4/7	D30603.dat
11	241-268	1/7	182	18:00	4/7	D30604.dat
25	620-643	2/7	183	17:00	4/7	D30605.dat
26	644-668	3/7	184	08:30	5/7	D306006.dat
23	572-593	3/7	184	20:00	5/7	D30607.dat
22	548-568	4/7	185	13:30	7/7	D30608.dat
1	1-24	5/7	186	01:00	7/7	D30609.dat
25	620-643	5/7	186	18:00	7/7	D306010.dat
27	668-691	5/7	186	18:30	7/7	D306011.dat
10	217-240	6/7	187	05:00	8/7	D306012.dat
6	121-144	6/7	187	20:30	8/7	D306013.dat
26	644-667	7/7	188	04:30	8/7	D306014.dat

Table 7.3.1: Salinity bottles used

7.4 MVP CTD data *(John Allen, Jon Short, Dave Teare, Adrian Martin & Roz Pidcock)*

Station Summary

Station no.	Start date	Start time	Stop date	Stop time	Duration	Distance run start (km)	end (km)	total (km)	Notes
Test deploy-ment	25/06/06	18:15	25/06/06	20:33	2 h 18 m	489	538	49	Run into PAP site
NE Quadrant	02/07/06	06:33	3/07/06	02:02	19 h 29 m	1593	1843	250	Incorporated a mooring recovery)
SE Quadrant	03/07/06	06:08	4/07/06	00:40	18 h 32 m	1856	2152	296	
NW Quadrant	04/07/06	06:12	5/07/06	02:25	20 h 13 m	2165	2463	298	Incorporated Autosub recovery
SW quadrant	05/07/06	06:25	6/07/06	00:47	18 h 22 m	2478	2759	281	Incorporated Autosub deployment
				Total	**3 d 6 h 54 m**			**1174**	

Table 7.4.1: MVP tows

Data

The BOT (Brooke Ocean Technologies) MVP 300, carried an AML micro CTD (Conductivity, Temperature, Depth) instrument (S/N 7027), a WETLabs fluorimeter, a SeaBird SBE23 oxygen sensor (S/N 230960) and two PAR sensors. To fit in with the time constraints imposed by the daily sampling at the PAP site, a fine-scale survey of four quadrants (Fig 7.4.1) was completed at a tow speed of 11-11.5 knots. At this speed the MVP was setup to cycle from the surface to 300 m every 12-13 minutes.

During MVP deployments data were recovered, in near real time, through the BOT software on a PC in the main lab. A series of files are created after each down/up cycle. The principal file containing most of the data had the suffix '.m1'. Eight other files were written, most duplicating some of the data streams in the '.m1' file but in a specific format for feeding into other instruments. The PAR data were not in the '.m1' file and only seem to be present in a raw counts instrument file. No attempt was made to read the PAR data in during the cruise, but the raw files were archived with all the other cruise data for later reference if required.

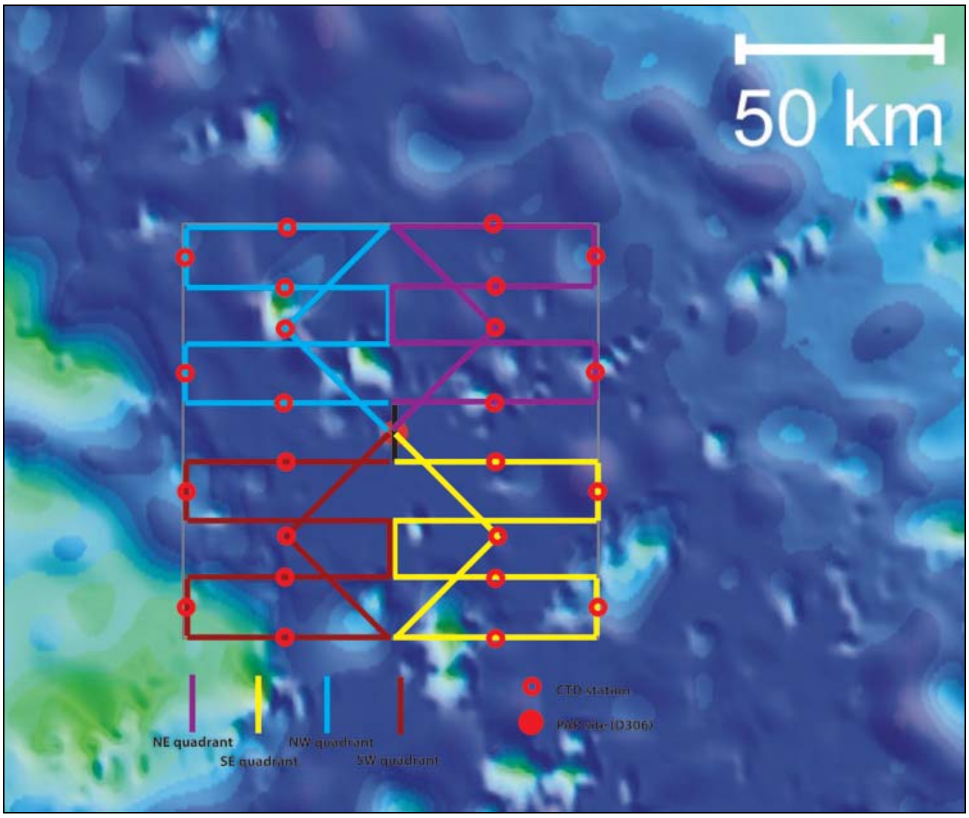

Fig 7.4.1: MVP Tows (lines) with CTD stations (circles)

With the exception of the 'user variables' channels, the data in the '.m1' files are in engineering units 'calibrated' using pre-set coefficients stored in the BOT software. The fluorimeter and the oxygen sensor were connected to the 'user variables' channels, U1 and U2/U3 for Oxy. Current/Temperature. The sensors sample at 25 Hz, and each data file (.m1) is time stamped with GPS time in the header only.

Owing to the short duration of this cruise, no attempt was made at in-situ calibration of either salinity, fluorescence or oxygen on board; the data therefore await this process post cruise.

Processing Steps

The following processing route was followed after each quadrant of the MVP survey:

After each quadrant of the survey was completed, the PC files were transferred to the ship's UNIX computer system by ftp over the ship's ethernet.

mvpexec0

Read the '.m1' data files, typically 55-60 files for each quadrant, e.g d306013.m1 – d306065.m1 data into PSTAR format files. Extract the start time from the header information and place it in the PSTAR headers, then create a relative 25Hz time variable for each PSTAR file. Calibrate variables as appropriate, and create a temperature difference variable. De-spike data and create 1Hz averaged files. Finally append the 1Hz files into a 1Hz survey file, e.g. mvp30604.raw.

mvpexec1

The main steps to mvpexec1 are firstly *pcalc* to apply a temperature lag correction (see below) which, having experimented with a number of larger corrections, turned out to be 0.12 and this remained constant throughout the whole fine-scale survey. Secondly *peos83* is run to calculate potential temperature, salinity and density.

Pedita was then used to remove the worst surface salinity spiking. No attempt was made at this time to edit the fluorimeter spikes which are simply too numerous to hand edit. There is clearly a signal in the fluorimeter data, but some thought will have to be given to its cleaning. Further editing for spikes, and salinity offsets due to fouling of the conductivity cell was carried out by inspection with *plpred*.

Temperature Correction

It is necessary to make a correction for the small delay in the response of the CTD temperature sensor for two reasons. Firstly, to obtain a more accurate determination of temperature for points in space and time. But, more importantly to obtain the correct temperature corresponding to conductivity measurements, so that an accurate calculation of salinity can be made.

A lag in temperature is apparent in the data in two ways. There is a difference between up and down profiles of temperature (and hence salinity) because the time rate of change of temperature has opposite signs on the up and down casts. The second manifestation is the "spiking" of salinity as the sensors traverse maxima in the gradients of temperature and salinity. The rate of ascent and descent of the MVP is greater (up to ~ 6 ms^{-1} during descent and at the beginning of ascent) than that of a lowered CTD package, thus the effects of the temperature lag are more pronounced. Thus, the following correction was applied to the temperature during ***mvpexec1*** before evaluating the salinity

$$T_{corr} = T_{raw} + \tau.\Delta T$$

where ΔT is defined above and τ is constant.

The best value of τ was chosen so as to minimise the difference between up and down casts and noise in the salinity profile. The best value was found to be $\tau = 0.12$ second.

7.5 Surfmet and thermosalinograph sensor information *(John Allen, Adrian Martin & Roz Pidcock)*

These sensors were logged continuously throughout the cruise. However, there was insufficient time to calibrate the data whilst at sea. Salinity samples to calibrate the TSG were only taken during the mesoscale survey when they were taken at least once per watch (4 hours). No chlorophyll samples were taken simply due to constraints on the available manpower. The mesoscale survey included 24 CTD stations and so more intense monitoring of surface salinity was not required.

The following information was provided by Martin Bridger. Calibrations will be supplied by him on return to NOCS.

Manufacturer	Sensor	Serial no	Comments
FSI	OTM temperature	1370	
FSI	OTM temperature	1360	remote
Wetlabs	fluorometer	247	
Seatech	transmissometer	CST-112R	
Vaisala	Barometer PTB100A	U1420016	Z4740021 is in spares bo
Vaisala	Temp/humidity HMP44L	UI1850012	S/N sticker missing
ELE	PAR	28558	Port Made by Sky, no S/N marking
ELE	PAR	28557	Stb Made by Sky, no S/N marking
Kipp and Zonen	TIR CMB6	47463	Port
Kipp and Zonen	TIR CMB6	47462	Stb
Sensors without cal			
FSI	OCM conductivity	1376	
Vaisala	Sensor collector QLI	S353014	Not checked
Vaisala	Anemometer WAA	P50421	
Vaisala	Wind vane WAV	S21214	S/N sticker missing
Rhopoint	+/- 5v		
Rhopoint	+/- 5v		
Spares			
Manufacturer	Sensor	Serial no	Comments
FSI	OTM temperature	1401	+1374 +1340
FSI	OTM temperature		
Wetlabs	fluorometer	246	
Seatech	transmissometer	CST-113R	
Vaisala	Barometer PTB100A	S3610008	
		Z4740021	
Vaisala	Temp/humidity HMP44L		
ELE	PAR	28563	
ELE	PAR		
Kipp and Zonen	TIR CMB6	962276	
Kipp and Zonen	TIR CMB6		
Sensors without cal			
FSI	OCM conductvity	1331	
Vaisala	Sensor collector QLI		
Vaisala	Anemometer WAA	45517	22306 added D306 ex-Darwin
Vaisala	Wind vane WAV	R07101	21213 added D306 ex-Darwin
Rhopoint	+/- 5v		
Rhopoint	+/- 5v		

Table 7.5.1: Sensor details

7.6: Turbulence measurements *(Hartmut Prandke)*

Chronology (Time: local time)

Date	Activity
June 20, 2006	Transport of MSS system to Southampton
June 21, 2006	Transport of MSS system from Southampton to Falmouth
June 22, 2006	Test of profiler function after transport: o.k.
June 23, 2006	Setting of new calibration coefficients in probe file, test of update probe file: o.k. 18.00 leaving Falmouth, steaming to PAP (Porcupine Abyssal Plain) area.
June 24, 2006	Steaming to PAP area. Installation of winch at the stern of *Discovery* (Port side), test of the complete system: o.k.
June 25, 2006	Steaming to PAP area Local time from now is UTC. Test station for instrument tests and water sampling before arriving PAP area. MSS test profiles for setting the sinking velocity and sensor tests Profiler adjustment: Standard protection guard (new) Buoyancy ring with fringes Set of large buoyancy rings (2+3) 2 standard buoyancy rings 7 weight rings 12.15 – 13.30 Station 176002 Cast D3060001 SHE1 = 6051, SHE2 = 6050 Exchange shear probe for SHE1 Cast D3060002 SHE1 = 6001, SHE2 = 6050 20.45 arriving PAP area. General observation: At all station in PAP area many jelly-fish like objects are swimming in the water. Several times the MSS hit such objects. In these profiles one ore both shear sensors are disturbed.
June 26, 2006	Mooring recovery and PAP station work Exchange shear probe for SHE1 05.10 – 07.30 Station 177004 Casts D3060003 – 16 SHE1 = PNS06 #1002, SHE2 = 6050 Exchange shear probe for SHE1 13.00 – 14.00 Station 177009 Casts D3060017 - 22 SHE1 = PNS06 #1001, SHE2 = 6050
June 27, 2006	Mooring recovery and PAP station work Exchange shear probe for SHE2 06.15 – 08.00 Station 178005 Casts D3060023 – 32 SHE1 = PNS06 #1001, SHE2 = 6001 Remove one weight ring to reduce sinking velocity 14.10 – 15.20 Station 178006 Casts D3060033 - 38 SHE1 = PNS06 #1001, SHE2 = 6001
June 28, 2006	Mooring recovery and PAP station work 04.45 – 06.10 Station 179004 Casts D3060039 – 45 SHE1 = PNS06 #1001, SHE2 = 6001
June 29, 2006	Final mooring recovery and PAP station work 04.35 – 06.30 Station 180004 Casts D3060046 – 55 SHE1 = PNS06 #1001, SHE2 = 6001

June 30, 2006	Lay moorings and PAP station work Exchange shear probe for SHE1 04.35 – 06.30 Station 181004 Casts D3060056 – 65 SHE1 = PSS #05, SHE2 = 6001 13.05 – 15.00 Station 181008 Casts D3060066 – 76 SHE1 = PSS #05, SHE2 = 6001
July 1, 2006	Lay moorings and PAP station work Exchange shear probe for SHE1 04.40 – 06.30 Station 182004 Casts D3060077 – 86 SHE1 = PNS06 #1002, SHE2 = 6001 11.35 – 15.35 Station 182009 Casts D3060087 – 105 SHE1 = PNS06 #1002, SHE2 = 6001
July 2, 2006	First day of CTD and MVP (Moving Vessel Profiler) tow fish sections around PAP station. 04.25 – 05.20 Station 183008 Casts D3060106 – 110 SHE1 = PNS06 #1002, SHE2 = 6001
July 3, 2006	2nd day of CTD and MVP tow fish sections around PAP station. 04.00 – 05.20 Station 184006 Casts D3060111 – 117 SHE1 = PNS06 #1002, SHE2 = 6001
July 4, 2006	3rd day of CTD and MVP tow fish sections around PAP station. Exchange shear probe for SHE1 03.50 – 05.15 Station 185004 Casts D3060118 – 124 SHE1 = PNS06 #1001, SHE2 = 6001
July 5, 2006	4th day of CTD and MVP tow fish sections around PAP station. 04.00 – 05.20 Station 186005 Casts D3060125 – 131 SHE1 = PNS06 #1001, SHE2 = 6001
July 6, 2006	PAP station work and recovery of sediment traps 04.30 – 06.30 Station 187005 Casts D3060132 – 141 SHE1 = PNS06 #1001, SHE2 = 6001 08.40 – 10.15 Station 187008 Casts D3060142 – 148 SHE1 = PNS06 #1001, SHE2 = 6001
July 7, 2006	PAP station work 04.20 – 06.30 Station 188004 Casts D3060149 – 158 SHE1 = PNS06 #1001, SHE2 = 6001 12.00 End of measurements Steaming for Cork Dismantling MSS system, cleaning and packing instruments.

Table 7.6.1: Activities undertaken

Dissipation measurement technology

Profiler description

During the *Discovery* D306 cruise, the microstructure profiler MSS90L, serial no. 10 was used for microstructure measurements. The profiler is produced by *Sea & Sun Technology GmbH* in co-operation with *ISW Wassermesstechnik.*

The MSS Profiler is an instrument for simultaneous microstructure and precision measurements of physical parameters in marine and limnic waters. It is designed for vertical profiling within the upper 500 m. The data are transmitted via electrical cable to an on board unit and further to a data acquisition PC.

The main housing of the MSS90L profiler consists of a cylindrical titanium tube with a length of 1250 mm and a diameter of 90 mm. The housing is pressure tight to 5 MPa (~ 500 m).

Adjusting weights and buoyancy rings can be fixed at both ends of the housing. This allows to give the profiler different buoyancy, and consequently, different sinking velocities.

The MSS Profiler was equipped with 2 velocity microstructure shear sensors (for turbulence measurements, SHE1, SHE2), a microstructure temperature sensor (NTC), standard CTD sensors for precision measurements (PRESS, TEMP, COND), a turbidity (light scattering) sensor, a vibration control sensor (ACC), a two component tilt sensor (TILTX, TILTY), and a surface detection sensor (SD) to indicate the water surface hit at rising measurements (see table below). The sampling rate for all sensors is 1024 samples per second, the resolution 16 bit. All sensors are mounted at the measuring head of the profiler (sensor end). The microstructure sensors are placed at the tip of a slim shaft, about 150 mm in front of the CTD sensors.

Sensor equipment of the MSS Profiler

Parameter	Principle	Sensing element	Length of sensor tip	Time constant
Microstructure temperature (with linear and pre-emphasized output channels: NTC, NTCHP, NTCAC)	Resistance measurement	Glass encapsulated micro thermistor	Approx. 0.25mm	10 ms
Current shear (SHE1, SHE2)	Lift force measurement at airfoil nose	Piezoceramic bending beam	4 mm	Approx. 3 ms

Table 7.6.2: Microstructure sensors

Parameter	Principle	Range	Accuracy	Resolution	Time constant
Pressure (PRESS)	Piezo-resistive	0 - 50 Bar	+/- 0.1 % of full scale	0.002 % of full scale	40 ms
Temperature (TEMP)	Resistor Pt 100	-2 ... +38 °C	+/- 0.01 °C	0.001 °C	160 ms
Conductivity (COND)	7-Pole-cell	0 ... 60 mS/cm	+/- 0.01 mS/cm	0.001 mS/cm	100 ms

Table 7.6.3: Precision CTD sensors

Parameter	Principle	Range	Accuracy	Resolution	Time constant
Turbidity (TURB)	Light scattering	0 – 25 FTU	Not specified	Not specified	Approx.40 ms

Table 7.6.4: Optical sensor

Parameter	Principle	Sensing element	Time constant
Tilt (TILTX, TILTY)	Conductivity measurements	Liquid over stray field	Approx. 100 ms
Surface detection (SD)	Capacity measurement	3 mm needle electrode	Approx. 3 ms
Horizontal profiler acceleration (ACC)	Lift force measurement at inertial mass	Piezoceramic bending beam	Approx. 3 ms

Table 7.6.5: Control sensors

The general behaviour of the MSS Profiler is described in detail by Prandke, Holtsch and Stips (2000).

Microstructure shear measurement technology

For measurements of velocity microstructure (turbulence), the MSS Profiler is equipped with two shear probes PNS01. This shear probes consist of an axially symmetric airfoil of revolution separated by a cantilever from a piezoceramic beam. The piezoceramic bending element is isolated by a Teflon tube against water. This gives the sensor an excellent long term stability. The length and diameter of the airfoil are 4 mm and 3 mm, respectively. The spatial resolution of the PNS shear probe belongs to approx. 8 mm. The general behaviour of an airfoil sensor have been described in detail by Osborn and Crawford (1980). The mean velocity due to the profiling speed of the probe is aligned with the axis of revolution. While the probe is not sensitive to axial forces, the cross-stream (transverse) components of turbulent velocity produce a lifting force at the airfoil. The piezoceramic beam senses the lift force. The output of the piezoceramic element is a voltage proportional to the instantaneous cross-stream component of the velocity field

Deployment and operation of the microstructure measuring system

For vertical sinking measurements, the profiler was balanced with a negative buoyancy which gave it a velocity of about 0.6 m/s. The MSS was operated via a winch SWM1000, mounted at the stern of the ship. During the MSS measurements, the ship was moving with approx. 0.5 to 1 kt against the wind. Disturbing effects caused by cable tension (vibrations) and the ship's movement were excluded by a slack in the cable.

With respect to the intermittence of marine turbulence, repeated MSS measurements were carried out in bursts of at least 5 casts at each station. The measurement interval was approx. 12 min. The length of the measurement periods varied between one and 2.5 hours.

Data collection and archiving

The raw data from the MSS Profiler are transmitted via RS 485 data link to the on board unit of the measuring system. For data registration, a notebook was used.

For the data acquisition, on-line display and storage of the data delivered by the MSS Profiler the software package SDA 180 (*Sea & Sun Technology GmbH*) was used. The data are stored in the MRD (Microstructure Raw Data) format at hard disk..

Calibration and sensor tests

Calibration of the shear sensors was performed by *ISW Wassermesstechnik* using a special shear probe calibration system. The probe rotates about its axis of symmetry at 1 Hz under an angle of attack in a water jet of a constant velocity. At different angles of attack the rms. voltage output of the probe is measured. The probe sensitivity is the slope of the regression (best fit of a cubic approximation) of the sensor output versus the angle of attack.

The calibration of the CTD sensors have been carried out by *Sea & Sun Technology GmbH* using standard calibration equipment and procedures for CTD probes.

The vibration control sensor and the tilt sensors were calibrated by *ISW Wassermesstechnik* using a special calibration equipment for both sensors.

Shear probe sensitivities

Channel	Sensor type	Serial No.	Sensitivity	Date of calibration.
SHE1	PNS01	6051	1.20e-4 $(Vms^2)/kg$	April 2006
SHE2	PNS01	6050	1.03e-4 $(Vms^2)/kg$	April 2006
SHE1, SHE2	PNS01	6001	1.40e-4 $(Vms^2)/kg$	May 2006
SHE1	PNS06	1001	6.18e-4 $(Vms^2)/kg$	May 2006
SHE1	PNS06	1002	4.30e-4 $(Vms^2)/kg$	June 2006
SHE1	PSS	05	0.36e-4 $(Vms^2)/kg$	June 2006

Table 7.6.6.: Details of shear probe sensitivities

Channel	Characteristics
ACC sensor channel	Gain = 22 High pass filter - 20dB/decade Low frequency cut-off f_0 = 1 Hz (-3dB)
SHE sensor channels:	Gain = 11 High pass filter - 20dB/decade Low frequency cut-off f_0 = 1 Hz (-3dB)

Table 7.6.7: Characteristics of sensor channels

References

Osborn, T.R. and W.R. Crawford, 1980: An airfoil probe for measuring turbulent velocity fluctuations in water. Ch. 19 in *Air-Sea Interaction: Instruments and methods*, F. Dobson, L. Hasse and R. David (editors), Plenum Press, New York, 369-386.

Prandke, H., K. Holtsch and A.Stips, 200: MITEC Report *Technical Note No. I.96.87*, European Commission, Joint Research Centre, Space Applications Institute, Ispra/Italy.

Dissipation measurements summary

Station Lat. N, Long. W (from – to)	Begin (UTC)	End (UTC)	Micro-structure profiles	No. of profiles	Remarks
176002 49° 15.377, 16° 11.858	25/06/2006 12.20	25/06/2006 13.20	D3060001 D3060002	2	Test station on the way to PAP area Wind ≈ 4Bf
177004 48° 50.119, 16° 30.003 48° 51.606, 16° 29.467	26/06/2006 05.05	26/06/2006 07.30	D3060003 - D3060016	14	Wind ≈ 3Bf
177009 48° 50.117, 16° 29.910 48° 50.740, 16° 29.616	26/06/2006 13.00	26/06/2006 14.00	D3060017 - D3060022	6	Wind ≈ 2Bf, sunny

178005 48° 50.237, 16° 29.284 48° 48.970, 16° 29.854	27/06/2006 06.15	26/06/2006 08.00	D3060023 - D3060032	10	Wind ≈ 3-4Bf, light rain, relatively warm
178006 49° 01.824, 16° 26.300 49° 01.190, 16° 27.658	27/06/2006 14.10	27/06/2006 15.25	D3060033 - D3060038	6	Wind ≈ 2-3Bf, cloudy
179004 49° 02.010, 16° 08.732 49° 01.890, 16° 09.980	28/06/2006 04.50	28/06/2006 06.00	D3060039 - D3060045	7	Wind ≈ 4Bf, cloudy
180004 48° 50.220, 16° 29.739 48° 50.284, 16° 31.751	29/06/2006 04.40	29/06/2006 06.30	D3060046 - D3060055	10	Wind ≈ 4Bf, cloud coverage ≈ 50%
181004 48° 49.988, 16° 29.174 48° 49.009, 16° 29.524	30/06/2006 04.35	30/06/2006 06.25	D3060056 - D3060065	10	Wind ≈ 4Bf, stronger swell, cloud coverage ≈ 25%
181008 49° 00.284, 16° 27.354 49° 00.308, 16° 28.369	30/06/2006 13.05	30/06/2006 14.55	D3060066 - D3060076	11	Wind ≈ 5Bf, stronger swell, light rain
182004 48° 50.110, 16° 29.976 48° 51.598, 16° 30.736	01/07/2006 04.40	01/07/2006 06.30	D3060077 - D3060086	10	Wind ≈ 3Bf, cloud coverage ≈ 75%
182009 48° 51.662, 16° 30.552 48° 57.163, 16° 29.286	01/07/2006 11.35	01/07/2006 15.35	D3060087 - D3060105	19	Wind ≈ 4Bf, cloud coverage ≈ 50%
183008 48° 49.920, 16° 29.927 48° 50.290, 16° 28.890	02/07/2006 04.25	02/07/2006 05.20	D3060106 - D3060110	5	Wind ≈ 4Bf, cloud coverage ≈ 75%
184006 48° 51.179, 16° 30.520 48° 52.258, 16° 30.251	03/07/2006 04.00	03/07/2006 05.20	D3060111 - D3060117	7	Wind ≈ 4Bf, cloudy

185004 48° 50.174, 16° 30.766 48° 50.989, 16° 32.044	04/07/2006 03.50	04/07/2006 05.15	D3060118 - D3060124	7	Wind ≈ 3-4Bf, cloud coverage 25%
186005 48° 50.172, 16° 30.386 48° 50.687, 16° 32.086	05/07/2006 04.00	05/07/2006 05.20	D3060125 - D3060131	7	Wind ≈ 3-4Bf, cloudy
187005 48° 50.000, 16° 29.945 48° 49.345, 16° 31.502	06/07/2006 04.30	06/07/2006 06.20	D3060132 - D3060141	10	Wind ≈ 4-5Bf, swell, cloudy, warm, light rain showers
187008 48° 50.087, 16° 30.432 48° 50.073, 16° 32.731	06/07/2006 08.45	06/07/2006 10.05	D3060142 - D3060148	7	Wind ≈ 5Bf, swell cloudy, light rain showers
188004 48° 49.990, 16° 30.031 48° 49.628, 16° 32.787	07/07/2006 04.25	07/07/2006 06.30	D3060149 - D3060158	10	Wind ≈ 4Bf, cloud coverage 25%
Total cruise	25/06/2006 12.20	07/07/2006 06.30	D3060001 - D3060158	158	

Table 7.6.8: Sampling information. Note that the time entry in the header of the MRD files is in UTC.

7.7 Inorganic nutrient analysis (*Mark Stinchcombe & Matt Patey)*

Objectives:

Our objectives of cruise D306 to the PAP site in the North Atlantic were to measure the levels of the inorganic nutrients nitrate, silicate and phosphate using segmented flow analysers. There were two systems employed to meet this objective, one looking at micro-molar concentrations and a second looking at the nano-molar concentrations found in the surface waters. The micro-molar system could measure nitrate, silicate and phosphate, whilst the nano-molar system just measured nitrate and phosphate.

Methods:

Micro-molar analysis

Analysis for micro-molar concentrations of nitrate and nitrite (hereinafter nitrate), phosphate and silicate was undertaken on a Skalar sanplus autoanalyser following methods described by Kirkwood (1994) with the exception that the pump rates through the phosphate line are increased by a factor of 1.5, which improves reproducibility and peak shape. Samples were drawn from niskin bottles on the CTD into 25ml sterilin coulter counter vials and kept refrigerated at 4^{o}C until analysis, which commenced within 24 hours. Stations were run in batches of 1 to 4 with most runs containing 2 or 3 stations. Overall 19 runs were undertaken. An artificial seawater matrix (ASW) of 40g/l sodium chloride was used as the intersample wash and standard matrix. The nutrient free status of this solution was checked by running

Ocean Scientific International (OSI) nutrient free seawater on every run. A single set of mixed standards were made up by diluting 5 mM solutions made from weighed dried salts in 1 litre of ASW into plastic 1 litre volumetric flasks that had been cleaned by soaking for 6 weeks in MQ water. This was in an effort to minimise the run-to-run variability in concentrations observed on previous cruises. Data processing was undertaken using Skalar proprietary software and was done within 24 hours of the run being finished. The wash time and sample time were 90 seconds; the lines were washed daily with 0.5M sodium hydroxide (P) and 10% Decon (N, Si). Time series of baseline, instrument sensitivity, calibration curve correlation coefficient, nitrate reduction efficiency and duplicate difference will be compiled at the National Oceanography Centre to check the performance of the autoanalyser over the course of the cruise.

Nano-molar analysis:

Analysis of nitrate + nitrite and phosphate at nanomolar concentrations was undertaken using a standard continuous-flow, gas-segmented autoanalyser connected to two liquid waveguide capillary flow cells (LWCCs). The capillary flow cells have an optical pathlength of 2 metres, and it is this that allows the detection of concentrations as low as 1 nM of phosphate or 2 nM of nitrate. Two tungsten-halogen lamps and two miniature fibre-optic spectrometers attached to the cells monitor the absorbance of specific wavelengths of light through the cell. The chemistry used is very similar to that used for the micromolar system. The procedure is described in detail by J-Z Zhang (2000 and 2002).

Low-nutrient seawater taken from the equatorial Atlantic was used as a wash solution and standard matrix. Standard solutions were prepared daily from stock solutions. All equipment was thoroughly cleaned before use by soaking in 10% HCl overnight and then rinsing with milli-Q water. Surface samples were taken in cleaned polyethylene bottles and analysed the same day. The majority of the samples had nitrate levels in excess of the range of linearity of the instrument (~0.5 μM). However surface phosphate concentrations were all below the 0.3 μM limit of the instrument.

This instrument has recently been built and, at this stage, there is no autosampler attached to the instrument. In addition, software has not yet been obtained to automatically measure the absorbance peaks created by samples and standards. For these reasons, there has not been sufficient time to analyse all the data on this cruise and this work will be carried out back in Southampton.

Station numbers and sampling regime

All the CTD stations were sampled for nutrients. All depths were sampled for micro-molar concentrations and only bottles fired at 60m or above were sampled for nano-molar nutrients. Table 1 represents the number of depth sampled for each method, although not all of those listed in the nano-molar column were necessarily analysed for nano-molar nutrients if the surface concentrations proved to be above 500nM for nitrate and 300nM for phosphate. The decision to actually proceed with nano-molar analysis was determined by the looking at the preliminary results of the micro-molar analysis as all depths, regardless of nutrient concentrations, were analysed using this method and preliminary results could be recorded a matter of hours after the CTD station.

CTD station	D306 no.	Number of depths sampled for μM nutrients	Number of depths sampled for nM nutrients
ctd30601	176001	12	0
ctd30602	176007	6	1

ctd30603	177003	12	3
ctd30604	177005	12	2
ctd30605	177008	7	2
ctd30606	178003	12	4
ctd30607	178004	6	3
ctd30608	179003	12	5
ctd30609	179009	8	6
ctd30610	180003	12	5
ctd30611	180005	12	2
ctd30612	180007	9	5
ctd30613	181003	12	5
ctd30614	181005	9	3
ctd30615	182003	12	5
ctd30616	182005	12	2
ctd30617	182008	12	2
ctd30618	182010	8	4
ctd30619	183007	12	5
ctd30620	183010	12	3
ctd30621	183011	12	3
ctd30622	183015	12	3
ctd30623	183016	12	3
ctd30624	183017	12	3
ctd30625	184001(183018)	12	3
ctd30626	184005	12	6
ctd30627	184008(184006)	12	3
ctd30628	184009	12	3
ctd30629	184010	12	3
ctd30630	184011	12	3
ctd30631	184012	11	2
ctd30632	184013	12	3
ctd30633	185003	12	6
ctd30634	185006	12	3
ctd30635	185008	11	2
ctd30636	185009	11	2
ctd30637	185010	12	3
ctd30638	185011	12	3
ctd30639	186001	11	3
ctd30640	186004	11	5
ctd30641	186007	12	3
ctd30642	186008	12	3
ctd30643	186009	12	3
ctd30644	186010	12	3
ctd30645	186011	9	3
ctd30646	186012	12	3
ctd30647	187004	12	6
ctd30648	187007	12	2
ctd30649	187009	9	9
	188003	12	6

Table 7.7.1. The number of depths sampled for inorganic nutrients for each of the CTD stations on cruise D306 using both micro-molar and nano-molar segmented flow autoanalysers.

Preliminary data

The water mass around the PAP site has been constantly changing, as has the community structure of the phytoplankton. These changes can be seen in the nutrient data in the surface waters. At the start of the cruise there was very little silicate in the surface waters above 40m, none that could be measured (Station 178003, fig. 1). Phosphate was also low (0.03uM) and nitrate was relatively high (0.68 µM). Silicate could not be found in the surface waters until cast 182003 (fig. 2), when the concentration of silicate increased to 0.06uM and the concentrations of nitrate and phosphate doubled (1.17 µM and 0.06 µM respectively). Later stations, such as 188003 (fig. 3), showed another increase in silicate concentrations (0.52 µM) whilst the nitrate concentration was decreasing in the surface, though it was still higher than at the start of the cruise (0.74 µM), and phosphate remained the same (0.06 µM).

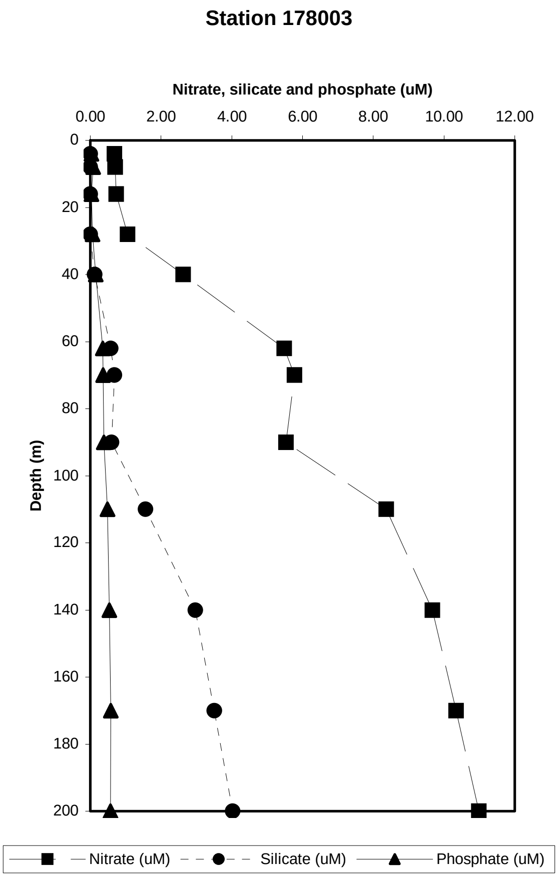

Fig. 7.7.1: Nutrient results for station 178003.

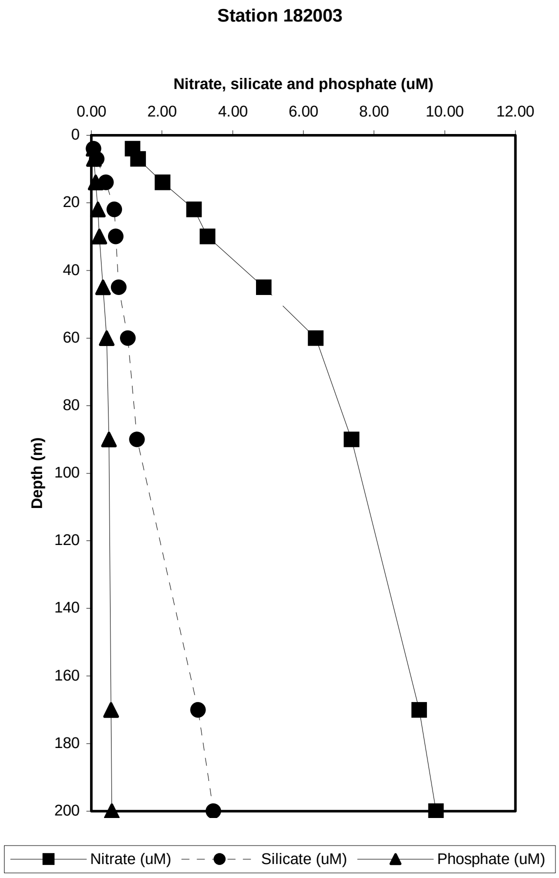

Fig. 7.7.2: Nutrient results for station 182003

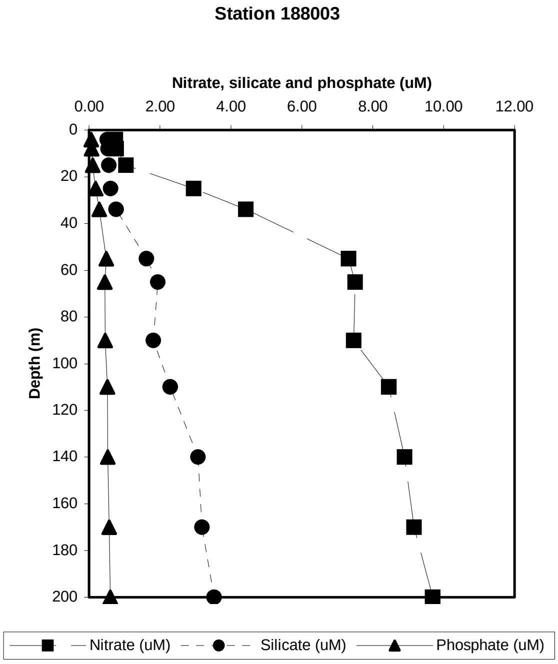

Fig. 7.7.3: Nutrient results for Station 188003

7.8 Dissolved oxygen analysis (*Mark Stinchcombe)*

Objectives:

The objectives of the dissolved oxygen analysis were to provide a calibration for the oxygen sensor mounted on the frame of the CTD for cruise D306 to the PAP site in the North Atlantic. For this, a Winkler titration was done from a number of water samples from the niskins bottles mounted on the CTD frame.

Methods:

Dissolved oxygen samples were only taken from the CTD casts and they were the first samples to be drawn from the Niskin bottles. Six oxygen samples were taken from the Niskin bottles that had fired. The depths sampled were decided by the trace from the oxygen sensor on the CTD, which provided near to real time results. Samples for calibration of the sensor are best taken where there are no gradients in the concentration of oxygen, so where the trace appears flat. The samples were drawn through short pieces of silicon tubing into clear, pre-calibrated, wide necked glass bottles. The temperature of the sample water at the time of sampling was measured using an electronic thermometer probe. The temperature would be used to calculate any temperature dependant changes in the sample bottle volumes. Each of these samples was fixed immediately using 1 ml of manganese chloride and alkakine iodide. The samples were shaken thoroughly and then left to settle for 30minutes before being shaken again. The samples were then left for a few hours before analysis.

The samples were analysed in the chemistry laboratory following the procedure outlined in Holley & Hydes (1995). The samples were acidified using 1ml of sulphuric acid immediately before titration and stirred using a magnetic stirrer. The Winkler whole bottle titration method with amperometric endpoint detection (Culberson and Huang, 1987), with equipment supplied by Metrohm, was used to determine the oxygen concentration.

The normality of the sodium thiosulphate titrant was checked using a potassium iodate standard. This was done four times throughout the cruise. Thiosulphate standardisation was carried out by adding the iodate solution after the other reagents had been added to a water sample in reverse order. This standardisation was then used in the calculation of the final dissolved oxygen calculation.

Station numbers and sampling regime

All the stations were sampled during the cruise, although only six samples from each cast were taken. These didn't correspond to any depth, but instead corresponded to regimes of low oxygen gradients as described above. The number of samples taken from each cast can be seen in table 1.

CTD station	D306 no.	Number of depths sampled for dissolved oxygen
ctd30601	176001	3
ctd30602	176007	7
ctd30603	177003	6
ctd30604	177005	5
ctd30605	177008	6
ctd30606	178003	6
ctd30607	178004	6
ctd30608	179003	6
ctd30609	179009	6
ctd30610	180003	6
ctd30611	180005	6
ctd30612	180007	6
ctd30613	181003	6
ctd30614	181005	5
ctd30615	182003	6
ctd30616	182005	6
ctd30617	182008	6
ctd30618	182010	6
ctd30619	183007	6
ctd30620	183010	6
ctd30621	183011	5
ctd30622	183015	6
ctd30623	183016	6
ctd30624	183017	6
ctd30625	184001(183018)	6
ctd30626	184005	6
ctd30627	184008(184006)	6
ctd30628	184009	6
ctd30629	184010	6
ctd30630	184011	6
ctd30631	184012	6
ctd30632	184013	6
ctd30633	185003	5
ctd30634	185006	6
ctd30635	185008	6
ctd30636	185009	6
ctd30637	185010	6
ctd30638	185011	6
ctd30639	186001	6
ctd30640	186004	6

ctd30641	186007	5
ctd30642	186008	6
ctd30643	186009	6
ctd30644	186010	6
ctd30645	186011	5
ctd30646	186012	6
ctd30647	187004	6
ctd30648	187007	6
ctd30649	187009	6
	188003	6

Table 7.8.1. The number of dissolved oxygen samples taken for each of the stations.

Preliminary data

Due to time and resource restrictions, the processing of the oxygen data will mainly be taking place at the National Oceanography Centre. The few stations that could be processed can be seen below in figs. 1 to 3. No correlation to the oxygen sensor has been done yet either so the closeness of fit of these two data sets cannot be reported as of yet.

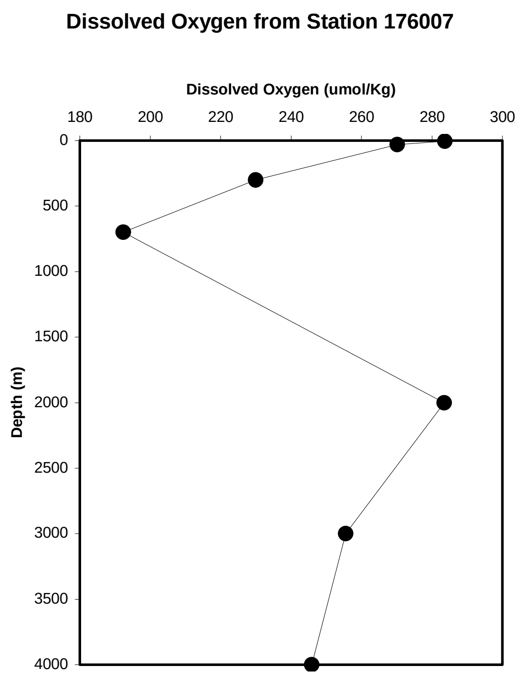

Fig. 7.8.1: Dissolved oxygen concentrations station 176007.

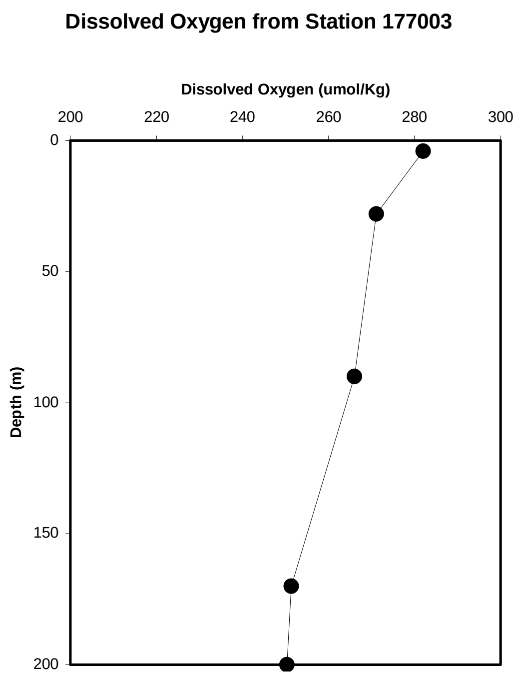

Fig. 7.8.2: Dissolved oxygen concentrations for station 177003.

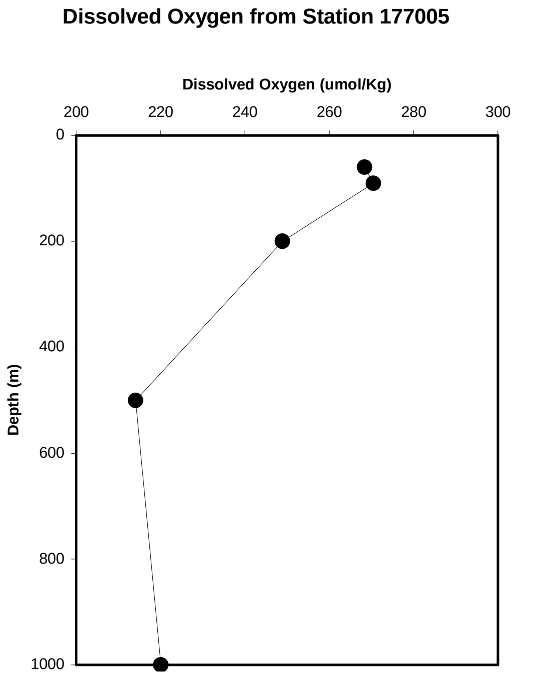

Fig. 7.8.3 Dissolved oxygen concentrations for station 177005.

7.9 HPLC & phytoplankton community structure *(Denise Smythe-Wright & Sandy Thomalla)*

Objectives

Quantifying the community composition and biomass of phytoplankton is essential to understanding the structure and dynamics of marine ecosystems and its effect on climate change. Phytoplankton have traditionally been measured by counting and identifying cells using light microscopy, but this method is time consuming and limits geographic coverage of field observations. Recent advances in the analysis of chlorophylls and carotenoids have enabled us to use these key light-harvesting pigments as taxonomic markers of a number of phytoplankton groups. For example 19' hexanoyloxyfucoxanthin has been found to be a biomarker of prymnesiophytes, including coccolithophores, and fucoxanthin a marker for diatoms. Consequently it is now possible to utilise pigment data to make quantitative estimates of individual class abundance. This is particularly important since individual classes of phytoplankton respond to and subsequently exert different influences on the turn over of nutrient elements and the export of carbon to the deep ocean. We, therefore, had three main objectives on this cruise:-

❖ To provide underpinning information on phytoplankton community structure for other shipboard studies

❖ To further extend our knowledge of the distribution of plant pigments and their degradation products in the water column and their relationship with individual species

❖ To qualify the nature of material exported to the deep ocean, in particular the pigment zeoxanthin which has been shown to be important in benthic organisms

Approach

CTD Casts

Approximately 10 l of water were collected from the CTD cast into plastic carboys, which were immediately covered with black plastic bags and where necessary stored in the cold room at 4° C prior to processing; no samples were stored for more than an hour. Between 2 and 8 litres of water (depending on source depth) were filtered through 25 mm, 0.2 µm GFF filters, using a specially designed positive pressure filtration rig that was designed to process 12 samples simultaneously. Duplicate filtrations were made where water availability and time permitted. The filters were placed in small cryovial sample tubes and immediately immersed in liquid nitrogen. Once frozen the vials were transferred to the –80°C freezer and at the end of the cruise were hand carried in dry shippers back to NOCS for storage at –80°C prior to analysis by High Pressure Liquid Chromatography. Table 7.9.1 gives details of the number of samples and the range of depths on each CTD cast from which the pigments were harvested.

In addition between 100 –150 ml (depending on bottle size) where placed in amber glass bottles to which 2 ml of lugols solution had previously been added. These samples were stored at 4°C prior to shipment to NOCS for light microscope identification and quantification. Samples were not collected at every depth, particularly those below 200 m; details are also given in Table 7.9.1.

Station number	Date	Time	Pigment Depths	Range	Microscope depths	Range
177003	26/06/06	03:57	12	0-200	12	0-200
177005	26/06/06	08:20	5	200-1000	0	
178003	27/06/06	03:34	12	0-200	12	0-200
179003	28/06/06	03:43	12	0-200	12	0-200
180003	29/06/06	03:43	12	0-200	12	0-200
180005	29/06/06	06:44	9	200-1000	0	
181003	30/06/06	03:43	12	0-200	12	0-200
182003	01/07/06	03:40	12	0-200	12	0-200
182005	01/07/06	07:05	6	300-1000	0	
183007	02/07/06	03:23	12	0-200	12	0-200
183010	02/07/06	07:26	6	0-100	6	0-100
183011	02/07/06	09:47	10	0-500	6	0-100
183015	02/07/06	16:28	6	0-100	6	0-100
183016	02/07/06	18:39	9	0-500	5	0-100
183017	02/07/06	20:47	10	0-500	6	0-100
184001	03/07/06	00:06	6	0-100	5	0-100
184005	03/07/06	03:20	12	0-200	12	0-200
184008	03/07/06	10:05	5	0-100	5	0-100
184009	03/07/06	10:05	9	0-500	6	0-100
184010	03/07/06	14:56	5	0-100	5	0-100
184011	03/07/06	17:08	10	0-500	6	0-100
184012	03/07/06	19:15	10	0-500	6	0-100
184013	03/07/06	22:28	6	0-100	6	0-100
185003	04/07/06	03:04	12	0-200	12	0-200
185006	04/07/06	07:35	10	0-500	6	0-100
185008	04/07/06	12:42	8	0-500	4	0-100
185009	04/07/06	14:59	8	0-500	4	0-80
185010	04/07/06	17:13	5	0-80	5	0-80
185011	04/07/06	22:04	10	0-500	6	0-100

186001	05/07/06	00:24	6	0-100	6	0-100
186004	05/07/06	03:18	12	0-200	12	0-200
186007	05/07/06	07:40	6	0-100	6	0-100
186008	05/07/06	09:35	10	0-500	6	0-100
186009	05/07/06	14:46	6	0-100	6	0-100
186010	05/07/06	17:05	10	0-500	6	0-100
186011	05/07/06	19:12	9	0-500	6	0-100
186012	05/07/06	22:44	6	0-100	6	0-100
187004	06/07/06	03:37	12	0-200	12	0-200
187007	06/07/06	07:28	11	200-1000	0	
188003	07/07/06	03:20	12	0-200	12	0-200

Table 7.9.1: Details of pigment and microscope samples taken from CTD casts

SAPS

In addition, 4 Challenger Oceanic in situ particle samplers were deployed on three occasions (detailed in Table 7.9.2). The first two to harvest pigments from deeper waters where large volumes of water are required and the third to look at particles being exported from the surface to the twilight zone. All samplers were fitted with 293 mm 0.2 um GFF filters and pumped for two hours. On collection the filters were folded and placed in cryogenic plastic sealed bags and stored in the –80°C freezer. They were subsequently transported back to NOCS in the dry shippers.

At Stations 180011 and 188006 two 150 ml samples of the filtrate (> 50 um fraction) were taken at 100 m and preserved with 2 ml lugols for light microscopy.

Station number	Date	Time	Depth	Volume Filtered L
180011	29/06/06	20:36	100	***
180011	29/06/06	20:36	200	2062
180011	26/06/06	20:36	500	2076
180011	27/06/06	20:36	750	2016
180011	28/06/06	20:36	1000	1963
182011	01/07/06	18:38	1500	2149
182011	29/06/06	18:38	2000	2198
182011	30/06/06	18:38	2500	2007
182011	01/07/06	18:38	3000	2015
188006	07/07/06	07:40	25	762
188006	07/07/06	07:40	50	457
188006	07/07/06	07:40	100	1795
188006	07/07/06	07:40	200	548

Table 7.9.2: Details of pigment samples taken from SAPS casts. *** membrane filter for thorium measurements not GFF

Pelagra traps

A total of four 50 ml samples of particles and water were taken from the Pelagra 2-6 July deployment for pigment analysis and light microscopy. Details are given in Table 7.9.3. The pigment samples were filtered, in duplicate, using a small Millipore filtration rig and the filters placed in cryogenic vials and immediately frozen in liquid nitrogen and then stored at -80°C. The light microscopy samples where preserved with 2 ml lugols solution. A third particulate sample of a salp faecal pellet was also harvested by filtration and frozen as above.

Station number	Date	Depth	Sample	Microscope vol ml	Pigments Vol ml
180003	2/07/06-06/07/06	~200	Particulate/water	~50	~20
180004	2/07/06-06/07/06	~150	Particulate/water	~50	~20
180004	2/07/06-06/07/06	~150	Salp faecal pellet	-	~15

Table 7.9.3: Details of pigment and microscope samples taken from Pelagra casts

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7.10 Phytoplankton physiology *(Thomas Bibby)*

Objectives

The objectives of this cruise were to measure the photosynthetic physiological parameters of communities of phytoplankton in the water column and make estimations of primary productivity at the PAP site of the North Atlantic using active fluorescence techniques.

Methods

Two techniques of measuring active fluorescence were employed both Fast Repetition Rate Fluorometery (FRRF, Chelsea Instruments) and Fluorescence Induction and Relaxation Emission Fluorometry (FIRe, Satlantic systems). Both of these instruments measure a suite of photosynthetic physiological parameters of phytoplankton at high sensitivity, *in vivo* and in real time. These techniques measure the photosynthetic capacity of a population of phytoplankton generating an approximation for rates of primary production and can be used as a sensitive monitor of the effect of nutrient limitation on the photosynthetic apparatus of phytoplankton.

Discrete analysis: Measurements of discrete water samples from depths throughout the euphotic zone collected during CTD casts of the using the FIRe system.

In addition to the photosynthetic physiological parameters of the whole phytoplankton community size fractionated measurements were taken on the filtrate from 2, 5, 10 and 20 µm size classes. This yielded information both on the distribution of chlorophyll and specific photosynthetic physiology between different size classes of phytoplankton. Size fractionated samples were measured from the chlorophyll maximum and surface samples routinely.

In order to make estimates of primary production for the water column controlled P/E curves were measured on discrete samples throughout the euphotic zone using the FIRe system with an ambient light source; complementary to these measurements chlorophyll and particle absorbance samples were taken (Mike Lucas).

In situ analysis: The FRRF instrument was attached to the CTD rosette for *in situ* data collection on all casts of less than 500m. PAR measurements were also acquired from this system. This data will provide a higher sampling resolution of the phytoplankton community and also enable estimation of water column primary production. Data from the FRRF and FIRe systems will provide a detailed and comprehensive study of phytoplankton photosynthetic physiology at the PAP site.

Underway sampling: When not measuring discrete samples the FIRe system measured the photosynthetic physiological parameters of the phytoplankton community from non-toxic sea water system.

Additional experiments:

- Discrete FIRe measurements of plankton net tows (Alan Kemp)
- Discrete FIRe measurements of growth rate experiments (Juliette Topping and Ludwig Jardillier)
- Discrete FIRe measurements of PELAGRA traps (Richard Lampit)
- Bioassy experiment from chlorophyll maximum at PAP site. Water spiked with combinations of Nitrate, Phosphate, Silicate and 1000m (Deep) water incubated on deck under controlled light and temperature conditions. Initial and end samples were taken for macronutrient concentrations (Mark Stinchcombe) community structure (Mike Zubkov) and physiology (FIRe)

Preliminary observations:

Chlorophyll was distributed in the upper 40 m of the water column for the entire cruise and the upper 20m of the water column were heavily quenched during hours of daylight. The community structure of phytoplankton oscillated between being dominated by large (>20 µm) individuals and smaller (5-10 µm) individuals that could be a result of environmental or physical forcing. A consistent trend of low Fv/Fm (photosynthetic capacity) in surface waters and higher Fv/Fm at depth was apparent at all stations, as shown in Figure 7.10.1.

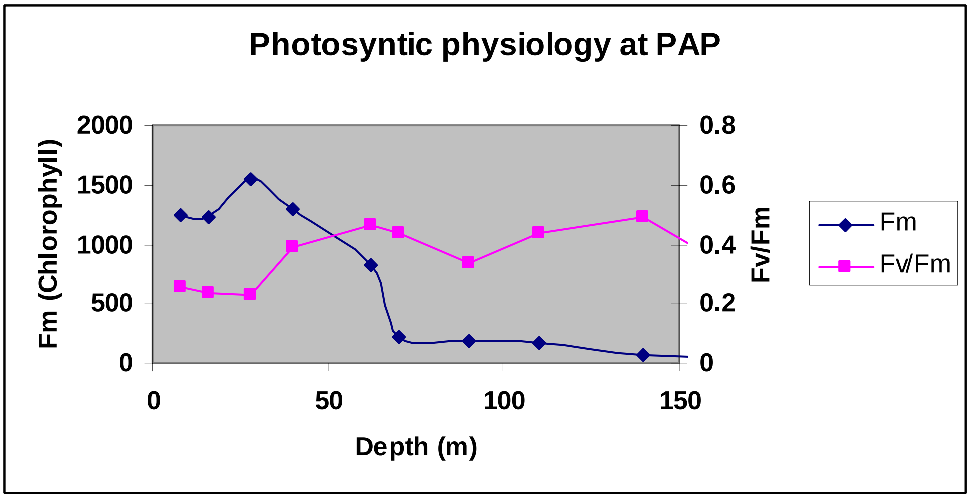


Figure 7.10.1: Preliminary analysis of phytoplankton physiology at PAP

CTD	Station	Depth	File
30603	1717003	200	1717003
		170	1717003
		140	1717003
		110	1717003
		90	1717003
		70	1717003
		62	1717003
		40	1717003
		28	1717003
		16	1717003
		8	1717003
30605	177998	130	17708
		120	17708.001
		90	17708.002
		60	17708.003
		30	17708.004
		20	17708.005
		10	17708.006
		5	17708.007
		20	17708.008
		10	17708.009
		5	17708.01
30606	178003	200	178003
		90	178003.001
		70	178003.002
		62	178003.003
		40	178003.004
		28	178003.005
		16	178003.006
		8	178003.007
30607	178004	5	PE178004
		20	
		40	
		60	
30608	179003	110	179003
		90	179003.001
		65	179003.002
		55	179003.003
		34	179003.004
		25	179003.005
		15	179003.006
		8	179003.007
		4	179003.008
30609	179009	5	PE179009
30610	180003	110	18003
		90	18003.001
		65	18003.002
		55	18003.003
		34	18003.004
		25	18003.005
		15	18003.006
		8	18003.007
		4	18003.008
30612	180007	5	PE001
30613	181003	110	181003
		90	181003.001
		60	181003.002
		45	181003.003
		30	181003.004
		24	181003.005
		15	181003.006
		8	181003.007
		4	181003.008
30614	181005	5	PE002
30615	182003	Depth	
		110	182003
		90	182003.001
		60	182003.002
		45	182003.003
		30	182003.004
		22	182003.005
		17	182003.006
		14	182003.007
		4	182003.008
30618	182010	5	PE003
30619	183007	110	183007
		90	183007.001
		60	183007.002
		45	183007.003
		30	183007.004
		22	183007.005
		17	183007.006
		14	183007.007
		4	183007.008
30620	183010	100	183010
		80	183010.001
		60	183010.002
		40	183010.003
		20	183010.004
		5	183010.005
30622	183015	100	183015
		80	183015.001
		60	183015.002
		40	183015.003
		20	183015.004
		5	183015.005
30623	183016	100	183016
		80	183016.001
		60	183016.002
		40	183016.003
		20	183016.004
		5	183016.005
30624	183017	100	183017
		80	183017.001
		60	183017.002
		40	183017.003
		20	183017.004
		5	183017.005
30625	184001(183018)	100	183018
		80	183018.001
		60	183018.002

		40	183018.003
		20	183018.004
		5	183018.005
30626	184005	110	184005
		90	184005.001
		60	184005.002
		45	184005.003
		30	184005.004
		22	184005.005
		17	184005.006
		14	184005.007
		4	184005.008
30627	184008(184006)	100	184006
		80	184006.001
		60	184006.002
		40	184006.003
		20	184006.004
		5	184006.005
30628	184007(184009)	100	184007
		80	184007.001
		60	184007.002
		40	184007.003
		20	184007.004
		5	184007.005
30629	184010	100	184010
		80	184010.001
		60	184010.002
		40	184010.003
		20	184010.004
		5	184010.005
30630	184011	100	184011
		80	184011.001
		60	184011.002
		40	184011.003
		20	184011.004
		5	184011.005
30631	184012	100	184012
		80	184012.001
		60	184012.002
		40	184012.003
		5	184012.004
30632	184013	100	184013
		80	184013.001
		60	184013.002
		40	184013.003
		20	184013.004
		5	184013.005
30633	185003	90	185003
		60	185003.001
		50	185003.002
		32	185003.003
		24	185003.004
		15	185003.005
		8	185003.006
		4	185003.007

30634	185006	5	185006
		20	185006.001
		40	185006.002
		60	185006.003
		80	185006.004
		100	185006.005
30635	185008	5	185008
		20	185008.001
		40	185008.002
		60	185008.003
		80	185008.004
		100	185008.005
30636	185009	80	185009
		60	185009.001
		40	185009.002
		5	185009.003
30637	185010	80	185010
		60	185010.001
		40	185010.002
		20	185010.003
		5	185010.004
30638	185011	100	185011
		80	185011.001
		60	185011.002
		40	185011.003
		20	185011.004
		5	185011.005
30639	186001	100	186001
		80	186001.001
		60	186001.002
		40	186001.003
		20	186001.004
		5	186001.005
30640	186004	110	186004
		90	186004.001
		60	186004.002
		50	186004.003
		40	186004.004
		32	186004.005
		18	186004.006
		8	186004.007
		4	186004.008
30641	186007	100	186007
		80	186007.001
		60	186007.002
		40	186007.003
		20	186007.004
		5	186007.005
30642	186008	100	186008
		80	186008.001
		60	186008.002
		40	186008.003
		20	186008.004
		5	186008.005
30643	186009	100	186009
		80	186009.001
		60	186009.002

		40	186009.003			5	186011.005
		20	186009.004	30646	186012	100	186012
		5	186009.005			80	186012.001
30644	186010	100	186010			60	186012.002
		80	186010.001			40	187004.003
		60	186010.002			20	187004.004
		40	186010.003			5	187004.005
		20	186010.004	30647	187004	110	187004
		5	186010.005			90	187004.001
30645	186011	100	186011			65	187004.002
		80	186011.001			34	187004.003
		60	186011.002	30648	187007	5	PEX
		40	186011.003				
		20	186011.004				

Table 7.10.1: Samples taken for physiology

7.11 Phytoplankton biomass, distribution, community structure and productivity *(Mike Lucas)*

Objectives

1. To measure phytoplankton biomass and distribution (chl-a & POC/N)
2. To determine phytoplankton community structure from preserved samples and HPLC (Denise Smythe-Wright)
3. To measure total and size-fractionated phytoplankton production using ^{14}C radio-nuclides.
4. To measure “new” production, i.e. nitrate uptake, including dark nitrate uptake, using ^{15}N-NO_3 tracers.
5. To estimate carbon export from f-ratio calculations
6. To compare nitrate uptake with the upward diffusive flux of nitrate determined from turbulence measurements (Prandke)
7. To assess Redfield C:N fixation rates from dual-labelling (^{13}C, ^{15}N) experiments
8. To assess phytoplankton production and physiological status in response to ambient light and nutrient gradients using FRRf (Tom Bibby)

General Approach & Methods

<u>PAP Site</u>

Measurements were made at the PAP site location on 12 consecutive days from 26 June (Julian Day 177) until 7 July (JD 188).

Phytoplankton biomass

For every PAP site dawn (~3.30am) CTD, measurements of phytoplankton biomass (as chl-a) were made at 12 depth horizons (to 200m) by filtering 250ml seawater through a Whatman GF/F filter to capture phytoplankton cells. Pigment was extracted in 90% acetone for 12 hours and then read on a Turner Designs fluorometer using the Welschmeyer protocol. Every alternate day, size fractionated chl-a measurements were made in the >0.2, >2 and >5µm fractions. At each of the 12 light depths for every PAP site CTD, chl-a samples were filtered as above, but the filters were stored frozen for later analyses back at NOC. This has been done to ensure proper fluorometer calibration and to provide chl-a replicates. Community structure and pigment signatures are available from preserved samples (Lugol’s) and from HPLC samples taken at every depth from every CTD (see report by Denise Smythe-Wright)

POC/N

At every dawn PAP site dawn CTD, 2.0L water samples from 12 depth horizons were filtered onto pre-ashed Whatman GF/F filters for particulate CHN analyses. Filters were stored frozen prior to analyses at NOC.

Particle Absorbance

At stations and depths where FRRf measurements were made to establish photosynthesis vs irradiance characteristics (P vs E), 2.0L samples were filtered onto GF/F filters (and stored at -80°C) to measure light absorbance characteristics. Whenever discrete FRRF measurements were made, chl-a extractions in 90% acetone were also made, as above. The extracted chl-a data will be used also to establish a calibration curve of FFRf fluorescence vs extracted chl-a (see report by Tom Bibby).

Phytoplankton productivity

Productivity measurements were made from dawn to dusk (~12 hours) using 14C radio-tracer on-deck incubations of water samples at six simulated *in situ* light depths; i.e. 97, 55, 33, 14, 4.4 and 1% surface irradiance. These light gradients were established in large Perspex incubation tubes wrapped appropriately with Lee misty blue and grey neutral density filters. The incubator tubes were cooled with a through-flow of surface (7m) seawater. At each light depth, three x light and one x dark polycarbonate bottles (70mls) were inoculated with ~10µCi ^{14}C labelled sodium bicarbonate. On alternate days, the incubations were size-fractionated into >0.2, >2 and >5µm fractions to target the productivity of particular phytoplankton fractions. At the end of the experiment, samples were filtered onto 0.2, 2.0 and 5.0µm polycarbonate Nuclepore filters which were then acid-fumed overnight to remove residual inorganic ^{14}C. After this, the filters were placed in 7ml “pony” vials and 5ml Ultima Gold scintillation cocktail was added to each vial. To determine the exact activity of the ^{14}C label, 100µl of ^{14}C stock was added to 10ml Carbasorb, and from that, 10 x 100µl aliquots were placed in 7ml vials and 5ml Permafluor cocktail was added. Total DPM activity of samples and standards were measured on a Wallac liquid scintillation counter.

New production, nitrate uptake and carbon fixation.

Concurrent with the ^{14}C measurements, dual-labelled (^{15}-NO3, ^{13}C-bicarbonate) light and dark nitrate (+^{13}C) incubations were conducted at the same light depths in 2.0L polycarbonate bottles. Light and dark bottles were inoculated with both 15N (0.1µmol $K^{15}NO3$ / 100µl) and ^{13}C spikes (4.2507g sodium bicarbonate / 100ml Milli Q water) to achieve ^{15}N and ^{13}C enrichments of ~10 and 4% respectively. After incubation, samples were filtered onto ashed GF/F filters; stored frozen (at -20°C) prior to measuring ^{15}N and ^{13}C enrichment on a mass spectrometer at NOC.

Mesoscale Survey

At every CTD station of this survey (see Report by John Allen), discrete FRRf measurements and associated chl-a extractions were made at typically 5, 20, 40, 60, 80 and 100m depth intervals. Chl-a was extracted and fluorescence was read on the Turner fluorometer as described earlier.

Station listings & measurements

Date	Sample	Measurements
26 June	177-003	Size fractionated primary production (SF-PP)
27 June	178-003	Total primary production (PP)
28 June	179-003	SF-PP
29 June	180-003	PP
30 June	181-003	SF-PP
1 July	182-003	PP
2 July	183-003	SF-PP
3 July	184-005	PP
4 July	185-003	SF-PP
5 July	186-004	PP
6 July	187-004	SF-PP
7 July	188-003	Chl-a and POC/N only (+HPLC, Lugol's)

Table 7.11.1: Phytoplankton biomass, community structure and production (^{14}C, ^{15}N + ^{13}C)

Date	Sample
26 June	177-008
27 June	178-004
28 June	179-008
29 June	180-007
30 June	181-005
1 July	182-010

Table 7.11.2: FRRf : P vs E + PAbs + chl-a

Date	Sample
2 July	183-010
2 July	183-011
2 July	183-015
2 July	183-016
2 July	183-017
3 July	184-001
3 July	184-005 (PAP site)
3 July	184-006 (chl-a sample lost)
3 July	184-007
3 July	184-010
3 July	184-011
3 July	184-012
3 July	184-013
4 July	185-003 (PAP site)
4 July	185-006
4 July	185-008
4 July	185-009
4 July	185-010
4 July	185-011
5 July	186-001
5 July	186-004 (PAP site)
5 July	186-007
5 July	186-008
5 July	186-009
5 July	186-010
6 July	187-004 (PAP site)

Table 7.11.3: Survey FRRf + chl-a

7.12 Dynamics of microbial communities *(Mike Zubkov, Juliette Topping, Ross Holland and Ludwig Jardillier)*

Aim & Objectives:

To compare abundance, spatial variability, composition and metabolic activities of planktonic microorganisms at the PAP site; specifically:

1) To determine vertical distribution of pico- and nano- plankton in the top 1000 m.

2) To compare the turnover rates of different labile organic molecules in twilight zone; to assess their vertical variability.

3) To compare CO_2 and amino acid uptake by different groups of microorganisms using stable isotope tracers.

4) To collect samples for analyses of microbial community composition using fluorescence in situ hybridisation and other molecular methods.

Enumeration of pico- & nano plankton by flow cytometry (Ross Holland & Mike Zubkov)

CTD casts. Samples were drawn from Niskin bottles during the CTD casts outlined in Table 7.12.1. Shallow pre-dawn casts were analysed for pico and nano plankton using bivariate dotplots of red (Chlorophyll) fluorescence against sideways light scatter. Populations of heterotrophic organisms were resolved by incubating samples with the DNA stain SYBR Green for at least an hour at 30°C before analysing flow cytometrically within bivariate dot plots of green fluorescence against 90^{o} side light scatter. Samples were analysed on the BD FACSort instrument.

CTD No	Heterotrophic Eukaryotes	Heterotrophic Bateria	Picophytoplankton	Nanophytolankton
177003		√	√	
177005		√	√	
177008		√	√	
178003		√	√	
179003		√	√	√
180003	√	√	√	√
180005	√	√	√	√
181003	√	√	√	√
182003	√	√		
182005	√	√		
187003		√	√	√
187004	√	√	√	√
188003		√	√	√

Table 7.12.1: Sampling of pico and nanoplankton

Size fractionation experiments on samples from pre-dawn CTD's outlined below in Table 7.12.2, were carried out. The aim of size fractionation was to investigate mean sizes of populations resolved by flow cytometry, to investigate the relationship between cell size and sidewards light scatter and to enable better distinction between pico and nanoplanktonic groups. In-line filters were installed on the sample line of the cytometer with filters of the following pore sizes: 0.2, 0.4, 0.6, 0.8, 1.2, 2.0, 5.0, 8.0, 10 μm.

Sizes of heterotrophic bacteria and eukaryotes were also investigated in later size fractionation experiments as outlined in Table 7.12.2.

CTD No	*Heterotrophic Eukaryotes*	*Heterotrophic Bacteria*	*Picophytoplankton*	*Nanophytolankton*
177008			√	√
178003			√	√
179003			√	√
180003			√	√
181003		√	√	√
182003		√	√	√
187004	√	√	√	√

Table 7.12.2: Size fractionation experiments on microbial communities

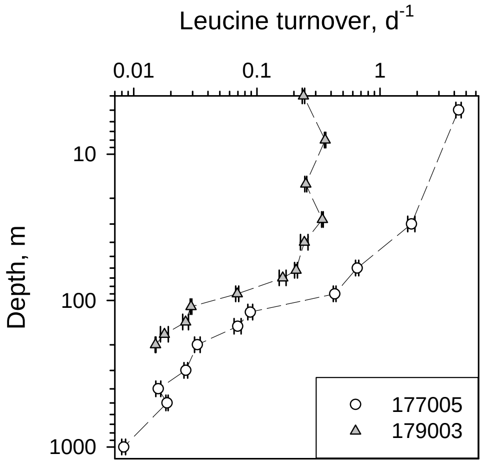
Underway Sampling Regime. Samples were drawn every 12 minutes from the ships non toxic seawater supply throughout the four day survey of day 183 -187. SYBR Green stained samples were analysed for bacterioplankton and protists. Samples collected at all CTD casts were frozen for offline analysis ashore in order to facilitate the intensive sampling regime.

Cytosub Studies. Three Autosub missions were carried out in association with the Cytosub flow cytometer to investigate the distribution and abundance of larger (>10µm.) phytoplankton taxa within a vertical profile of the range 1 - 160m, in situ within the environment. The missions also aimed to demonstrate the effectiveness of the instrument as an autonomous submersible cytometer. Samples were drawn by the instrument once every 8 minutes with a maximum sampling time of 5 minutes and threshold values of 10µm size and 100 units (arbitrary scale imposed by Cytobuoy software) of red fluorescence. Mission 1 was intended to last three days, however the Autosub aborted it's mission prematurely. Preliminary analysis of data from mission 1 revealed infrequent (~ 1 in 5 samples) peaks of high phytoplankton abundance corresponding to samples taken in surface waters, followed by a succession of very low (<20 / sample) cell counts corresponding to deep water sampling. Due to the infrequent sampling of the Cytosub, regulated by it's data sifting process, it was not possible to resolve any depth gradient in change in cell number.

Mission 2 was redesigned to incorporate longer periods spent closer to the surface (15m depth) to enable Cytobuoy to sample in waters with higher phytoplankton abundance. Mission 2 was due to last 5 days, however, autosub aborted before it's conclusion. By the end of the cruise this data had not been fully downloaded due to the lengthy process of data transfer via Bluetooth and the quick turnaround time between missions 2 and 3.

Determination of microbial activity in the twilight zone (Mike Zubkov)

Microbial production and the compound turnover rates were determined on board by incubating samples with isotopically labelled precursor molecules: ^{35}S-methionine, ^{3}H-leucine, ^{3}H-glucose, ^{3}H-glucosamine and ^{33}P-ATP. Experiments were done with samples collected on CTD casts 177003, 179003, 180005, 182005, 187007. Examples of vertical profiles of microbial leucine uptake at two stations were presented on the figure to the right. Detailed analysis of the collected samples will be done back at the NOCS.



Role of micro-organisms in CO_2 and amino acid uptake *(Juliette Topping, Ludwig Jardillier, Mike Zubkov, Ray Leakey & Tom Bibby)*

Approach: A series of experiments using stable isotope tracer techniques were conducted during the cruise. Sodium ^{13}C-bicarbonate was used to trace photosynthetic fixation by microbes to determine relative contribution made to primary production in surface waters by different groups of micro-organisms. Additionally, the possibility of $^{13}CO_2$ uptake by bacterioplankton incubated in the dark was investigated, as a potentially important ecological occurrence. Biogeochemical cycling of nitrogen sources by bacterioplankton and picoeukaryotes was also investigated, by adding ^{15}N-leucine to the incubations.

The incubations were conducted in 12 l carboys. There were two replicates per experiment, the first replicate containing both ^{13}C and ^{15}N, the second only ^{13}C. Samples were taken (sacrificing a carboy at each time point) at 0, 2 and 6 hours. Eukaryotic and bacterial cells were concentrated, flash frozed in liquid nitrogen and stored at –80°C. At NOCS these samples will be flow sorted to separate these two groups, and the amount of ^{13}C and ^{15}N incorporated into the cells will be analysed using mass spectrometry. Samples to analyse total amounts of ^{13}C and ^{15}N in the incubation water were taken at each time point (including 0 hours, to provide background information).

The role of grazers (primarily protists) was also investigated using the longer incubation time of the experiment (6 hours). Isolation of grazers occurred on board, by Ray Leakey. Back at NOC, any uptake of ‘labelled’ micro-organisms by these grazers will be investigated using mass spectrometry. In addition to isolated grazers obtained during the cruise, samples for total amounts of $^{13}C/^{15}N$ for the 0.3-10 µm fraction were also taken; the difference between these samples and the total $^{13}C/^{15}N$ in unfiltered seawater will show the amount of ^{13}C incorporated into the ‘grazers’ during the experiment.

Other samples collected during the experiment included those for flow cytometry, taken at each time point and for each replicate, to indicate the numbers of cells available to flow sort, and also to provide information on the communities present. Samples were also collected at 0 and 6 hour time points of all experiments for analysis by fast repetition rate fluorometry (FRRF), conducted during the cruise by Tom Bibby. These samples were size fractionated and then analysed, providing information on the physiological activity or ‘health’ of the different groups of photosynthetic organisms. Samples were also collected for fluorescence in-situ hybridisation (FISH), a molecular technique for identifying bacteria and picoeukaryotes, allowing us to better characterise the communities present.

By collecting water at different times of day (early morning, midday and evening) for these incubations, it is hoped that any diel variations in these production/cycling roles will be observed. Additionally, the evening (dark) incubation will act as a control to indicate any non-photosynthetic uptake of ^{13}C.

Although the initial aim was to compare surface and DCM waters, the lack of a DCM at the site meant this was not possible. Therefore, more experiments were conducted at the surface. Experiments had either 3% or 6% enrichment of ^{13}C. Experiments 1-6 and 11 cycled through the 3 times of day previously mentioned. Experiments 7-10 were conducted at a site in each of the 4 quadrants of the mesoscale survey conducted at the latter part of the cruise, to show any spatial variation in the role of micro-organisms in primary production and biogeochemical cycling.

Experiments:

Exp. No.	Station No.	Date	Enrichment	Details
1	177008	26/06/06	3% ^{13}C	Midday, 5m
2	178004	27/06/06	3% ^{13}C	Early am, 5m
3	179009	28/06/06	3% ^{13}C	Dusk, 5m
4	180007	29/06/06	6% ^{13}C	Midday, 5m

5	181005	30/06/06	6% ^{13}C	Early am, 5m
6	182010	1/07/06	6% ^{13}C	Dusk, 5m
7	183011	2/07/06	6% ^{13}C	Survey, NE4, 5m
8	184009	3/07/06	6% ^{13}C	Survey, SE4, 5m
9	185008	4/07/06	6% ^{13}C	Survey, NW12, 5m
10	186008	5/07/06	6% ^{13}C	Survey, SW4, 5m
11	187009	6/07/06	6% ^{13}C	Midday, 5m

Table 7.12.3: Experimental details

Preliminary Data: There is no data to present so far, as most of this depends on the use of the flow sorting and mass spectrometry facilities at NOC.

Molecular diversity of marine photosynthetic picoeukaryotes *(Ludwig Jardillier, Mike Zubkov, Juliette Topping, Dave Scanlan)*

Introduction: Photosynthetic picoeukaryotes (PPEs), comprising cells smaller than 3 µm in diameter, are widespread in marine environments and may be responsible for the majority of C fixation in the world's oceans. Thus, even though they are less numerous than their prokaryotic counterparts their slightly larger cell size and higher cell specific C fixation rates means that they are globally significant in terms of primary productivity. However, while the prokaryotic component of the marine photosynthetic picoplankton is dominated by just two genera (*Prochlorococcus* and *Synechococcus*), the eukaryotic component is much more diverse with virtually every algal class being represented e.g. the Heterokonta, Chlorophyta, Prasinophyta and Haptophyta. Unfortunately, the contribution of the different taxonomic groups to the picoplanktonic biomass, diversity and ecology is poorly known because simple and reliable methods to detect and quantify such organisms in natural samples are lacking. It is of obvious importance to quantify the dominating phylogenetic groups of PPEs in the natural environment in order to begin to understand their contribution both to the microbial food web and to global C cycling.

Approach: To assess total PPE diversity clone library will be constructed using both 18S rDNA eukaryote primers and 16S rDNA primers targeting specifically photosynthetic eukaryotes. Moreover, two BAC libraries will be constructed for two sites of the survey. To determine the distribution, the abundance and the contribution of specific PPE classes to total phytoplankton biomass both dot blot hybridisation and TSA-FISH technologies will be used.

Therefore, to determine the vertical variation of the PPE diversity and the abundance of PPE classes samples were collected at 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 65, 80, 95 and 110m. Moreover, the potential variations over small time scale of the PPE diversity and abundance of PPE classes 5 and 30m depths were sampled daily for 6 days. To determine the geographical variation of the PPE diversity and of the abundance of PPE classes 15 stations were sampled during the survey. Finally, the PPE community composition will be determined for the samples used for the stable isotope tracer experiments (see objective 3, above).

Samples taken to construct clone libraries and for dot blot hybridisation consisted of the filtration of 5L of seawater on filters of 0.45µm after a prefiltration through 3µm to screen out larger organisms. The filters were then stored with a DNA lysis buffer and frozen at -80°C. To extract DNA and RNA two replicates were taken for each sample.

To construct BAC libraries cells contained in 100L of seawater were concentrated in a final volume of 20-50µL. A first step consisted to screen out large organisms by pre-filtering the sample through 100µm mesh and 3µm filters. Secondly, a tangential flow equipped with a membrane of 0.16µm allowed concentrating cells of 100L within a final volume of 500mL. Then a Vita Flow filtration system (0.2µm) was used to concentrate the filtrate to 20mL. The cell pellets obtain after centrifugation were then flash frozen and kept at -80°C.

Picoeukaryote cells contained in 300-400mL were also harvested on 0.2µm and 0.6µm for the TSA-FISH analyses. For this purpose, cells were fixed for 1h with a solution of paraformaldehyde (1%

final concentration). Samples were also taken for bacterioplankton analyses using TSA-FISH method. The same method as for picoeukaryotes was used except that 150mL were filtered.

Sampling details

Station No.	Depth sampled	DNA/RNA sample	BAC Library sample	FISH sample	Details
177 008	5, 10, 20, 30, 40m	Yes	No	Yes	Vertical profile
178 004	5, 25, 30, 35, 40, 50m	Yes	No	Yes	Vertical profile
179 009	5, 10, 15, 20, 25, 30m	Yes	No	Yes	Vertical profile
180 007	5, 30, 35, 40, 45, 50m	Yes	No	Yes	Vertical profile
181 005	5, 30, 65, 80, 95, 110m	Yes	No	Yes	Vertical profile
182 010	5, 10, 15, 20, 25, 30m	Yes	No	Yes	Vertical profile
183 011	5m	Yes	No	Yes	Geographical distribution
183 016	5m	Yes	No	Yes	Geographical distribution
183 018	5m	Yes	No	Yes	Geographical distribution
184 007	5m	Yes	No	Yes	Geographical distribution
184 010	5m	No	Yes	Yes	Geographical distribution
184 011	5m	No	No	Yes	Geographical distribution
184 013	5m	Yes	No	Yes	Geographical distribution
185 008	5m	Yes	No	Yes	Geographical distribution
185 009	5m	No	Yes	Yes	Geographical distribution
185 010	5m	No	No	Yes	Geographical distribution
185 011	5m	Yes	No	Yes	Geographical distribution
186 008	5m	Yes	No	Yes	Geographical distribution
186 010	5m	Yes	No	Yes	Geographical distribution
186 011	5m	Yes	No	Yes	Geographical distribution
186 012	5m	Yes	No	Yes	Geographical distribution
187 009	5, 10, 15, 20, 25, 30	Yes	No	Yes	Vertical profile

Table 7.12.4: Sampling for molecular analyses

Preliminary Data: No result is available at the moment. Samples will be analysed next month at Warwick University.

7.13: Microzooplankton grazing *(Ray Leakey)*

Objectives

The main objective of this study was to measure microzooplankton grazing rates in surface waters at the PAP station. The data obtained will be used, in combination with other pelagic state and rate measurements, to derive estimates of microzooplankton grazing impact on phytoplankton biomass and production.

A secondary objective of the study was to assess the use of stable isotopes as tracers of grazing in pulse-chase experiments using stable isotope labelled natural phytoplankton (see report by J.Topping). Samples were collected from these experiments for post-cruise measurement of stable isotope uptake by microzooplankton cells.

Approach

Grazing rates were measured during the cruise using fluorescently labelled algae (FLA) as tracers of ingestion (Sherr & Sherr 1993 Protistan grazing rates via uptake of fluorescently labelled prey. in Kemp, et al. Eds. *Handbook of methods in aquatic microbial ecology*). Two types of FLA assay were conducted, both using FLA prepared from *Chlorella stigmataphora* cells which had been fluorescently labelled with DTAF stain. The first direct assay involved incubating microzooplankton samples with a single concentration of FLA for up to 40 minutes and observing uptake of FLA by individual protozoan cells using fluorescence microscopy. The second indirect assay involved incubating microzooplankton samples with three different concentrations of FLA for 24 hours and observing disappearance of FLA by flow cytometry; the different concentrations allowing the effect of increased food concentration to be examined. The FLA used in the direct assays were also labelled with stable isotope (^{13}C sodium bicarbonate and ^{15}N sodium nitrate) to enable post-cruise verification of stable isotope incorporation by microzooplankton in order to inform pulse-chase experimental results. The microzooplankton samples in the indirect assay were initially screened though 100 micron mesh to remove metazoan predators.

Samples (1.5 litres) for measurement of stable isotope uptake by microzooplankton cells feeding on stable isotope labelled natural phytoplankton were preserved with Lugol's iodine for post cruise isolation of microzooplankton cells after concentration by settling.

Sampling details are given in the table below. Due to the time consuming nature of post-cruise analysis, only 5 FLA experiments were undertaken with preliminary counts undertaken on ship to gain initial feedback and check methods.

Date	Station Number	Depth	Details	FLA Assay Direct	FLA Assay Indirect	Stable isotope Samples
26/6/06	177008	5	Midday	√	√	
28/6/06	170009	5	Dusk	√	√	√
30/6/06	181005	5	Morning	√	√	√
1/7/06	182010	5	Dusk			√
3/7/06	184009	5	Survey SE4	√	√	√
4/7/06	185008	5	Survey NW12			√
5/7/06	186008	5	Survey SW4	√	√	√
6/7/06	187009	5	Midday			√

Table 7.13.1: Sampling for experiments

Preliminary Results

Microplankton Composition: Observation of 20 micron net samples at the beginning of the cruise revealed a micro-sized phytoplankton community dominated by bloom of a small centric diatom approximately 20 microns in diameter and 15 microns tall. No chains of this diatom were observed (just single or twin dividing cells) and, whilst resembling *Coscinodiscus*, it was not possible to identify the diatom genus. Abundance, determined from settling chamber counts, was approximately 10^5 litre^{-1}.

The diatom *Rhizosolenia* sp. and the dinoflagellate *Ceratium furca* were also common with abundances of approximatley10^2 litre^{-1}. There were also high numbers of a small slender pennate diatom, 40 microns in length, in whole water samples which may have been under-represented in the 20 micron net tow.

Other species of phytoplankton and microzooplankton recorded recorded in net samples and settled whole water samples were as follows.

Diatoms: *Chaetoceros* sp.

Dinoflagellates: *Ceratium fusus*, *C.tripos*, *Gonyaulax* sp., *Gymnodinium* spp., *Gyrodinium* spp., *Heterodinium* sp., *Protoperidinium* spp.

Tintinnid ciliates: *Amphorides quadrilineata*, *Dadayiella bulbosa*, *Dictyocysta speciosa*, *Eutintinnus* sp.

Aloricate ciliates: *Laboea strobila*, *Lohmaniella* sp., *Mesodinium rubrum*, *Strobilidium* sp., *Strombidium* spp., *Rhabdoaskenasia* sp., *Tontonia* sp.

Grazing Experiments: Preliminary microzooplankton abundance estimates, based on single replicate counts of whole water samples, revealed a community dominated by small dinoflagellates during the first half of the cruise, and small dinoflagellates and ciliates during the second half. Larger protozooplankton cells were present in low numbers throughout the cruise. Overall the data suggest the presence of a protozooplankton community feeding on smaller nanoplankton and picoplankton. Small metazoans were also present despite initial screening of samples. Incubation for 24 hours under 55% ambient light resulted in changes the abundance of the protozooplankton with some species increasing in abundance and some declining. These changes may reflect differential predation pressures on different species or incubation "bottle" effects.

Preliminary observations from the direct assays revealed FLA ingestion by several ciliate species in all five experiments. Reductions in FLA abundance over 24 were also recorded in the indirect assays. Full analysis of the experimental samples will be undertaken post-cruise.

Date	26/6		28/6		30/6		3/7		5/7	
Species	T_0	T_{24}	T_0	T_{24}	T_0	T_{24}	T_0	T_{24}	T_0	T_{24}
Amphorides quadrilineata	ND	ND	0	0	0	0	60	80	0	0
Dadaydiella bulbosa	ND	ND	0	0	0	0	80	120	20	60
Dictyocysta speciosa	ND	ND	0	0	0	0	0	0	0	0
Eutintinnus spp.	ND	ND	0	0	0	0	20	0	0	0
Laboea strobila	ND	ND	20	0	0	0	0	20	0	0
Lohmaniella sp.	ND	ND	660	200	360	240	240	160	600	380
Mesodinium rubra	ND	ND	0	0	0	0	20	40	160	40
Strobilidium sp.	ND	ND	60	0	40	40	60	0	80	20
Strombidium spp. (S)	ND	ND	140	240	240	360	720	520	3080	3500
Strombidium spp. (M)	ND	ND	540	360	900	1400	4160	5100	2940	1900
Strombidium spp. (L)	ND	ND	120	200	420	80	640	560	800	420
Rhabdoaskenasia sp.	ND	ND	40	40	40	20	20	20	40	480
Tontonia sp.	ND	ND	0	0	40	0	0	0	0	0

Unidentified species	ND	ND	20	0	40	20	40	20	200	80
Total Ciliates	440	780	1600	1040	2080	2160	6060	6640	7920	6880
Gymnodinium spp. (small)	ND	ND	12240	6660	4000	3600	240	160	1300	1960
Gymnodinium sp. (large)	ND	ND	0	0	560	0	0	20	920	200
Gyrodinium spp. (small)	ND	ND	2640	840	640	180	380	300	720	420
Gyrodinium sp. (large)	ND	ND	2760	880	880	60	560	100	2820	1640
Protoperidinium sp.	ND	ND	20	0	60	20	40	20	0	0
Unidentified species	ND	ND	20	0	0	0	20	20	180	240
Total Dinoflagellates	ND	ND	17680	8380	6140	3860	1240	620	5940	4460
Copepodite	300	ND	0	20	20	0	0	0	60	40
Naupli	380	ND	120	200	220	80	120	80	0	80
Total Protozoans	ND	ND	19280	9420	8220	6020	7300	7260	13860	11340
Total Metazoans	680	ND	120	220	240	80	120	80	60	120

Table 7.13.2: Initial and final microzooplankton abundance (no litre^{-1}) in experimental samples incubated with FLA for 24 hours. Data is preliminary and based on count from only one 50 ml replicate sample. Metazoan data for 26/6 is from unscreened samples. ND = data not yet available.

7. 14: Plankton netting (Alan Kemp)

WP2 200 micron nets for zooplankton assay:

Following a protocol set down by Peter Burkill, the WP2 nets were deployed regularly at the PAP site twelve times from 24th June (station 177-01) to 7th July (station 188-02). On each occasion the nets were first hauled from 300m, then from 50m to the surface with two station numbers allocated. The timing of the deployment was typically 02.30 or 02.00 hrs UTC. The haul in the cod-end was divided in a plankton splitter with half typically deposited in a pre-prepared Killner jar with formalin for future taxonomic study. A further split, typically 5 times or 1/32 of the collected sample was filtered onto a GFA filter and placed in a freezer prior to analysis for organic carbon content. Initial net hauls became regularly clogged with jellies. A protocol was established to remove large jellies from the cod-end as necessary. This procedure was necessary only at the first few sites.

Closing Apstein 20 micron nets for phytoplankton assay

Apstein nets were deployed at different depth levels with the number of levels sampled dependent on time allocated and the depth interval sampled informed by the preceding CTD cast fluorescence (chlorophyll) trace. Following the first deployment all subsequent deployments were allocated a single station number irrespective of the number of net casts.

Following recovery a 1/2 split was decanted into a 100 ml lugols bottle with a further sub-sample into a flat culture tube for microscopy. From and including station 181 further samples were taken for FRRF measurements. Also from station 181, haul times of the various intervals were recorded giving approximate water volume sampled.

Station no	Haul Depths			
177-06		35-25		
177-07	10-0			
179-07	10-0	35-25	60-50	
181-06	10-0	35-25	60-50	110-100
182-06	10-0	35-25	60-50	

183-09	10-0		35-25	50-35	60-50			
184-07	15-0	30-15		45-30		60-45		
185-05	30-0			50-30		65-55	75-60	
186-06	15-0	30-15		45-30		60-45		
187-06	15-0	30-15		45-30		60-45		115-100
188-00	15-0	30-15		45-30		65-45		120-100

Table 7.14.1: Haul depths taken

Post cruise research:

Research will target detailed quantitative optical and SEM microscopy of the diatoms. In addition to the Apstein net samples splits of the CTD Lugol's samples will be required for some quantitative diatom counts.

7.15 Particulate export *(Richard Lampitt)*

The objective of this part of the program was to measure the export of particulate material from the upper mixed layer using a variety of approaches and to link these to contemporaneous measurements of other parts of the biological, chemical and physical system. The two techniques which specifically address particle export are the indirect measurement using upper water column budgets of ^{234}Thorium (see report by Thomalla) and the direct measurement using the drifting PELAGRA sediment traps.

Direct measurement

The PELAGRA trap comprises four cones with sampling cups arranged around an Apex float to control its buoyancy. After a CTD cast to determine local water density and temperature, the ballast required for each trap is calculated for the desired depth (range 100-400m) and they are deployed for a predetermined period of time. Two older traps (P1 and P2) collect single samples, the cups for which are deployed open but isolated by a shutter mechanism before the trap rises to the surface. Previous experience was that rust from the ship frequently enters the cups on deployment and thus contaminates the samples. Two new traps (P4 and P5) were designed and constructed for this cruise which have the added advantage that the cups are opened and closed at a predetermined time and independently of each other. A depressor weight takes the traps to a depth of 150m before it is jettisoned and another weight is dropped at the end of the mission to provide rapid assent and enhanced buoyancy at the surface in addition to that provided by the Apex. All traps had been fitted with new PC programmable digital timers to determine the end of mission and in the case of the new traps to determine the times of cup movement. Once on the surface the location of the traps is determined by Argos and e-mailed to the ship. Each trap is fitted with three recording temperature sensors two of which have conductivity and pressure cells. These are placed at different heights on the structure to estimate slippage of the structure through the water and to provide independent records of trap performance.

The intention had been to fix a GPS to each trap but construction was not completed in time for the cruise. Prior to deployment for scientific purposes each trap is deployed for a short period 6-12 hours) in order to check the ballast. Although considerable care is taken before cruises to calculate the ballast required for specific water column structures, such trials are necessary as uncertainties of 50g are an unsolvable feature. The entire trap has a mass of about 120Kg.

Achievements

Nine deployments were made and all traps were successfully recovered from each deployment. There were however some significant technical problems on most deployments some of which prevented release of the mission-end drop weights and others prevented collection of samples. The greatest success was however on stations 18303 and 18304 during which P1 and P2 collected material over a 4 day period at the complementary depths of 150 and 250m. They remained consistently at these target depths and as they were deployed within a few hundred meters of each other and recovered about 1.5 miles apart they provide an outstanding set of samples for examining export flux and rates of remineralisation with depth. A summary of each deployment is given below.

Cruise STN	Disco STN	Trap ID	Start Date/Time	End Date/Time	Start Lat	Lon	End Lat	Lon
177012	15879	P4	26/06/2006 21:05	27/06/2006 21:20	48.8782	-16.3154	49.0222	-16.1854
177013	15880	P1	26/06/2006 21:10	28/06/2006 11:30	48.8782	-16.3144	49.0729	-16.1147
177014	15881	P2	26/06/2006 21:13	28/06/2006 08:18	48.8785	-16.3137	49.0279	-16.1371
180009	15908	P4	29/06/2006 19:02	30/06/2006 19:00	48.6909	-16.7098	48.8453	-16.6093
180010	15909	P5	29/06/2006 19:10	30/06/2006 19:51	48.6901	-16.7078	48.8287	-16.6246
183002	15934	P5	02/07/2006 01:59	06/07/2006 17:19	48.8609	-16.5161	48.5037	-17.1696
183003	15935	P2	02/07/2006 02:04	06/07/2006 18:39	48.861	-16.5168	48.4679	-17.0506
183004	15936	P1	02/07/2006 02:10	06/07/2006 19:16	48.862	-16.5167	48.4425	-17.0467
184004	15951	P4	03/07/2006 03:04	06/07/2006 14:03	48.8425	-16.4986	48.9528	-17.0052

Table 7.15.1: Table of activity

177012: P4 Ballast test

Trap set to open three cups simultaneously. During the 1.5 hours following release of the depressor weight, the trap steadily rose to the surface and the accumulated 10g decreased ballast from the Apex were unable to prevent it reaching the surface. Mechanism worked perfectly and drop weight was released.

177013: P1 Ballast test

During the 1.0 hours following release of the depressor weight, the trap steadily rose to the surface and the accumulated 6g decreased ballast from the Apex were unable to prevent it reaching the surface. All data loggers functioned perfectly. Drop weight was not released and as a result, buoyancy at the surface was slight and recovery difficult.

177014: P2 Ballast test

During the 11.0 hours following release of the depressor weight, the trap steadily rose to the surface. This was due to incorrect Sigma theta setting on Apex which continued to increase buoyancy. All data loggers functioned perfectly. Drop weight was not released and as a result, buoyancy at the surface was slight and recovery difficult.

180009: P4 Ballast test

Trap set to open two cups simultaneously (On deck trials of P5 indicated insufficient power to open 3 cups simultaneously). Satisfactory test reaching stability after 5 hours adjustment at a depth of about 260m. Evidence of some slippage through the water with clear temperature gradients along height of trap and occasional temperature inversions. All data loggers functioned well. Cup mechanism jammed at the start of cup 1 and mission-end drop weight not jettisoned.

180010: P5 Ballast test

Trap set to open two cups simultaneously. Satisfactory test reaching stability after 4 hours adjustment at a depth of about 360m but continuing to adjust buoyancy to return to target density at a depth of about 200m. about 15 hours after loss of depressor weight. Cups 1&3 sampling from 210h on 29th till 0300h on 30th had significant quantities of material in contrast to subsequent 6 hours (cups 2 & 4) where there was no apparent flux. All Data loggers functioned correctly and mission-end drop weight was lost on schedule.

183002; P5 Science mission

Trap set to open two cups simultaneously. Stability reached at target density at depth of 200m after 36g increasing buoyancy over 12 hours. It remained at target for subsequent 3.5 days. However cups failed to close causing loss of material on recovery. Idronaut logger failed to record any data.

183003: P2 Science mission

Stability reached at target density at depth of 250m after about 30g increasing buoyancy over 8 hours. It remained at target for subsequent 3.5 days. Excellent sample of material collected and prepared for various analysis including DW, POC, PIC, PON and ^{234}Thorium. Idronaut logger stopped prematurely at 2039h on 2nd. Apex logger is only capable of 2 days recording.

1183004: P1 Science mission

Stability reached at target depth of 150m after about 85g increasing buoyancy over 30 hours. It remained at target for subsequent 3 days. Excellent sample of material collected and prepared for various analysis including DW, POC, PIC, PON and ^{234}Thorium (see photo). Idronaut logger stopped prematurely at 1658h on 5th. Apex logger is only capable of 2 days recording.

1184004: P4 Science mission

Difficulty turning on the Apex float caused a delay in programming and hence deploying this trap. Trap set to open two cups simultaneously. Stability reached at target density at depth of 220m after 15g decreasing buoyancy over 2 hours. It remained at target for subsequent 4 days. However cups failed to close causing loss of material on recovery. Idronaut logger failed to record any data.

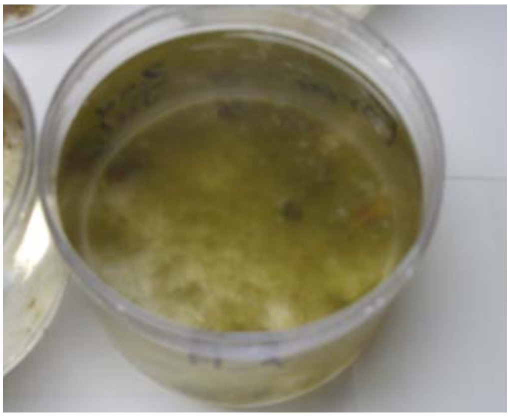


Figure 7.15.1: Examples of sample cups from P1 (Left from 150m) and from P2 (Right from 250m)

Figure 7.15.2: GFF filters for analysis - P1 (Left 1/40th splits from 150m) and P2 (Right 1/32nd splits from 250m)

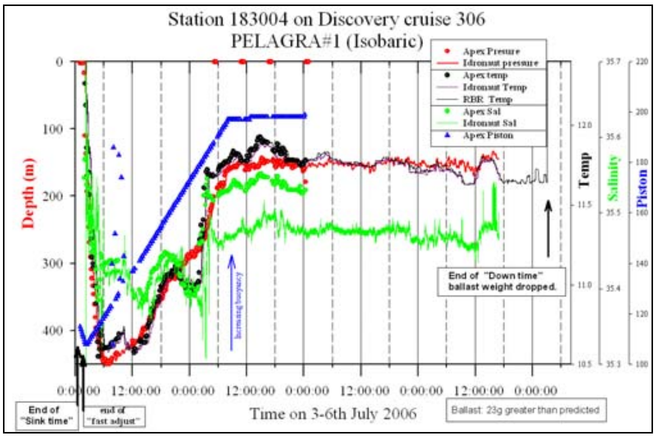


Figure 7.15.1. Deployment time trace of Pelagra 183004

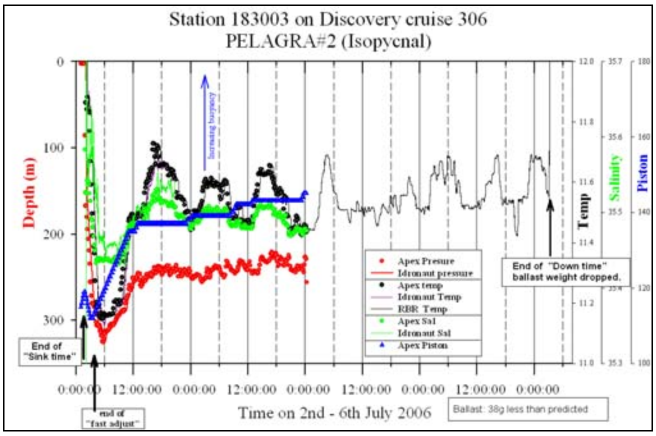


Figure 7.15.1. Deployment time trace of Pelagra 183003

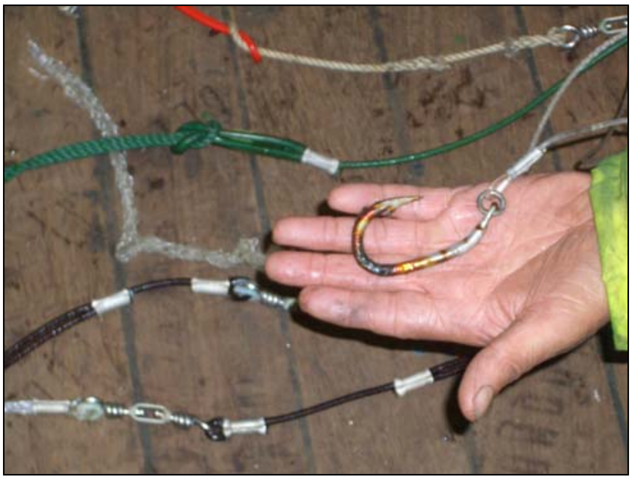


Figure 7.15.3 Example of long line fishing equipment found entangled with the PAP observatory moorings

The PAP observatory

Since 2003 a number of European programmes have supported efforts to maintain a multidisciplinary observatory at the PAP site as part of the OceanSITES network. The objectives of this are to determine the time varying biogeochemical and physical properties of a site representative of the temperate open ocean Atlantic with a focus both on the upper ocean and the seabed. There are 4 moorings and one lander. The upper ocean component comprises sensors at 40m for Nitrate, Fluorescence, Backscatter, PCO_2, (PAP#1) Current profiles and CTD over the top 1000m (PAP#2). Downward particle flux is measured at the bottom of the water column at 3000 and 4700m (PAP#3). A McLane moored profiler had been deployed at the site in July 2005 (PAP#4). A *Bathysnap* records the temporal variability of the appearance of the seabed. The current partners are from IFM-GEOMAR, Kiel, University of Bremen and ICCM Canaries.

During the past year it was known that parts of PAP#2 and PAP#4 had been lost and indeed the satellite transmitter of PAP#2 had been recovered with 5 Microcats in 2005. We were not however prepared to find that all three of the upper ocean moorings had been completely destroyed and no sensors remained on them. Significant quantities of fishing long line was found on one mooring and the damage on the others is consistent with damage also by long line fishing activity.

As a result of this new threat it was decided not to deploy the new observatory moorings during the cruise but to wait until they have been substantially strengthened to cope with such an assault in the future.

Deep water particle flux

A major and continuing program has been to measure directly the downward flux of particulate material in the deep part of the water column at the PAP observatory site. This has been in progress since 1989 although not continuously with the objective to record the time varying flux, its nature and to seek explanations for the seasonal, inter-annual and long term variability.

The McLane time series sediment traps were deployed in July 2005 at depths of 3000m and 4700m (100mab) and recovered successfully during this cruise. Unfortunately due to an electronic malfunction neither trap collected a full set of samples. Trap A at 3000m stalled between 4th and 18th June A further surprise for which an explanation is not currently plausible is that there was virtually no material in any cups between 28th August 2005 and 9th May 2006 and very little in any cup. Trap B at 100mab stalled between 23rd April and 7th May 2006 with a very large amount of material in the last open cup. Battery voltages of both traps were dangerously low.

New traps were deployed with two traps at 3000m and one at 4700m (100mab). The timing schedule for trap A and all others is given in Table 7.15.2.

Sample code	Open Date at 1200h (UK)	Julian day	Interval days
XXXXI-A-1	28/06/06	179	11
XXXXI-A-2	09/07/06	190	14
XXXXI-A-3	23/07/06	204	14
XXXXI-A-4	06/08/06	218	14
XXXXI-A-5	20/08/06	232	14
XXXXI-A-6	03/09/06	246	14
XXXXI-A-7	17/09/06	260	28
XXXXI-A-8	15/10/06	288	56
XXXXI-A-9	10/12/06	344	70
XXXXI-A-10	18/02/07	49	42
XXXXI-A-11	01/04/07	91	28
XXXXI-A-12	29/04/07	119	14
XXXXI-A-13	13/05/07	133	14
XXXXI-A-14	27/05/07	147	14
XXXXI-A-15	10/06/07	161	14
XXXXI-A-16	24/06/07	175	14
XXXXI-A-17	08/07/07	189	14
XXXXI-A-18	22/07/07	203	14
XXXXI-A-19	05/08/07	217	14
XXXXI-A-20	19/08/07	231	14
XXXXI-A-21	02/09/07	245	14
Final move to open hole	16/09/07	259	-

Table 7.15.2: Timing for deep water traps

7.16 Carbon export estimated from ^{234}Thorium and ^{238}U disequilibria *(Sandy Thomalla)*

Biological activity in surface waters drives the oceanic particle cycle, which in turn controls the scavenging of trace metals and sedimentation to the sea floor. Carbon fixation and carbon export is central to understanding oceanic productivity, and its long term effect on atmospheric CO_2 concentration. The particle- reactive radioisotope ^{234}Th (half life 24.1 days) is often in disequilibrium with its parent nuclide ^{238}U in surface ocean waters. This occurs because ^{234}Th but not ^{238}U partitions strongly onto particle surfaces and its removal on the sinking flux of material leads to radioactive disequilibrium. Consequently ^{234}Th/^{238}U disequilibrium is potentially a powerful tool to study the downward flux of carbon in the ocean via sinking particles.

Knowledge of the integrated disequilibrium in the water column combined with a steady-state assumption and with the decay constant of ^{234}Th yields an estimate for the flux of ^{234}Th from the surface ocean caused by settling particles. To calculate the POC flux from the surface ocean, the ratio of POC to ^{234}Th on sinking particles is multiplied by the estimated ^{234}Th flux.

Methods

Four ^{234}Th profiles were sampled from the PAP site during D306 (see Table.1). Ten litre water samples for total (particulate + dissolved) ^{234}Th were taken with a CTD bottle rosette from 8-10 depths to a maximum depth of 1000m. The sampling distribution is concentrated in the surface 100m where a significant export of thorium on settling particles is expected. The deeper samples at 500m and 1000m represent radioactive equilibrium between ^{234}Th and ^{238}U.

Potassium permanganate, manganese chloride and ammonium reagents were added to the sample to form a MnO_2 precipitate which preferentially scavenges ^{234}Th, leaving its parent ^{238}U in the dissolved phase. The precipitate was allowed to accumulate and grow for a minimum of 8hrs before being filtered onto 142mm diameter polycarbonate filters (0.8µm pore size). After filtration, all filters were air dried in covered plastic petri dishes and folded in a reproducible manner to form 18x18mm packages that are then wrapped in mylar foil. These filters will be analysed for total ^{234}Th activity on return to the National Oceanography Centre, Southampton using non-destructive beta counting on a RISØ National Laboratory low-background gas flow counter, operated in anticoincidence mode. Samples will be counted multiple times over the following months (at least six ^{234}Th half lives) to determine the background activity due to the intrinsic detector background and long-lived radionuclides that contribute to the beta signal on the filter. All the ^{234}Th data will be decay corrected to the point of sample collection and reported in units of disintegrations per minute per litre of sea water (dpm l^{-1}).

The reproducibility and precision of the method was tested at station 18707 where 5 samples were collected from 1000m. At this depth, the removal rate of ^{234}Th is slow compared to its radioactive decay rate, and the total ^{234}Th activity should equal the ^{238}U activity. The extraction efficiency of the precipitate was also tested at this station by collecting the filtrate and repeating the precipitation and filtration process.

Uranium-238 activity (A_U, dpm kg^{-1}) is calculated from salinity where $A_U = 0.0686$ x salinity, based on the average uranium concentration in seawater normalised to salinity 35 of 3.238 ng g^{-1}.

Water samples (2L) for particulate organic carbon and nitrogen (POC, PON) were collected from the CTD rosette at each of the thorium depths. These samples were prepared by filtering onto pre-combusted 25mm GF/F filters and stored in -80^{o}C for subsequent POC and PON analysis. These samples were collected in conjunction with the ^{234}Th samples in order to determine the ratio of total POC and PON to ^{234}Th through the water column.

The ratio of organic C and N to 234^{Th} in the sinking particulate pool was measured in two ways. For the first method, large particles >50µm are considered to represent the bulk (~90%) of particulates rapidly settling out of the water column into traps. This size class was therefore collected by filtering large volumes of sea water (average 2615 litres) through a 50µm (293mm diameter) nylon mesh using battery operated *in situ* pumps (Stand Alone Pumping Systems – SAPS). The pumps were placed at 100m (considered the base of the export layer and in accordance with the majority of ^{234}Th/^{238}U based export studies). Three SAPS stations were carried out over the course of the cruise (see Table 2). Once on board the sample on the mesh was re-suspended using one litre of thorium free filtered sea water and split using a fulsam splitter. ¾ of the sample was filtered onto 142mm 0.8µm polycarbonate filter for ^{234}Th analyses. 1/8th of the sample was filtered onto pre-combusted and pre-weighed 25mm GFF filter and 1/8th filtered onto 25mm GFF filter for HPLC analysis. The GFF filters are stored frozen (-80^{o}C) for subsequent POC, PON and HPLC analysis. The final 1/8th of the sample was stored in Lugols for microscopy.

In the second method the sinking particulate pool was collected using the neutrally buoyant barotropic PELAGRA traps which collected the sinking flux at 150m and 250m over 4 days. The sample collected from the trap was split with a fulsam splitter and filtered onto 142mm 0.8µm polycarbonate filters for ^{234}Th analyses and onto pre-combusted and pre-weighed 47mm GFF filter for POC and PON analysis. It will be interesting to see how the C: ^{234}Th ratio from the >50µm size fraction collected with the SAPS pump compares with the C: ^{234}Th ratio of the settling material collected using the PELAGRA trap and how these ratios compare with the C: ^{234}Th ratios of the >0.2µm size fraction collected from the CTD rosette.

Station Number	Date	Latitude	Longitude
17705	26/06/2006	48^o 50.08' N	16^o 30.11' W
18005	29/06/2006	48^o 50.31' N	16^o 31.88' W
18205	01/07/2006	48^o 50.05' N	16^0 30.01' W
18707	06/07/2006	48^o 50.00' N	16^o 30.00' W

Table 7.16.1 Thorium station positions

Station Number	Date	Latitude	Longitude
18011	29/06/2006	48^o 49.99' N	16^o 29.72' W
18211	01/07/2006	48^o 49.98' N	16^o 30.09' W
18806	07/07/2006	48^o 49.88' N	16^o 30.59' W

Table 7.16.3 SAPS station positions

7.17 Autosub *(Steve McPhail, Miles Pebody, Peter Stevenson, Maaten Furlong)*

The Missions

Autosub ran four missions during the D306 cruise covering a total 529Km in approximately 7 days of water time. These are summarised in the table below. Initial analysis of the sensor data showed that the sensors were functioning. See the section in scientific sensors. Autosub had a number of problems of varying severity. During mission 401 the upwards ADCP was discovered to be configured as a downwards instrument and so caused navigation errors by tracking the sea surface. In mission 402 problems with both the propulsion motor and stern-plane actuator caused the mission to terminate prematurely. Mission 403 was also terminated early due to continuing problems with the propulsion motor and the recovery line. Mission 404 completed all but the final 8Km (approximately) again due to the defective propulsion motor.

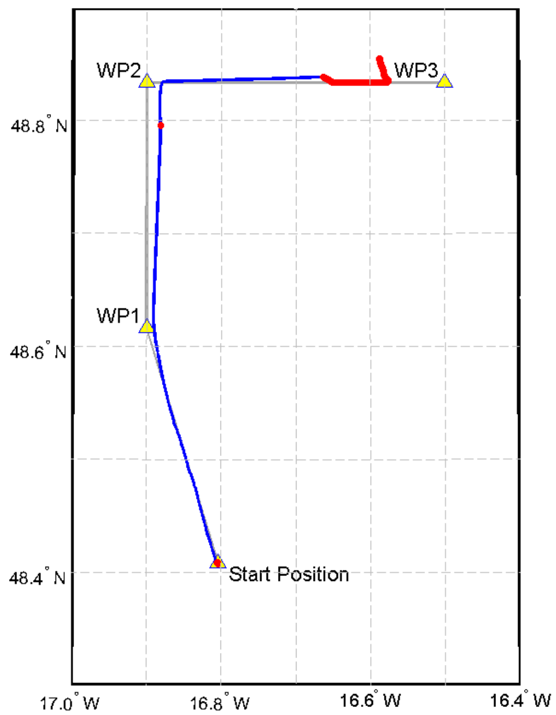


Figure 7.17.1. Example trace of the corrected Navigation for mission 404. The blue traces are corrected (post processed) navigation. Red circles are GPS fixes. The programmed waypoints are the yellow triangles.

Mission 401 and 402 were run on a continuous profiling mode from 10m to 160m. The profiling scheme was changed for missions 403 and 404 in order to better place the flow cytometer at a constant depth of 15m. Each leg of the mission was started with a dive from 10m to 160m followed by an alternating 15m constant depth and further dives from 10m to 160m. The duration of the constant depth run was 1hour 40minutes and 20 minutes was allowed for the dive. Unfortunately, later dives in mission 403 and 404 do not attain the full depth of 160m as a result of the slow speed of the Autosub.

In all missions the positional navigation accuracy was as expected for the area. Given the water depth and consequential lack of ADCP bottom tracking the Autosub was dependant on surfacing for GPS position fixes for its navigation. Consequently errors due to prevailing water currents were significant but unavoidable.

#	Date	Time: Start - End	Start Position	Description and comment
401	16/06/06	Start 16/06/06 12:23:01 End 16/06/06 14:12:10	49:15.0N 16:11.1W.	Systems shakedown test prior to running long missions. Run on profiling mode between 10m and 160m on two tracks. There were navigation errors due to upwards ADCP configuration. Mission duration 2h 39min 55s Mean speed through water : 1.5m/s Distance travelled 7.5km
402	26/06/06	Start 26/06/06 14:33:38 End 29/06/06 10:16:15	48:50.9 N 16:29.4W	Run a large profiling box survey around the PAP site to collect flow Cytometer and physical ocean data. Each side of box was run in profiling mode between 10m and 160m The mission aborted half way along leg 5. This was triggered by communication dropouts on the vehicle's control network. Problems were also apparent with the stern plane actuator and main propulsion motor. Mission duration 2days 19h 49m 37s Mean speed through water :1.127m/s Distance travelled 274.7km
403	02/07/06	Start 02/07/06 00:10:45 End	48:51.6 N 16:32.7W	Large box survey around the PAP site with modified depth profile: Repeating - 8Km at 15m for cytometer data collection followed by a single 10m-160m dive for CTD, Fluorometer and ADCP data collection.

		04/07/06 08:53:12		The vehicle became stuck on the surface due to propeller entanglement with the jack-in-the-box recovery line which had been washed out of its storage during a long GPS acquisition surface interval. This was at waypoint 5, at then end of leg 4 of the mission. Vehicle speed was again reduced as a result on continuing problems with the propulsion motor. Mission duration 2days 8h 42m 27s Mean speed through water : 1.037m/s Distance travelled 174.6km
404	05/07/06	Start 05/07/06 19:59:32 End 06/07/06 22:32:27	48:24.5N 16:48.3W	Two leg run to PAP site from the SW. Running the same depth profile sequence as M403 Vehicle mission timed out 8 Km short of final waypoint as a result of low speed and the continuing problems with the propulsion motor. Mission Duration Mean speed through water : 1.02 m/s. Distance travelled 75 km.

Table 7.16.1 Summary of Missions

Autosub Scientific Sensors

For D306 the Autosub vehicle was fitted with the following scientific sensors:

- RDI 150kHz ADCP looking downwards
- RDI 300kHz ADCP looking upwards
- Seabird 911 CTD system.
- Flow Cytometer

The data from these (with the exception of the Flow cytometer, which self records), plus the navigation data, and clock synchronisation data, will be made available to the cruise PI's on a DVD.

These instruments are described separately in the following sections. The table in Appendix 1 of this report shows the exact sensor locations. All the electronic systems on the vehicle are connected to a single control network. The data from all sensors apart from the cytometer system are recorded on the Autosub data logger. The Autosub logger uses a proprietary data format but the data is translated into standard ASCII text files using the Logger File Translator software running on a PC. The resultant ASCII file is then imported into the Axum processing software and a standard script is run to produce the general post processed navigation file (Mxxx.bnv file), see below.

Sensor Synchronisation

The Autosub TimeSync monitoring software is run during each mission in order to monitor the clock drift between underwater systems and various shipboard systems. The results are stored in the TimeSync directory for each mission. The .txt file is the more verbose version while the .dit file contains the differences in an ASCII table which can be read by most data processing software. In addition to this, the Laptop used for the Flow Cytometer and the Autosub main control computer were manual at various times throughout the cruise. (Table 7.16.2). Simultaneously, the time on the Autosub logger was noted (this information is in the .dit file).

Date	Autosub Control Computer	Autosub Logger	Ross Holland's Laptop for Flow Cyto Control
25/6/2006	08:47:00		08:47:53
25/6/2006	10:24:12	10:25:06	
26/6/2006	13:46:30		13:45:47
26/6/2006	13:30:58	13:30:11	
5/7/2006	19:43:00		19:42:09

Table 7.16.2 Table of synchronisation

Seabird 911 CTD system

Autosub is fitted with a Seabird 911 CTD system which includes two sets of conductivity and temperature sensors. These are mounted in a ducted system with sea water pumped through them at a precisely known rate. Depth is measured by a Digiquartz pressure sensor. In addition, a Wetlab Wetstar Fluorometer is fitted which is situated in the same duct as the secondary CT sensors. The output from these sensors is recorded at a rate of 24Hz.

Sensor	Location	Serial Number
Primary Temperature	Port Side	4458
Primary Conductivity	Port Side	2937
Secondary Temperature	Starboard Side	4457
Secondary Conductivity	Starboard Side	2938
Fluorometer	Port Side	WS3S-431P, Calibration date: 08/17/98, vblank 0.000, scale factor 1.000

Table 7.16.3: Details of onboard Seabird CTD system

Data from the system is continuously logged whenever Autosub is switched on but, in order to prevent excessive wear on the pump, water is only pumped through the C/T sensors once a predetermined pressure threshold has been exceeded. The data is stored on the Autosub logger in a proprietary format but is translated into a Seabird format data file (.dat) at the end of each mission. This data file, together with the necessary configuration file was then passed to the scientific party for further processing. Sensor calibration data is stored in a separate file with the .con extension. For the D306 cruise the data was processed using "D306\CTD setup\D306 Fluorometer on V0.con" file which contained calibration data from March 2005.

Cytometer

The Cytometer was a self-contained instrument taking only power from the Autosub (and providing a leak sensor output that was linked in with the Autosub leak sensors). All data logging was carried out on the instrument and to date has not been analysed.

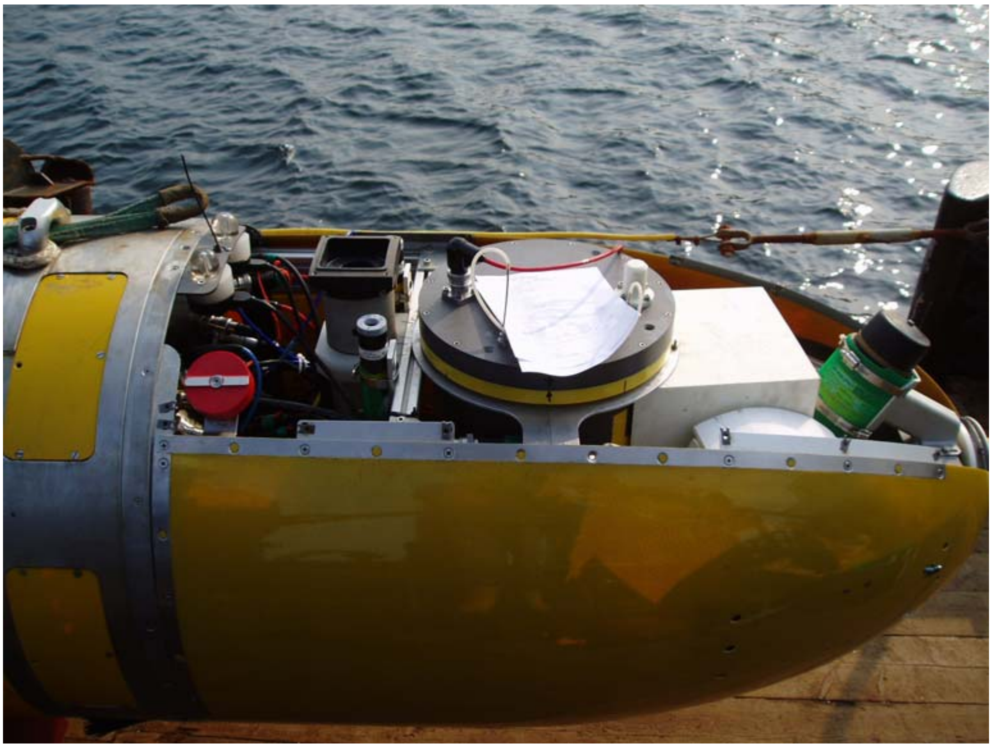


Figure 7.16.2: The flow cytometer located in the Autosub nose section.

ADCP

Physical Arrangement

Autosub has two RDI ADCPs, both mounted in the tail section:

A 300 kHz RDI Workhorse pointing upwards.

A 150 kHz RDI Workhorse pointing downwards.

Both can provide velocities in bottom tracking mode (or ice tracking, if appropriate, for the upward looking ADCP), as well as current profiling. The range information for the four beams is also used in the control of the vehicle, where it is set to keep a constant distance from the seafloor. The collision avoidance system also takes input from the ADCP beam ranges. Both are currently set with 8m profiling bins.

Files

The ADCP data is contained within the ASCII mxxx.ls2 files, where xxx is the mission number.

The first line of this file is a header of field names). The second line are the units used. The data is 2 seconds sorted (new set of data each 2 seconds).

This file also contains Autosub engineering and (unprocessed) navigation data, some of which might be of interest.

For post processed (more accurate) navigation data, you might want to use the Mxxx.bnv (best navigation) file which is described in a separately.

Where there is no data within a 2 second period the missing data value is represented by –999

The ADCPs produce new data every 2.6 seconds. This explains why, in the 2 second binned data file (ls2), there are regular missing data values (-999).

The ADCPs themselves use –32678 to represent no or bad data.

ADCP Data Fields in the Mxx.ls2 files

Field Name	UNIT	Description
CellIdx0*	0.24 dB	ADCP beam 3 intensity for bottom target
Inten0*	0.24 dB	ADCP beam 1 intensity for bottom target
Veast0	mm/s	Starboard velocity relative to seabed
Vnorth0	mm/s	Forward velocity relative to seabed
Vdown0	mm/s	Down velocity relative to seabed
Verr0	mm/s	Error velocity
ADCPVersion		RDI firmware version and revision
ADCPRev		
HeadingBias	0.01 deg	Always set to 0.
Number of Water Pings		Number of water pings per ensemble. Usually set to 1.
Size of cell	Cm	Vertical length of profile cell in cm.
Blank after TX	Cm	Blanking distance. 1st bin begins after this.
Number of Cells		Number of profiling bins. Up to 48.
Minimum Threshold		64 usually
Heading Align	0.01 deg	4500 for the down. –4500 for the up. The ADCPs heading axis are rotated 45 degrees relative to the vehicle.
Salinity		User set Salinity used in velocity calculation. Eg. 35
SoundSpeed	m/s	Calculated by ADCP based on Salinity (fixed), temperature (measured in ADCP and, and depth (externally measured).
ADCPTemp	(0.1 Celsius)	ADCP measured temperature.

Table 7.16.4: ADCPbin[0] Frame 0 is a special frame with ADCP configuration data (prev. page)

Field Name	UNIT	Description
CellIdx1*	0.24 dB	ADCP beam 3 intensity.
Inten1*	0.24 dB	ADCP beam 1 intensity.
Veast1 Vnorth1 Vdown1 Verr1	mm/s mm/s mm/s mm/s	Water profile velocities are in levelled ship frame of reference, relative to the PHINS forward axis. starboard, forward, down, and error.

Table 7.16.5: ADCP water profiling data bins[1 to N]. Example shown for the first bin (index 1)

For the Upward looking ADCP, the field names have '_2' appended.

Field Name	Units	Description
Date	e.g.7/07/2006	Date
Time	e.g. 09:40:02	Time of day (UTC)
Seconds	e.g. 1092735602.0000	Seconds since 1/1/1970
Roll	Radians	Roll angle of Autosub. (+ve to starboard).
Pitch	Radians	Pitch angle. +ve is nose up.
Heading	Radians	Heading. In Navigation convention. Heading north is 0. East is pi/2.
INSLat	Degrees (decimal)	Latitude (not post-processed)
INSLong	Degrees (decimal)	Longitude (not post-processed)
DpCtlDepth	Metres	Depth of Autosub (m).

Table 7.16.6: Other Data fields in the ls2 files which are of interest to users of ADCP data

* There is a bug in our logging software, which causes the intensity values to "wrap around" for values greater than 127. The correction, easily applied in Matlab is:

```
// for all val..

if(val <0); val = val+256; end;
```

Hints for processing the ADCP data.

You'll only get good current data when the down ADCP has bottom track.

Processing steps:

Transform "Ship Levelled" to geographical.

e.g.

Vnorth = Vfwd*cos(heading) -Vstbd*sin(heading)

Veast = Vfwd*sin(heading)+ Vstbd*cos(heading).

(In the ls2 file : Vfwd is *called* Vnorth , Vstbd is *called* Veast).

Produce Current profiles from the vector equation. Vwater(geog) = Vbottomtrack(geog)+ Vcurrent(geog).

Map the current profiles to real depths, by adding on the Depth sensor reading to the profile depths (based on bin size, bin number, blanking distance).

For D306, there is no bottom track data, hence absolute values of currents are more difficult to obtain. A rough correction can be made by using the GPS fixes which bracket the dive to estimate the mean current (and from that an approximation for the velocity over the ground).

Physical arrangement of sensors mounted in the nose section

Autosub is fitted with twin Sea Bird 911 CTD suite as standard, in addition to this a Wet Labs Fluorometer was plumbed into the port CTD (fig1)

Since the Cytometer instrument needs its pump kept primed throughout the mission, the inlet and outlet pipes were sited on the outside of Autosub's starboard panel beneath the water line (Figure 1). The inlet and outlet were placed close by each other to ensure a minimal pressure distribution between the two and not impede the pumped flow. The outlet was sited slightly behind the inlet to prevent exhaust water being re-circulated and sampled a second time.

The inlet pipe bore and length was 1mm and 820mm respectively (0.64ml)

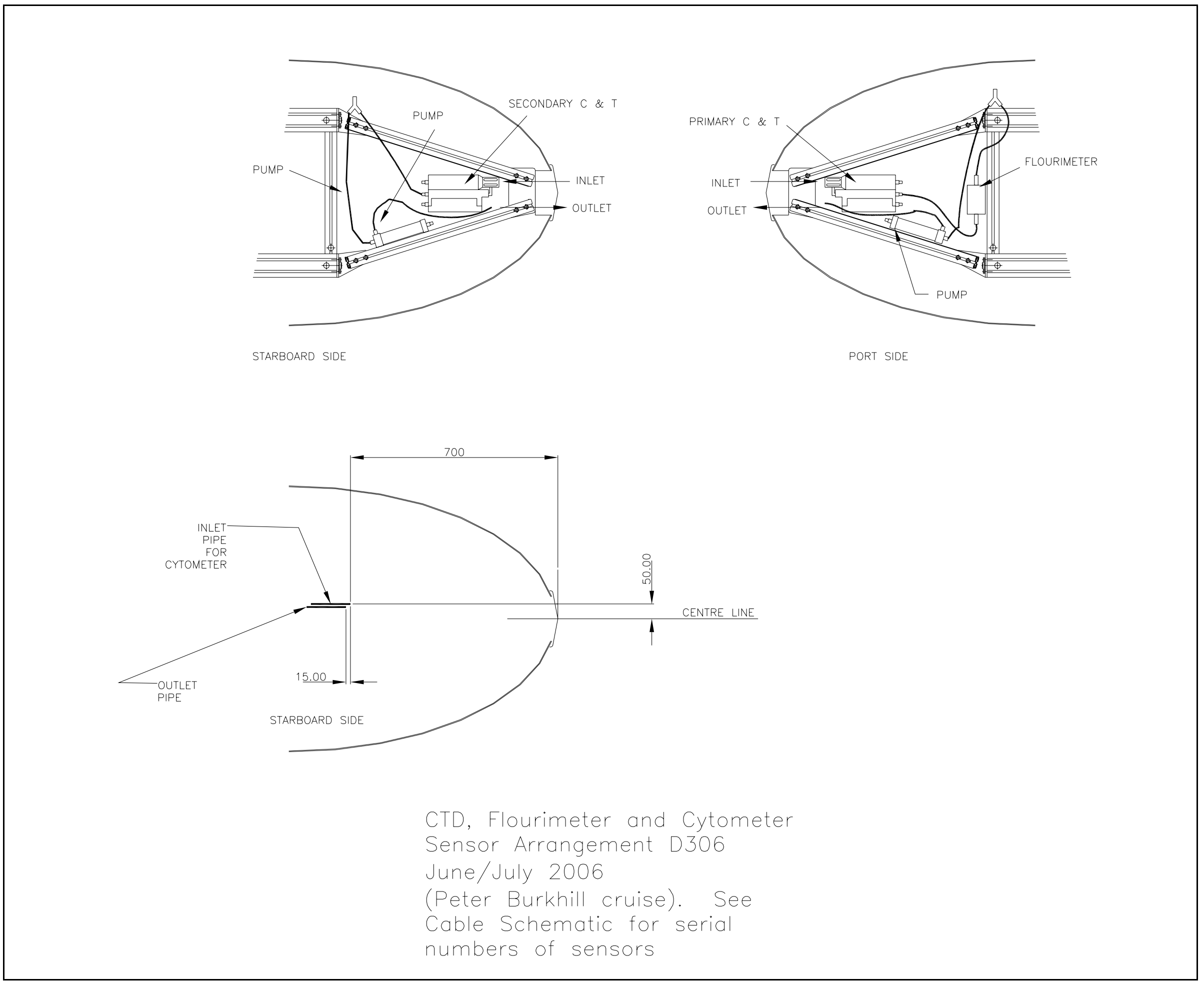


Figure 7.16.3: Physical arrangement of sensors mounted in the nose section

Autosub Post processed navigation data format

Post processed navigation data is provided in a file Mxxx.bnv, where xxx is the mission number. The file is ASCII text with comma separators. The first line is the column headers names (comma separated). Missing data is represented by "–999". The frequency of data output is once every 2 seconds.

Field	Units	Description
Date	m/d/yr	mm:dd:yy Julian Data.
Time	hr/mn/s	hh:mm:ss. UTC
Seconds	s	Seconds Since 00:00:00 1/1/1970
Elapsedtime	s	Since start of navigation file.
Pos_E	degrees	"Best estimate" Longitude. (jumps at GPS fixes removed)
Pos_N	degrees	"Best estimate" Latitude. (jumps at GPS fixes removed)
Depth	m	Depth of vehicle.
Vel_E	ms^{-1}	"Best estimate" East Velocity component.
Vel_N	ms^{-1}	"Best estimate" North Velocity component.
PosRaw_E	degrees	Raw (unprocessed) Longitude.
PosRaw_N	degrees	Raw (unprocessed) Latitude.
PosError	m	Estimate of the position error.
Posfix_E	degrees	GPS Fix: longitude
Posfix_N	degrees	GPS Fix: latitude
FixType	enumeration	GPS fix type. Obsolete. All GPs fixes are 3 D.
TSLF	s	Time since the last accepted GPS fix.
ADCPVelMode	enumeration	ADCP mode of operation: 0,1,2 0 – bottom track, 1 water track, 2 – based on propeller RPM (essentially a fault condition).
ADCPVel_E	ms^{-1}	East Velocity output by Autosub ADCP (down looking).
ADCPVel_N	ms^{-1}	North Velocity output by Autosub ADCP. (down looking).
ADCPAlt	m	Altitude measured by ADCP.
Driftrate_E	ms^{-1}	North Drift rate (or current) estimate.
Driftrate_N	ms^{-1}	East Drift rate (or current) estimate.
Travelled_km	km	Distance traveled (over ground) in km.
LPVel_E	ms^{-1}	North component Low pass filtered (smoothed) velocity.
LPVel_N	ms^{-1}	East component Low pass filtered (smoothed) velocity.
Vwater_E	ms^{-1}	North velocity through water.
Vwater_N	ms^{-1}	East velocity though water.
WaterSpeed	ms^{-1}	Speed through water.
LPGroundSpeed	ms^{-1}	Ground speed. Low pass filtered (smoothed).
LPWaterSpeed	ms^{-1}	Through water speed. Low pass filtered (smoothed).
Pitchdeg	degrees	Pitch of vehicle (degrees)
Headingdeg	degrees	Heading of vehicle (degrees)
Rolldeg	degrees	Roll of vehicle (degrees).
Splanedeg	degrees	Stern Plane degrees
Rudderdeg	degrees	Rudder degrees
prop_rpm	Rev per minute	Propeller Radial Speed
WaterDepth	m	Depth of water. Is Depth + ADCPAlt. Is "-999" , if vehicle is out of bottom track range (400m) of seabed.
Total Power	Watts	Total electrical power usage.
battery_V	Volts	Battery Voltage.

Table 7.16.7: Data Field Definitions

M#	km	Description	Specific Fault Identified. (including relatively minor)	Fault Diagnosis and Correction
M401	7.5 km	Test Mission at the start of *Discovery* Cruise D306. Was to be simple profiling 10 to 160 m, for a range of 1 mile. Mission took twice as long as expected to complete.	Configuration Mistake. ADCP up was configured as a downward looking ADCP. This cause navigation problems as the sub was using the tracking of the sea surface as the reference. This velocity data was very noisy and put the vehicle navigation out by a factor of 1.5.	Fix configuration setting : ADCPup.ncADCPup ← TRUE.
M402	274 km	Was planned to be approx 320 km box around the PAP site. Mission was cut short by Abort. Vehicle was unable to dive immediately prior to the abort. Propulsion motor going progressively slower during, each dive, and vehicle speed reduced from nominal 1.5 m/s to 1.0 m/s and less. Prop recovered speed immediately following a surfacing.	Aborted due to netYdown. Abort release could not communicate with the Depth control node for Period of 403 seconds.	The abort is thought to be a side effect of the leak problems with the actuators and perhaps also the propulsion motor. It is suspicious that the only network dropouts appeared immediately after the Stern Plane failed to move.
M402			Stern Plane stuck up during attempt to dive , 2 days 20 hours into the mission.	Found that the stern plane actuator had flooded. It was under pressure when recovered, and contained a good deal of water. The diaphragm seal associated with the moving push rod is suspected, although nothing definite found. Possibly the ingress of water was where the holes were pushed in the diaphragm for attaching it to the body. One of the three holes seemed to be elongated.
M402			Motor windings had resistance of 330 ohm to the case	This possibly explaining the loss of RPM (and water speed) during each dive. Motor was dismantled and windings for phases were separated. Two windings with resistance of 380 , and 3.8 k ohm to chassis were cut out (each phase has 5 parallel windings). Motor showed about 2M ohm to chassis following this. We did not Mega the motor at this stage – (we should have).

M402			Noticed that satellite fixes coming in more frequently from the tail mounted ARGOS transmitter, rather than the nose transmitter (only one position fix).	For subsequent missions, addition of a 30 cm mast for the nose ARGOS antenna. (This cured the problem).
M403	140 km	Similar plan as M402. 4 day mission planned this time. After only 48 hours the vehicle became stuck on the surface and could not dive. It had not aborted.	Recovery light line was observed to be wrapped around the propeller, on recovery. The flaps covering the main recovery lines (and where the light line was towed, were open).	Due to relying on the flaps which cover the lifting lines along the back of the vehicle to also secure the light line. The flaps, were washed open during the long period on the surface, allowing the light line free to foul the prop. In the future the light line must be secured with a cable tie so that it is impossible for it to foul the prop under any circumstances. Need more secure way of securing the flaps (ie not plastic tape).
M403			Took over 1 hour to get GPS fix at final waypoint.	It is not clear why this was the case. Possible washover due to a particular sea state/ wave period ? To eliminate possibility that the ARGOS transmissions were interfering with the GPS reception (possibly exacerbating washover issue ?), for future mission, ARGOS antenna was moved from below the GPS antenna on the same mast (0.2 m away), to its own mast 1.5 m away.
M403			Propeller speed was showing the same problem as before, Dropping off gradually during a dive. Subsequent testing of the motors with the Mega showed that there were resistances of a few k ohm between windings.	Motor dismantled again. This time need to cut out a further three windings, leaving only two windings (out of the original five) on one of the phases. However, calculations show that the I^2R losses due to this higher resistance are acceptable still, and motor was tested on deck under full load for several minutes. Mega'd at 1 kV showed resistances of greater than 20 M ohm between phases and from the phases to the chassis.
M404 pre		Prior to launch, during rep –launch tests.	The abort weight could not be successfully loaded. It could be made to stick in, and then it fell out. This is a hazard because, if not spotted, it could have dropped out during the mission.	Due to the abort weight keeper being distorted, probably when dropped onto the deck. Abort weight needs to be checked for damage before loading.
M404 pre			When investigating the motor drive problem, we noticed a resistor, clearly added as an after-thought on the motor control board, which was soldered by two short peaces of	This late modification to the circuit was concerned with the circuit which measured motor current. As this is a non essential function, we cut out the resistor. Quality Control should have been stricter and not

			wire to a small surface mount IC. One of these wires had come loose, and was potentially shorting against other components, potentially stopping the motor.	allowed this through.
M404	75 km	L shaped mission. Mission almost completed. Autosub surfaced 8 k short of end waypoint due to mission timeout.	Similar problems as seen in previous missions. The propulsion motor ran progressively slower during each dive.	Motor MEGA 'rd following recovery. Phases showing less than 0.01 M ohm to case at 250 volt test. Same problem with motor assumed.
M404			CTD dropping out for period of 1 hour during the mission. Detailed analysis shows that the were shorter (120 minute) drop outs during previous missions.	Data analysis shows that the power to the Seabird CTD and the associated LonWorks nodes was simultaneously failing. The CTD was inspected. Soldered joints on Seabird power supply PCB were redone, and the parallel redundant power supply was wired in for the CTD. (Previously this had not been done because the CTD is considered "non critical", hence should not use the dual redundant supply. However, as we have control of the seabird CTD interface, which is powered through our own, protected power supply, I assessed that this was acceptable).
M404			The recovery for M404 was complicated due to us trapping the lifting lines and streaming line on the rudder (probably stuck on the Bolen where the two were attached). Recovery from the situation required that the trapped lifting lines be grappled for astern of the ship, attached to the gantry lines, and the caught end cut. The forward Sternplane was lost due to lifting line trapping between the fin and its flap. Te SeaPam nose transducer was damaged due to collision with the ship.	The captain has filed an accident report for the incident. Sternplane repaired .. suggest the use of lanyards from Fins to the body so that we do not loose the fin if this happed again. SeaPam nose transducer repaired.

Table 7.16.8: Table of faults logged

Summary

Two major faults occurred on Autosub during D306 :

1) A flooded actuator on M402 (repaired).

2) A problem with the propulsion motor armature windings, which cause the vehicle it to run progressively slower during the dives in missions. Despite our best efforts, this was not repairable during the cruise.

8.1 Brooke Ocean Technology Moving Vessel Profiler *(Jon Short)*

The BOT MVP is a towed undulating CTD profiler that can produce near vertical CTD casts to 300m at a towed speed of 12 knots.

The MVP carried out 251 casts in five surveys, four of ~18 hours and one of ~12 hours.

The towed body, MSFFF (Multi-sensor freefall fish) was fitted with the following sensors;

AML CTD s/n-7027

SeaBird 23Y Dissolved Oxygen s/n-0960

Satlantic OCR-507-R10W Irradiance sensor s/n-074

Satlantic OCR-507-ICSW Radiance sensor s/n-0136

Wet Labs Flash Lamp Fluorometer s/n-FLF370s

The towed fish was deployed over the port quarter using its own winch system and was towed at a depth of ~2m. The fish was recovered whilst on station at the PAP site.

8.2 Challenger Oceanographic Deep Sea In-situ Water Sampler *(Jon Short).*

A total of five Deep Sea In-situ Water Samplers (AKA Stand Alone Pumps or SAPs) were used on this cruise there serial numbers were: 03-01, 03-03, 03-04, 03-05 & 03-06

8.3 CTD Report *(Dave Teare)*

The CTD comprised of the following instruments and sensors. Seabird 911+ CTD with dual pumped temperature and conductivity. Seabird 43 oxygen sensor in line on the primary temperature and conductivity line. Chelsea Instruments Fluorometer and transmissometer. RDI 300Khz upward and downward looking ADCP Workhorses.. The majority of cast of 500 meters or less had a Chelsea Instruments Fast Repetition Rate Fluorometer and PAR sensors fitted

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8.4 Mooring Operations *(Peter Keen)*

Recoveries

PAP 1 recovery on 27 June 2006

Lat: 49 2.8 N

Long: 016 37.5

Release AR861 s/n 323 Arm Code: 14D3

0941: Establish communications with release. 4838m, release vertical, voltage 8.9V

0944: Send release command. Release OK

0949: Ascent rate determined at 90m/min

1010: Middle set of 17" glass floats sighted on bridge. No sign of instrument buoy on surface

1040: Lower set of 17" glass floats sighted. Still no sign of instrument buoy so decision made to recover tail first. Ship maneuvers accordingly.

1130: Bottom-most set of glass spheres with release successfully brought onboard. Parafil tail attached to reeling winch and recovery commenced. ~3500m of parafil recovered, along with middle set of 6x17" glass. Mooring line parted approximately 100m up from the last 1000m length of Parafil. No instruments recovered.

1320: Recovery operations completed.

PAP 2 recovery

Lat: 49 01' 57" N

Long: 016 26' 14" W

Release AR861 s/n 264 Arm Code: 14B5

1539: Initiated communications with release, 5 cables from position, no response

1550: Change to port hull transducer, no response. Request to bridge to stand off two cables.

1555: Still no response from release

1612: Attempt communication with over the side transducer and other deck unit. One response.

1619: Other attempts to communicate failed but release codes sent anyway.

1625: Consistent responses indicate release has worked and rig is ascending at 20m/min

1640: First set of 17" glass spheres sighed after mistakenly identifying a fishing float as the top buoy.

1650: Second set of 17" glass floats sighted and vessel maneuvers for recovery tail first – no top buoy sighted.

1720: Line attached to parafil and bottom glass and release recovered. Recovery commenced. 3500m of parafil recovered. Wire parted at about 1000m depth, just above beginning of 6mm wire. No instruments recovered

1900: Recovery operations complete

PAP 4 recovery on 28 June 2006

Lat: 48 55.5 N

Long: 016 37.5 W

Release AR861 s/n 324 Arm Code: 14D4

1431: Begin pinging release two cables downwind of position. One return at 4833m

1434: Coherent diagnostic. 4786m, 4817m, Vertical, voltage 8.7V

1438: Sent release codes. 4818m, 4817m, Release OK

1439: Ascent rate determined at 80m/min

1510: Bridge reports first set of floatation sighted on the surface. As this mooring had previously been known to have lost the main subsurface buoy it had been decided to wait until all remaining buoyancy was on the surfaced before attempting a recover

1539: Second set of buoyancy surfaces. Vessel maneuvers for recovery.

1835: Recovery operation complete. The mooring was tangled with long line fishing gear caught around the middle six pack of backup buoyancy at a depth of 2000m. A further 1000m was recovered in a tangled state. . Recovered elements up to, and including, the lower MMP stop. Parafil line cut approximately 100m up from this point.

PAP 3 Recovery on 02 July 2006

Lat: 49 01.70 N

Long: 016 21.60 W

Release AR861 s/n 322 Arm Code: 14D2

1235: Establish diagnostic communications with release through the single element on the PES fish. Range 4777m, release vertical, voltage 8.9V

1250: Sent release codes. Received ranges back but no release status. Subsequent sends indicate that release had, infact, worked through decreasing slant ranges but none gave a release status. Ascent rate ~80 m/min. Release code was delayed until this time due to the wishes of RSL to ensure that the final bottle movement scheduled to 1200 GMT had infact occurred based on a 1 minute per week onboard clock slippage[*].

1328: First set of buoys sighted on port beam. Vessel maneuvers for recovery.

1355: Recovery float grappled and line secured

1405: First Sediment trap on board. Chain tangles in RCM 8 rotor and breaks it off.

1440: Second buoyancy pack comes on board tangled with mooring line. Release on board. Untangled – recovery continues

1455: Second Sediment trap and RCM 8 on board

1500: Recovery operation complete.

[*] As was subsequently observed this was entirely unnecessary since the bottle sequence had failed to complete for other reasons.

Deployment

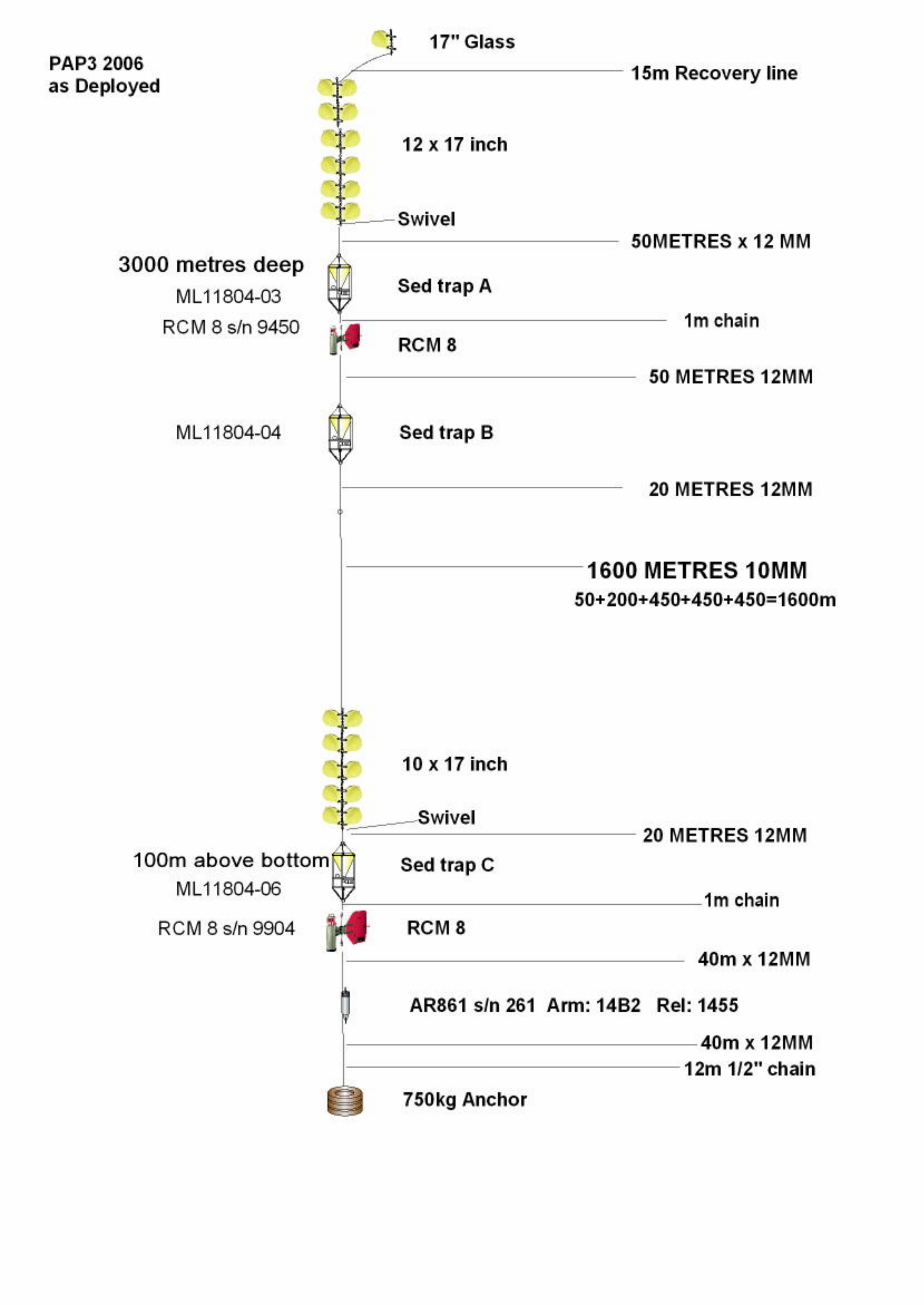
National Oceanography Centre **Ocean Engineering Div. UKORS** **NATIONAL OCEANOGRAPHY CENTRE**	**MOORING RECORD SHEET** **MOORING NAME : PAP 3** **PROJECT : PAP**

SHIP	*Discovery*	**DEPLOYMENT DATE/TIME :**	Monday, 26 June 2006, 1745 GMT
LATTITUDE :	48° 59.158' N	**LONGTITUDE :**	016° 25.650' W
WATER DEPTH :	4806m Uncorrected	**METHODS:**	**Free fall**
RECOVERY CRUISE:		**RECOVERY DATE/TIME:**	

EQUIPMENT Brief description	**Serial No.**	**Height off Bottom**	**COMMENTS Observations made during operation**
1 x 17" glass sphere	N/A	1874	Recovery sphere
15m recovery line	N/A	1873	
12 x 17" glass sphere	N/A	1858	First set of main buoyancy
50m 12mm Polyester rope	N/A	1852	
21 bottle Sediment Trap	ML11804-03	1802	Last bottle closes 16/09/07 12:00:00
RCM 8 Current meter	9450	1798	One hour sampling. Includes pressure sensor
50m 12mm Polyester rope	N/A	1797	
21 Bottle Sediment Trap	ML11804-04	1747	Last bottle closes 16/09/07 12:00:00
20m 12mm Polyester rope	N/A	1743	
1600m 10mm Polyester rope (450+450+450+200+50)m	N/A	1723	
10 x 17" glass spheres	N/A	123	Second set of buoyancy
20m 12mm Polyester rope	N/A	118	
21 Bottle Sediment Trap	ML11804-06	98	Last bottle closes 16/09/07 12:00:00
RCM 8 Current meter	9904	94	One hour sampling interval
40m 12mm Polyester rope	N/A	93	

AR861 Acoustic release	261	53	Arm Code: 14B2 Firing Code: 1455
40m 12mm Polyester rope	N/A	52	
12m ½" Chain	N/A	12	
Anchor	N/A	0	750 kg

Descent rate: ______ **Ascent rate:** ______ **Diagnostic:** ______



PAP3 2006
as Deployed
17" Glass
15m Recovery line
12 x 17 inch
Swivel
50METRES x 12 MM
3000 metres deep
ML11804-03
RCM 8 s/n 9450
Sed trap A
1m chain
RCM 8
50 METRES 12MM
ML11804-04
Sed trap B
20 METRES 12MM
1600 METRES 10MM
50+200+450+450+450=1600m
10 x 17 inch
Swivel
20 METRES 12MM
100m above bottom
ML11804-06
Sed trap C
1m chain
RCM 8 s/n 9904
RCM 8
40m x 12MM
AR861 s/n 261 Arm: 14B2 Rel: 1455
40m x 12MM
12m 1/2" chain
750kg Anchor

9 CHARTS

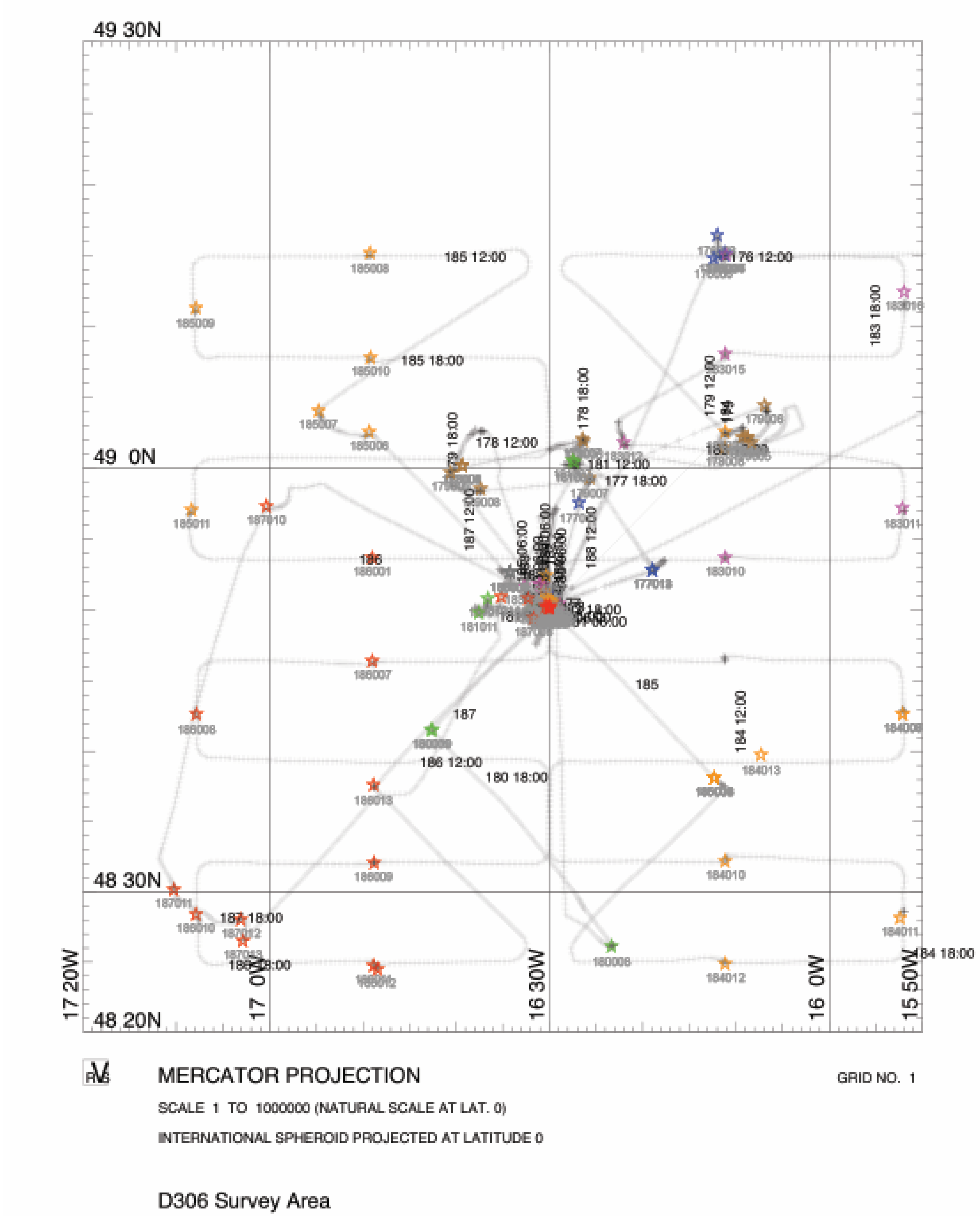


Figure 9.1: Chart of operational survey area

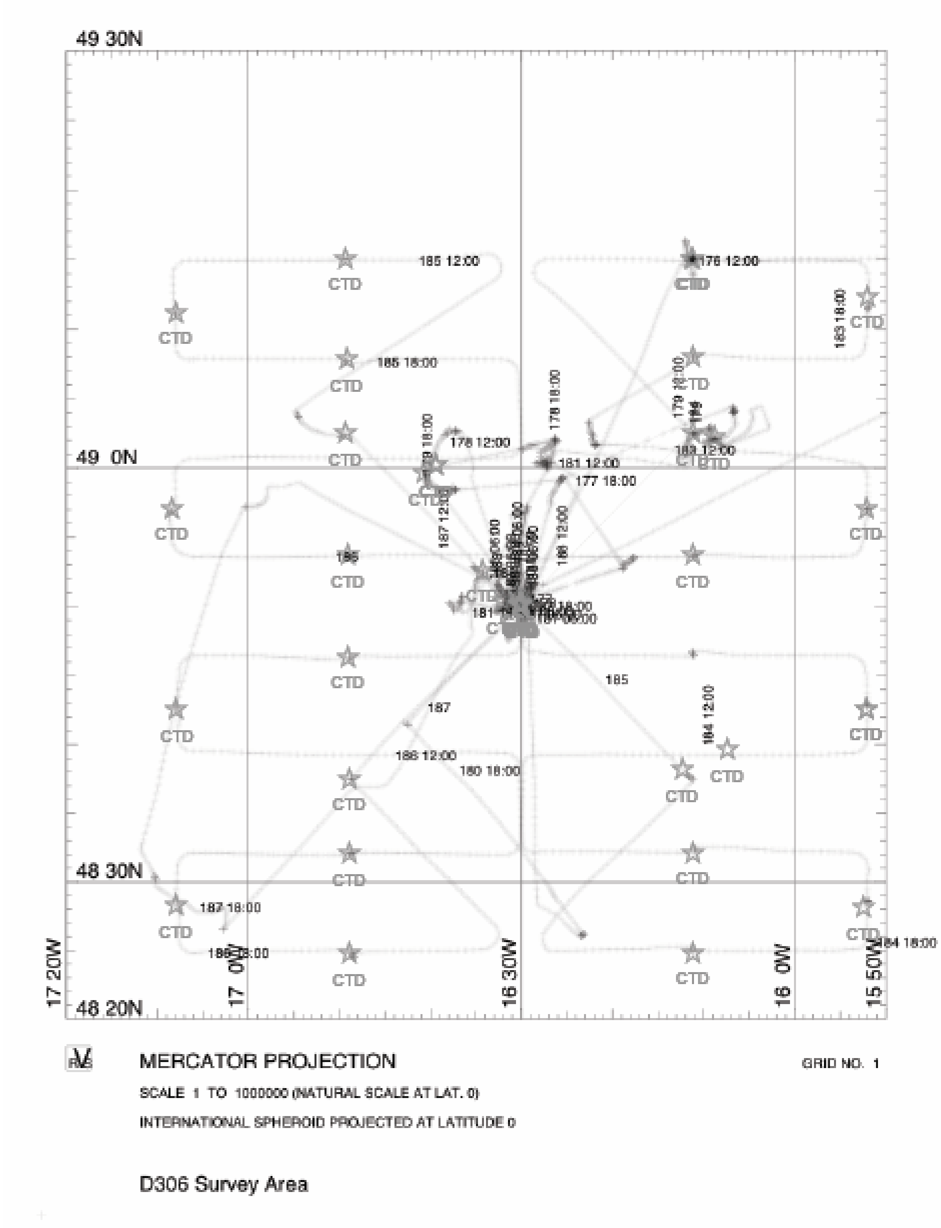


Figure 9.2: Location of CTD stations

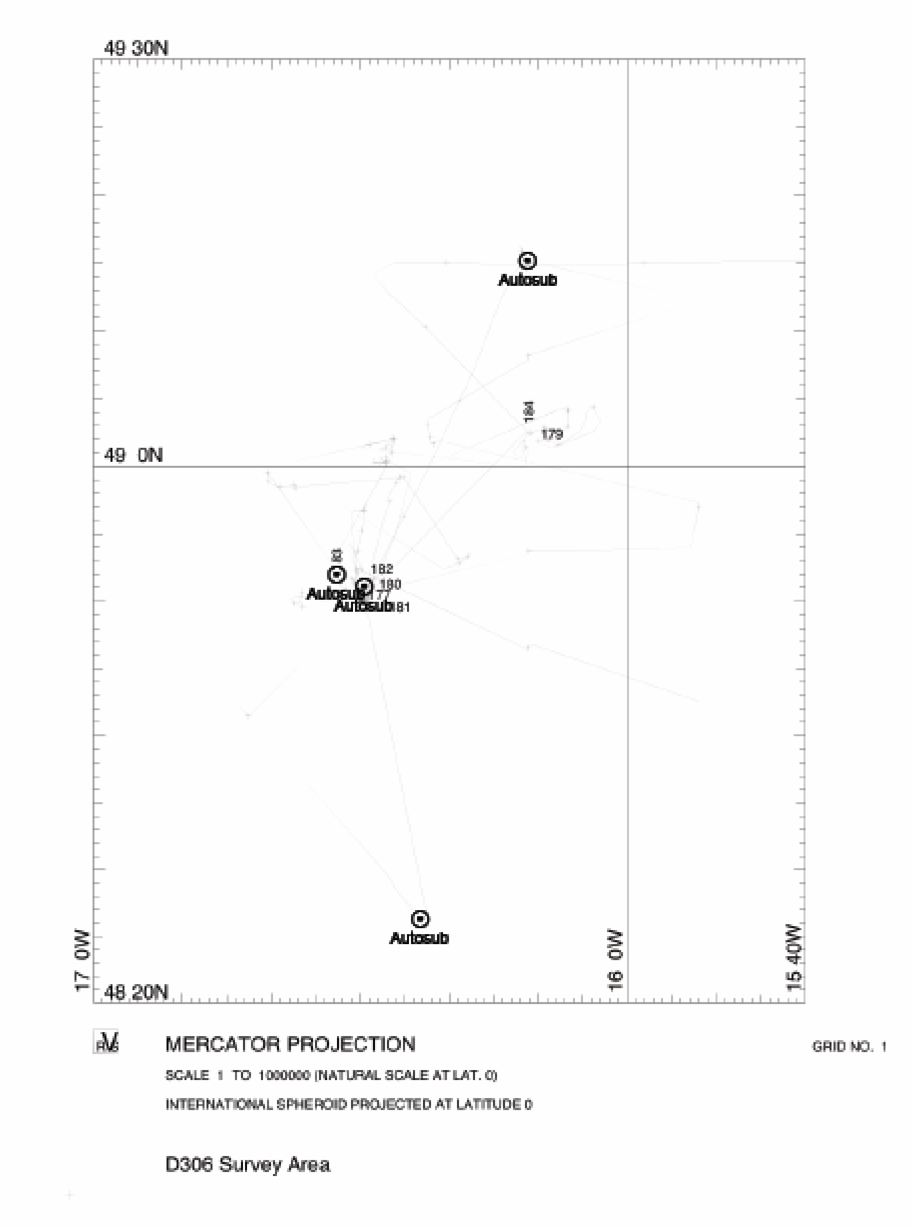


Figure 9.3: Autosub survey tracks