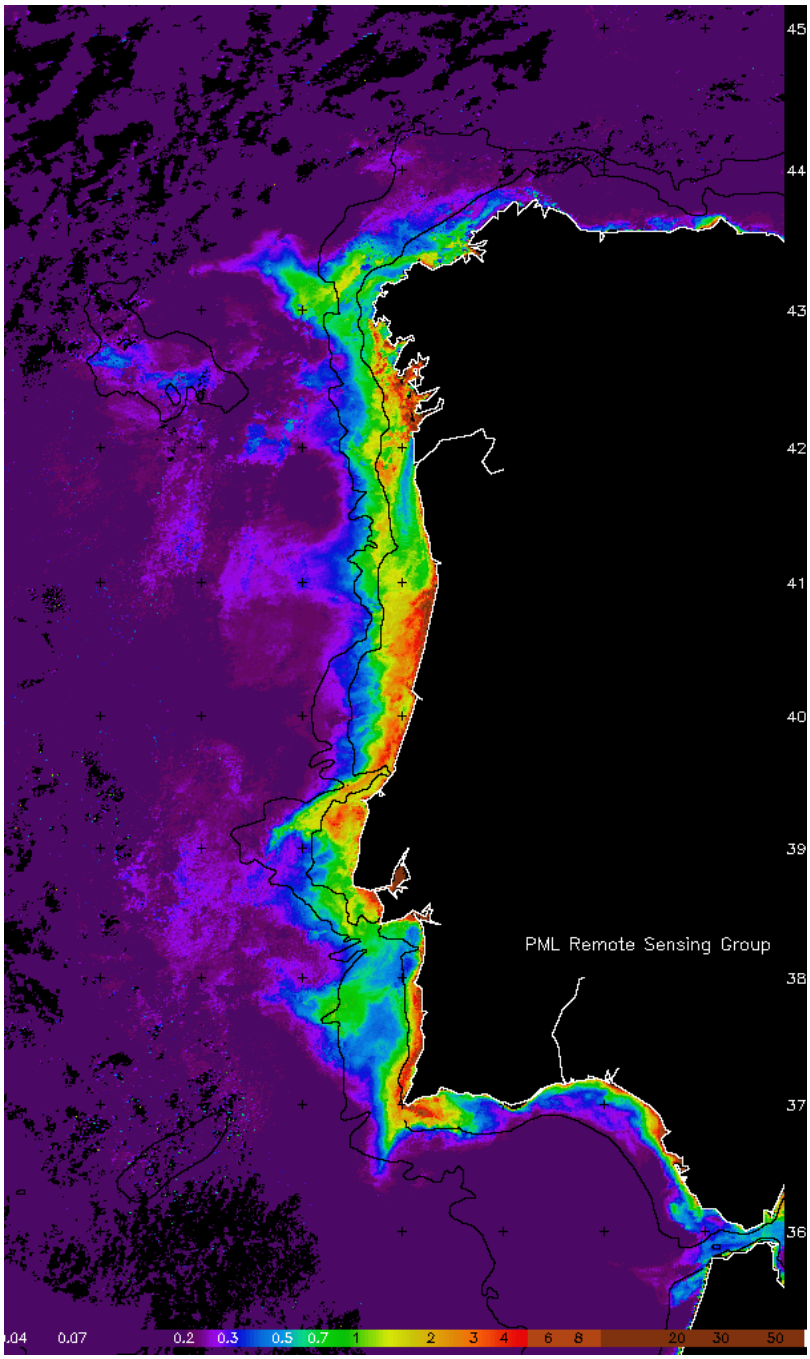
PML Core Science Cruise 2005



CRUISE REPORT

Plymouth
Marine Laboratory

PML Core Science Cruise 2005

19th June – 9th July 2005

Lisbon (Portugal) to Falmouth (UK)

CRUISE REPORT

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Cover image: MODIS Aqua chlorophyll-a composite for 03-09 July 2005

ABSTRACT

This report documents scientific activities on board the Royal Research Ship Charles Darwin during the PML Core Science Cruise, 19th June to 9th July 2005. The objective of the cruise was to improve our understanding of biochemical processes in the near-surface and microlayer of the ocean. We examine gradients in major nutrient concentrations and cycling, production and consumption of key biogases and variability in biological communities between micro-layer, near-surface and deeper water; and between productive and oligotrophic waters along a transect from offshore oligotrophic to coastal upwelling waters off western Spain and Portugal. We also aimed to examine the influence of gradients in physical, biological and photochemical processes at or near the surface micro-layer on the transport of heat and bio-gases across the air-sea interface.

The existence and measurability of a microlayer biological community depends upon calm conditions infrequently encountered in the open ocean. During 15 days of scientific work we were fortunate in successfully deploying near-surface and microlayer sampling devices on 11 and 8 days respectively, in diverse ecological conditions along the transect from oligotrophic to productive waters. Detailed scientific results are not yet available, but preliminary analysis of the data indicates that differences in microbial communities and processes and chemical properties between the bulk and near surface and microlayer waters are highly variable. Bacterial production, microbial abundance and community structure, and biogas production were often several times higher in the near surface and microlayers than in the bulk sea water.

We have obtained some very interesting, and in some cases, unique measurements of the gradients in biological properties and processes in this layer. As data processing and analysis is completed over the coming months, we expect to publish our results. We believe these will include some completely new insights into these properties and processes in the near-surface and microlayer of the oceans.

ACKNOWLEDGEMENTS

We would like to express our thanks to the master of the RRS Charles Darwin, Peter Sarjeant and his officers and crew for the friendly and professional way they conducted their ship and supported our science programme. As usual, this was completed with the minimum of fuss and enabled the maximum science program possible to be undertaken. Particular thanks are due to Peter for the way in which he handled a requirement for compassionate return of a member of the science party to the UK midway through the cruise, ensuring that the scientist was able to get home with the minimum delay possible. Special mention should also be made of the first officer, Malcolm Graves, who completed the suturing of a severe cut to a scientist's hand under very difficult circumstances, saving us the loss of further time and personnel during the cruise. If the scientist concerned is able to put the detailed memory of the experience from his mind, I am sure he joins me in offering thanks to Malcolm.

We also express our thanks to Mr. Andy Louch and Mr. Colin Day, of the Research Ship Unit and UK Ocean Research Services respectively, and their staff, for their support of our cruise both in the months preceding, and during the execution of it.

Special thanks go to Pedro Montero and his colleagues at MeteoGalicia, Consellería de Medio Ambiente e Desenvolvemento Sostible Área Central in Santiago de Compostela, Galicia, who supplied us on a daily basis with high-quality meteorological forecasts for the cruise area. This was invaluable in our attempts to anticipate the onset of upwelling, forced as it is by the periodic switch to northerly winds.

Finally, thanks are due to PML staff in support of this cruise, in particular to Mrs Chris Wing and her colleagues for administrative support, and to Peter Miller and his colleagues in the NERC Remote Sensing Unit at PML for providing daily satellite remote sensing imagery of the area of our cruise, without which the conduct of the cruise would have been near-impossible.

CONTENTS

1.INTRODUCTION

1.1 SCIENTIFIC BACKGROUND AND RATIONALE

Ocean biogeochemistry is driven by an `engine' that is primarily a function of activity in the upper ocean. Light dependent photosynthesis is responsible for the fixation of inorganic carbon (dioxide) into autotrophic cellular biomass, which also requires the fixation of the other major elements (nitrogen, phosphorus, etc.). All of the subsequent heterotrophic processes in the ocean are dependent upon this upper-ocean autotrophy. Given the logarithmic decline in irradiance with depth the steepest gradients in the light driven processes occur in the uppermost few to 10s of metres. We would therefore expect to see major changes and gradients in the majority of the biogeochemical processes over the first few metres of the ocean.

We speculate that this will be observed in:

- the major nutrient cycling processes
- production and consumption of key biogases
- variations in biological communities (at all scales -- virus to zooplankton)

Whilst the general processes in the upper ocean are well know there has been little focus on the very near-surface communities and processes. There are a number of other key reasons for studying the extreme upper ocean. First, the upper few metres of the ocean interact with the atmosphere in what is the largest interface region on the planet. This interface controls the transport of a wide range of materials (e.g. sea-salts, biogases, dust, etc.) and physical transports (e.g. heat). The extreme interface (the sea-surface microlayer) must therefore be an important feature and is likely to exhibit unexpected biogeochemical properties that are important to this general interface layer. Virtually nothing is known about this interface.

Secondly, it is becoming increasingly apparent that there are a number of important non-biological light driven chemical processes in the extreme upper ocean; for example, photo-chemical degradation of refractory material to produce potentially biologically available compounds. Photochemical destruction may also moderate the flux of materials across the interface; for example, biogases. These and other similar processes may significantly modify the rates of a wide range of biogeochemical processes, and are also virtually unknown.

1.2 CRUISE OBJECTIVES

We planned to sample at least two contrasting sites - one in a productive upwelling area off the western coast of the Iberian Peninsula, and one at an oligotrophic site further offshore. The sampling sites were to be chosen opportunistically from study of near-real time satellite imagery of ocean colour, received from the NERC Remote Sensing Unit at PML immediately before and during the first few days of the cruise, in combination with continuous underway measurements of sea surface temperature and chlorophyll fluorescence. This plan was subsequently modified to include a number (5 to 6) of sites along a productivity gradient from the offshore oligotrophic site to the productive upwelling site closer in to the Iberian coast.

We planned to examine the gradients in major nutrient concentrations and cycling, production and consumption of key biogases and variability in biological communities between near-surface (<<2m) and bulk surface (2-10m) water, and between productive and oligotrophic waters along this transect. We planned also to examine the influence of these gradients in physical, biological and photochemical processes at or near the surface micro-layer on the transport of heat and bio-gases across the air-sea interface.

1.3 SAMPLING STRATEGY

Using near-real time satellite imagery of ocean colour in combination with continuous underway measurements of sea surface temperature and chlorophyll fluorescence we aspired to identify a suitable upwelling patch or filament to conduct the initial study, possibly of around three days duration. This was to include day/night sampling of surface water, and possibly the sampling of a diel cycle. We would then identify an offshore oligotrophic site to conduct the 'background' study, and select a series of intermediate stations to provide a gradient of physical, biological and chemical conditions between these two extreme sites. Given 15 days of science time during the cruise, and 5 stations along the transect, we would be able to spend three days at each station, although this would be left flexible enough to respond to changing conditions from day to day.

An alternative strategy was also considered - to identify an upwelling filament, mark it and track and sample it through its transport offshore and decay. These stategies had several potential pifalls, not least of which is that we were to arrive in the target area quite early in the year in terms of the upwelling processes, and so might not find a suitable site at all. In the event, the satellite information available to us at the time of departure indicated a quiescent period between upwelling events, so that the initial plan was reversed – an oligotrophic site was identified at 42 N, 10 30'W, approximately 25nm off the coast just north of the border between Spain and Portugal, an area where in satellite imagery for June/July in previous years, upwelling have been noted to be frequent and strong.

Daily sampling regime

A standard daily sampling regime was established, although intended to be subject to change in response to changing conditions (see Appendix 1 for details). This was to include:

- Night-time deployment of neuston net and pump, shortly after midnight;
- Pre-dawn CTD cast for productivity experiments throughout daylight hours;
- Main daily CTD cast mid-morning;
- Deployment of near-surface and microlayer sampling devices once or twice per day, where conditions permit;
- Daytime deployment of neuston net and pump, around middle of the day;
- Optics profiling casts 5-6 times per day, including pre-dawn and post-dusk;
- Turbulence probe casts 5-6 times per day, including pre-dawn and post-dusk (from ship and from RIB where possible);
- SAPS pre-dawn and post dusk, every day or every other day;
- Shallow CTD casts for nitrification and nitrogen cycling experiments, as required;
- Other opportunistic CTD casts as required.

SECTION 2 – CRUISE ITINERARY AND NARRATIVE

2.1 ITINERARY

16th June 2005	Science party depart PML, flight to Lisbon via Heathrow airport.
16th – 18th	Hotel accommodation in Lisbon. Cruise mobilization.
18th June 2005	Embark science party aboard RRS Charles Darwin.
18th – 19th	Cruise mobilisation.
19th June 2005	Delayed vessel departure Lisbon 16:15 GMT.
20th June 2005	Test station 09:30 en route to first Science station 40°44'N, 9°51.7'W. Successful deployment of CTD, SAPS, Neuston net & pump, Optics Rig & turbulence Probe. Under way 17:25 GMT.
21st June 2005	On first station 02:07 GMT, Science work commenced.
23rd June 2005	Depart station 22:14 GMT.
24th June 2005	On Station 2, 05:23 GMT, 41°44'N, 9°20'W.
25th June 2005	Station interrupted 19:13 GMT – requirement to make for Vigo for compassionate disembarkation of science party member.
26th June 2005	Recommence Station 2, 08:45 GMT, 41°43'N, 9°20'W
26th June 2005	Station complete, depart station 19:03 GMT.
27th June 2005	On Station 3, 01:00 GMT, 41°51.5'N, 8±°58'W.
27th June 2005	Station complete 11:35 GMT. 11:35 – 01:00 Survey of coastal waters Vigo to Cape Finisterre.
28th June 2005	On Station 4, 01:00 GMT, 42°12.5'N, 9°00.5'W.
29th June 2005	Station interrupted 18:40 – Return to Vigo for water.
30th June 2005	Recommence Station 4 12:00 GMT.
2nd July 2005	Complete 19:10 GMT, Depart Station.
2nd July 2005	On Station 5, 23:00, 41°46.7'N, 9°01.5'W.
3rd July 2005	Station complete, 19:00 GMT, depart station.
4th July 2005	On Station 6, 08:34 GMT, 41°47'N, 9°06.6'W
6th July 2005	Station complete 17:30 GMT. All Science Complete.
6th July 2005	Depart Station for Falmouth, 17:54 GMT.
9th July 2005	Arrive Falmouth 08:30 GMT.
9th July 2005	Demobilisation complete 14:00. Science party disembarked for Plymouth.

2.2 NARRATIVE
(all times are given as GMT unless otherwise stated)

19th June 2005 Departure from Lisbon was scheduled for 09:00, but due to the need to fly out a Flow cytometer technician the previous evening, sailing was delayed. Repairs to the HPLC were completed by 12:30, and a 16:00 sailing time was determined by the availability of a pilot. Eventually departed Lisbon 16:17. Satellite information available to us at the time of departure indicated a quiescent period between upwelling events, so an oligotrophic site was chosen as the first station, whilst we awaited the anticipated onset of upwelling near the coast. Station 1 identified at 42°N, 10°30'W, approximately 25nm off the coast just north of the border between Spain and Portugal, an area where in satellite imagery for June/July in previous years, upwelling has been noted to be relatively frequent and strong.

20th June 2005 Passage interrupted at 09:30 for 'shakedown station' to check equipment and deployment operations. Completed successful deployments of CTD, SAPS, Neuston net & pump, Optics Rig and Turbulence Probe. Conditions fresh, northerly wind ~20-25kts. Vessel under way 17:25.

21st June 2005 Arrived on first station (42°00'N, 10°30'W) at 02:07, Science work commenced with plankton nets. Conditions initially fresh becoming progressively calmer (25->5kts) during our stay on this station. First deployment of near-surface sampler (NSSD), Garrett screens (GS) and turbulence probe from RIB well away from ship at 14:00 on second day at this station. Remained on station for three days, as planned.

23rd June 2005 Depart station 1 at 22:14, bound for station 2, identified further inshore around 12nm offshore of Spain/Portugal border. This decision guided by evidence in SST imagery of cooler water along coast in this region, although no chlorophyll signal detected.

24th June 2005 Arrive on Station 2 (41°44'N, 9°20'W) at 05:23. Conditions light 6-12kts. Commenced sampling with Neuston net and pump. Further successful deployments of GS, NSSD and MLSD from RIB on all three days at this station.

25th June 2005 News received requiring compassionate disembarkation of one of the science party due to family health reasons. Agreed with the Captain to make for Vigo immediately after successfully finding a flight from Vigo the following morning. Depart station at 23:07 for Vigo.

26th June 2005 Boat transfer complete at 04:32, heading back to Station 2. Recommence science programme at Station 2 at 08:45. Conditions light 5-10kts. Near flat calm conditions, large patches of a visible biogenic slick had developed on the surface, and the GS, NSSD and microlayer sampler (MLSD) were successfully deployed within one such patch.

26th June 2005 Station complete, depart station at 19:03. Satellite imagery indicated no significant upwelling, moving further inshore in expectation. Selected site from monitoring underway temperature an chlorophyll as vessel moved inshore.

27th June 2005 Arrive on Station 3 (41°51.5'N, 8°58'W) at 01:00. Conditions light 6-12kts. Commenced sampling with Neuston nets and pump. First early deployment of GS, NSSD & MLSD from RIB at 06:00. During the day, it becomes apparent that we are sampling a dead bloom – indicated by presence of dead plankton 'mat' in neuston nets, and presence of high levels of breakdown products in the water column. In the absence of any satellite support imagery since 24th we decide to conduct a survey along the coast 4nm offshore from present position to Cape Finisterre to detect any signs of incipient upwelling.

27th June 2005 Depart Station 3 at 11:35 proceeding north along coast. Monitoring underway sensors. Off Cape Finisterre at 17:30 – no indication of colder water or enhanced production - returning southward. Given that upwelling and associated production often begins at the mouth of the Rias (local knowledge) we select a station around 4nm off Ria Vigo to await developments.

28th June 2005 Arrive on Station 4 (42°12.5'N, 9°00.5'W) at 01:00. Conditions freshening, wind 21-24kts. Commenced sampling with Neuston nets and pump at 01:10. Deployment of RIB with GS, NSSD, MLSD scheduled for 06:10 and 14:00 cancelled due to conditions (Wind 20kts).

29th June 2005 Conditions easing 7-10kts. Two deployments of GS, NSSD and MLSD from RIB at 05:50 and 13:40. Station interrupted 18:40 in order to return to Vigo to take on fresh water due to reduced capacity of vessel to make water.

30th June 2005 Vigo at 04:00, commenced taking on water, depart Vigo 11:18 returning to station 4. Recommence Station 4 12:00. Winds 10-15kts. Still no indication from satellite imagery, remaining on Station 4 awaiting developments.

30th June 2005 Depart station for survey to south of Vigo at 21:50. Completed survey 23:12, returning to station 4. Sea temperature around 18.8°C, with 0.35° drop across mouth of Ria. Vessel back on Station 01:00, scientific work continues. Deployment of RIB with GS, NSSD, MLSD scheduled for 16:00 cancelled due to RIB engine failure.

1st July 2005 Science work continues. Conditions freshening 17-21kts. Deployment of GS, NSSD from RIB at 13:30. Conditions judged unsuitable for MLSD (18kts). Further exploratory survey south at 22:12, completed at 23:36, return to Station 4. Sea surface temperature has dropped to around 18.2°C, no reduction across mouth of Ria. Indication of change?

2nd July 2005 Arrive on Station 4 at 01:00. Resumed science work. Conditions initially fresh (14-18kts) easing thoughout the day (6-14kts). Freefall optics probe entangled with stern gear at 11:15. Attempts to free it failed, probe lost at 12:02. Deployment of GS and NSSD at 13:50. 15:00 – wind freshening again 14-22kts. Vessel departs station for more comfortable position in swell toward 12 mile limit. Commenced exploratory transect south along 12 mile limit at 22:12. Sea temperature dropped from 18.64C to 17.24C during this transect, underway fluorometer marginal increase. Selected potential Station 5 along this transect based upon temperature minimum – deployed CTD to 40m at 23:05 for 'quick & dirty nutrients analysis. Elevated nitrate levels in surface water – confirmed position for station 5 (41°46.7'N, 9° 01.5'W).

3rd July 2005 Sampling commenced with Neuston nets and pump at 01:10. Conditions fresh 17-22kts. 04:45 & 12:15 - RIB deployments cancelled due to conditions. Vessel proceeds offshore at 19:11 on more comfortable heading to allow suturing of fairly severe cut to the hand of a scientist.

4th July 2005 Conditions deteriorating, wind 30-35kts. Science programme 01:00-09:00 cancelled. Commence exploratory transect on course 290°T at 07:14. Sharp decline in surface temperature to around 13°C along this transect. Alter course 180°T at 08:00. Sea temperature increase 13.25°C to 14.72°C, fluorimeter increase 95mV to 249mV. Station 6 selected at 41°47'N, 9°06.6'W.

4th July 2005 On station 08:34, sampling commenced with CTD, Neuston nets & pump. Conditions fresh, 20-25kts. No RIB deployments. Exploratory survey along 290°T commenced at 21:21. no indication of better conditions, return to station 6. Satellite imagery for 3rd & 4th July confirm temperature indications of onset of upwelling and enhanced chlorophyll production all along coast between 41° and 41°50'N extending to ~25nm offshore.

5th July 2005 Recommenced work on Station 6 with nets at 01:15. Conditions eased 6-13kts, freshening 17-24kts after noon. GS, NSSD & MLSD deployed from RIB, 06:20.

6th July 2005 Sampling continues, conditions worsening 19-28kts through day, no further deployment of RIB & surface samplers. Station complete 17:30 GMT. All Science Complete. Depart Station for Falmouth, 17:54 GMT.

8th July 2005 PSO's birthday. General rejoicing.

9th July 2005 Vessel arrives in Falmouth 08:30 GMT. Demobilisation of science equipment complete by 14:00, science party disembarked for Plymouth.

2.3 CRUISE PERSONNEL

Scientific Party

Plymouth Marine Laboratory

Chris Gallienne	Principal Scientist
Ruth Airs	Pigments & MAAs
Steve Archer	Biogases & volatiles
Delphine Bonnet	Mesozooplankton
Darren Clark	Nitrogen cycling
Denise Cummings	Biogases & volatiles
Jo Dixon	Primary productivity
Claire Evans	Microbial community & the viral shunt.
Malcolm Liddicoat	Biogases & volatiles.
Alex de Menezes	Microzooplankton & microbial community.
Gavin Tilstone	Optics, FRRF & CDOM
Ricardo Torres	Physics & Turbulence.
Willie Wilson	Microbial community & the viral shunt.
Malcolm Woodward	Nutrients & nitrification.

Newcastle University

Emma Suddick	Nutrients and photoammonification

UKORS personnel

Darren Young	SAPS, CTD, Instrumentation
Peter Keen	CTD, Instrumentation.
Paul Duncan	Computing support.

SECTION 3 – SAMPLING METHODS AND EQUIPMENT

3.1 GENERAL SCIENTIFIC APPROACH

Standard CTD, SAPS and non-toxic ships seawater systems were to be used for sampling the mixed layer during the cruise. In addition, several devices for sampling in and around the surface microlayer were to be deployed, as described in the following sections.

3.2 EQUIPMENT AND METHODOLOGY

Garrett screens

The Garrett screen sampler (Garrett, 1965) is a hand-held device consisting of a 50cm square frame enclosing a stainless steel mesh (fig. 3.1.1). The screen is slid gently through the water surface at an angle, and then lifted flat back through the surface. Small rectangular cells of water from the sea surface are captured in the interstitial spaces of a wire mesh by means of surface tension. Thickness of the microlayer sample collected by the screen is calculated from the void area of the screen and the volume of sample collected (typically 400-600μm in our experience). This value is determined primarily by the diameter of the screen mesh filaments and the surface tension of the water.

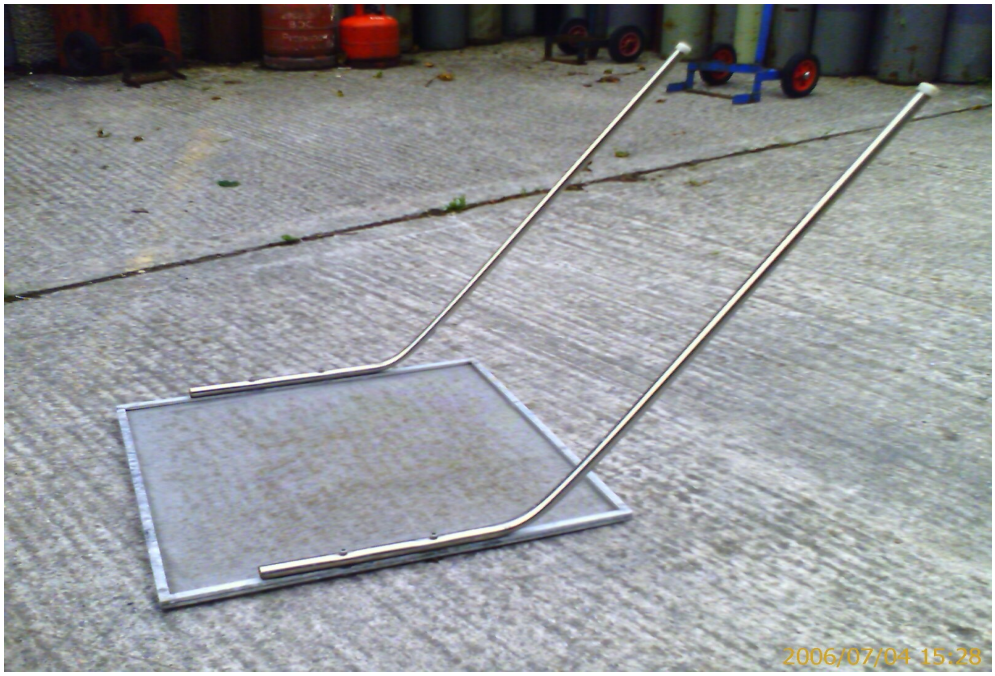


Figure 3.1.1 Garrett Screen Sampler

Near-surface sampling device

A floating near-surface sampling device (NSSD) had been constructed at PML (figure 3.1.2). This device consists of a flotation ring (1.2m diameter) supporting a central vertical spar. This spar carries a series of 8 sampling bottles spaced at 20cm intervals (upper 5; lower 3 at c. 30cm), and an array of thermistors spaced at logarithmic intervals between a few mm below the surface and ~2m depth. An analogue of skin temperature (~500μm depth) can be obtained from concurrent remote sensing of sea surface temperature. Atop the spar is a control system which continuously logs thermistor data and transmits it up the cable to a host computer on board the ship. The control system also allows for the remote firing of the sampling bottles from the host computer. The NSSD is deployed from the ship and allowed to drift away from the ship on a conductor-core tether. The tether carries two conductors for DC power supply to the NSSD and two conductors for RS-485 communication between the NSSD and the host computer.

Figure 3.1.2. Near-surface sampling device

Microlayer Sampling Device

The surface microlayer sampling device (MLSD, figure 3.1.3) is a rotating drum device mounted between the hulls of a small (1.5m long) catamaran platform. The MLSD will be deployed tethered to the NSSD. The rotating glass drum picks up water from the microlayer, which is then removed by a Teflon wiper blade and collected in small sample pot. The contents of this pot are continuously

removed by a peristaltic pump to a larger (2.7 litre) storage vessel on the upper hull.

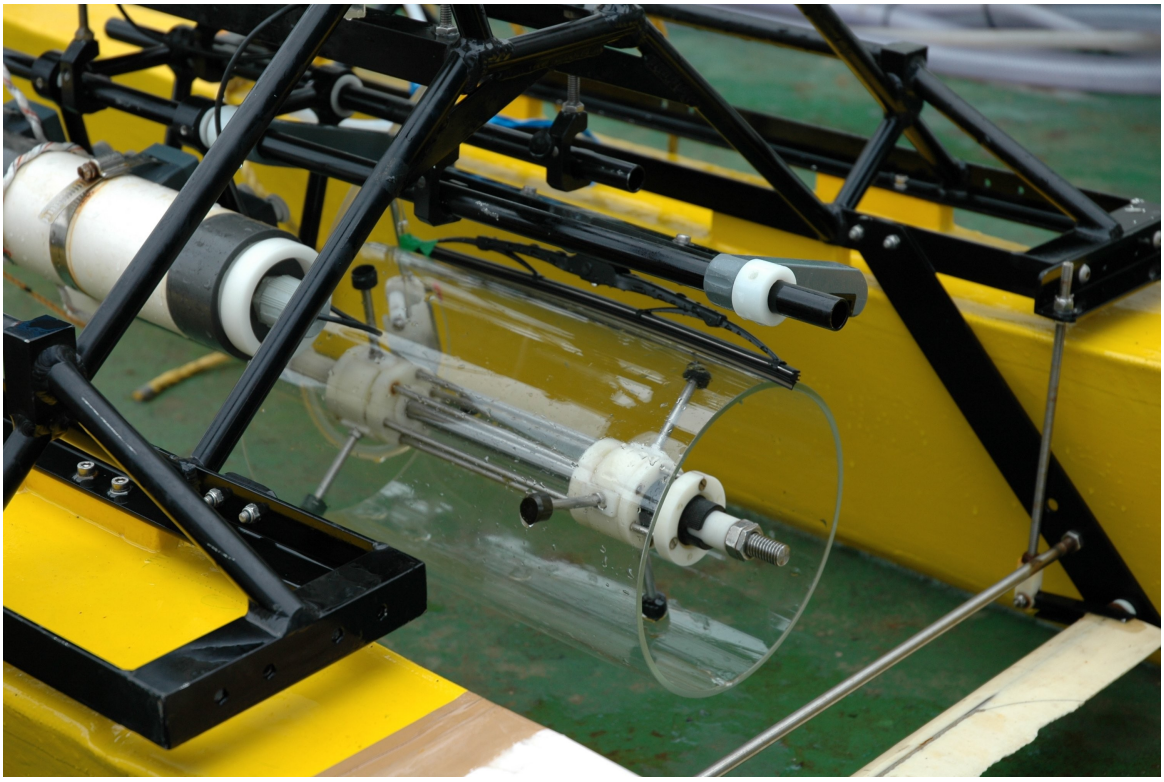


Figure 3.1.3. Microlayer Sampling Device (MLSD)

A simplistic calculation of the thickness of the layer sampled by this device can be made by dividing the volume collected by the area of a notional layer swept by the drum in the sampling period. The sample volume was typically 2.7L. The swept area is the length of the drum (40cm) multiplied by the rotation speed (around 6cm/sec) multiplied by the sampling time (~30 minutes). In units of metres and seconds, this is calculated as

$$0.0027 / (0.4 * 0.06 * 1800) = 62.5\mu m$$

This simplistic calculation makes several unrealistic assumptions, principally that all the water picked up by the drum will be wiped off into the sample collection vessel. In reality, some of the sample will probably run back off the drum before it reaches the wiper. Variations in viscosity (for example, due to the presence of a surface slick) and temperature will also affect this value. Further dedicated experimentation will be necessary to determine a true sampling thickness. If we assumed a sample recovery ratio of 25% then the thickness figure would be a more realistic 250μm, around half the thickness sampled by the Garrett Screen.

The mechanical processes involved in sample recovery by these devices will, as always, have an effect upon the properties of the water samples. This is a particular problem in the case of gases dissolved in the water – any mechanical agitation of the sample water can result in out-gassing, and therefore an underestimate of concentration of the gases concerned. Although they sample very differently, and acquire samples from different thicknesses of microlayer, it was useful to have two rather different methods for acquisition of water samples from the surface microlayer for intercomparison.

Near-surface zooplankton pump
The near-surface pump is a floating device consisting in a floating ring supporting a central vertical spar (fig. 3.1.4). This spar is 2.5 m long, and supports a pump which can sample from 0.3 to 2.3 m deep. The flow rate of the pump is approximately 50 L min^{-1} and the organisms collected are not damaged (we tested the device). Some collectors with different mesh sizes (63 and 200 µm mesh are available) can be adjusted to the end of pipe to collect and concentrate the zooplankton. Collection over a predetermined period of time will allow quantification of the sample.

Figure 3.1.4 Near-surface zooplankton pump

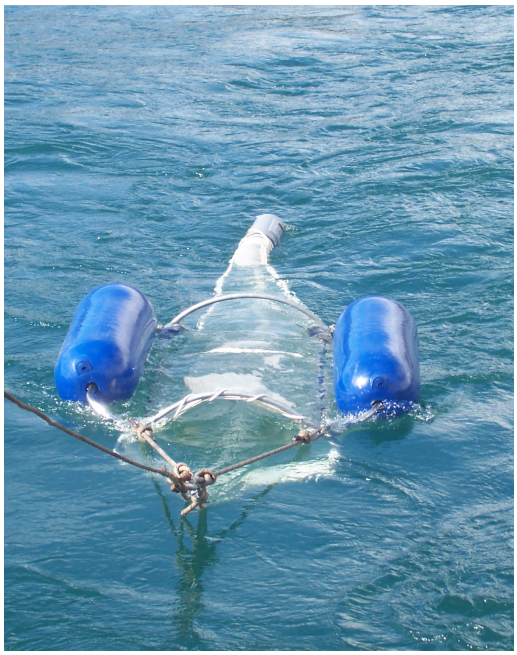


Figure 3.1.5a and b. Neuston Net

Neuston net
A neuston net has been designed and constructed for the cruise (fig. 3.1.5). It comprises of a WP2 net (200μm mesh size) with two floatation buoys attached, and will collect the zooplankton living at the surface (= neuston). The net is be towed horizontally from the ship at a constant speed (4 knots expected) and for a duration of 10 minutes to make the tow quantitative.

SECTION 4 – CRUISE SYNOPSIS

4.1 EARTH OBSERVATION DATA - Peter Miller and Rory Hutson

Introduction
Near-real time Earth Observation (EO) support was essential to achievement of cruise aims - to locate areas of upwelling for studying near-surface biology. PML Remote Sensing Group (RSG) has a well developed capability for real-time cruise support, based on polar-orbiting satellite sensors for estimating ocean temperature (AVHRR, MODIS) and colour (SeaWiFS, MODIS, MERIS).

Methods
We focussed on two products for this study: sea-surface temperature (SST) from the NOAA Advanced Very High Resolution Radiometer (AVHRR); and chlorophyll-*a* (chl-*a*) from NASA MODerate resolution Imaging Spectroradiometer (MODIS). SST indicates the colder deep water reaching the surface during upwelling, while chl-*a* depicts the change in phytoplankton abundance caused by upwelled nutrients. Both raw data types were acquired at the NERC Dundee Satellite Receiving Station then immediately transferred to PML for processing and mapping using automated software - the MODIS system is based on NASA SeaDAS software. Note that the algorithms are inaccurate in turbid coastal water and this will tend to exaggerate chl-*a* values near the coast should be viewed with caution as are likely to be biased by the presence of suspended sediment. Individual scenes are merged to generate 3-day and weekly composite maps, providing a more synoptic view despite cloud masking. RSG also obtained meteorological forecasts, in particular wind speed and direction to allow the upwelling situation to be predicted a few days in advance. The met forecast was provided courtesy of the CAMMEO project and Norwegian Meteorological Institute (http://metoc.met.no/). To generate a wind map we followed the following procedure: from METOC menu select 'ffi_metno_surface', tick '3) Magnitude Wind' and '3) Wind', then click redraw button (circular arrows). Select time from menu or use clock forward and back button on map viewer. Use magnify icon then click on Portugal to zoom in. For longer-range forecast select 'DNMI-ec' from METOC menu. Wind speed is represented by a short barb for 5 knots, or a long barb for 10 knots.

Preliminary results
Time-series composite data
The time series of SST data for the Iberian Peninsula is shown as a weekly sequence of composite maps (figure 4.1.1). It can be seen that there is only weak upwelling during the first three weeks, mainly near Finisterre, with significant upwelling only in the final week. This situation is mirrored in the weekly chl-*a* maps (figure 4.1.2), with all high values (>0.5 mg m^{-3}) constrained in a very narrow band along the coast for the first three weeks, followed by increased phytoplankton abundance at Finisterre and Vigo in the final week. The colour scale used in chl-*a* maps enhances concentrations between 0.2 and 5.0 mg m^{-3}, though in this period much of the area is <0.2 mg m^{-3} (purple). Comparing the chl-*a* data with those from previous years, it can be seen that this period was unusually low in upwelling, though not radically different to 2004 (figure 4.1.4). A further visualisation of the time-series is presented as the MODIS chl-*a* values for the entire cruise track (figure 4.1.3). This indicates the long time the ship remained in a low productivity water before sampling upwelling during the last few days of the cruise. For the purposes of this figure the chl-*a* values were approximated using the weekly composite maps shown in figure 4.1.2, so discontinuities seen at day 177 and 184 are artefacts of this approach. This analysis could be repeated using individual daily data, though with more missing data due to cloud cover.

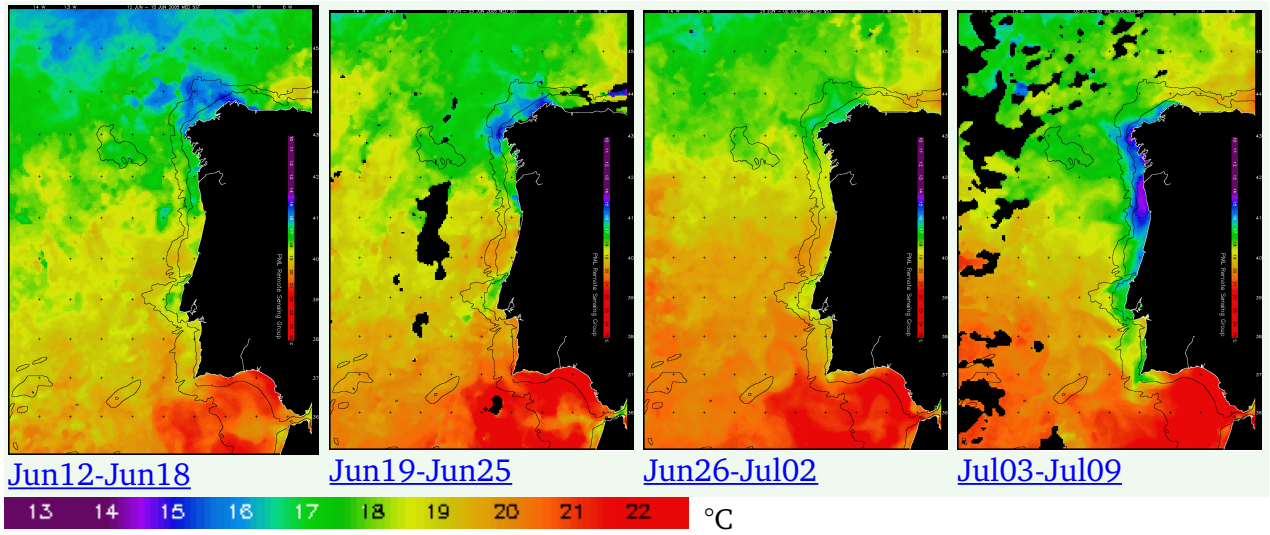


Figure 4.1.1. AVHRR SST weekly composites for period of cruise in 2005.

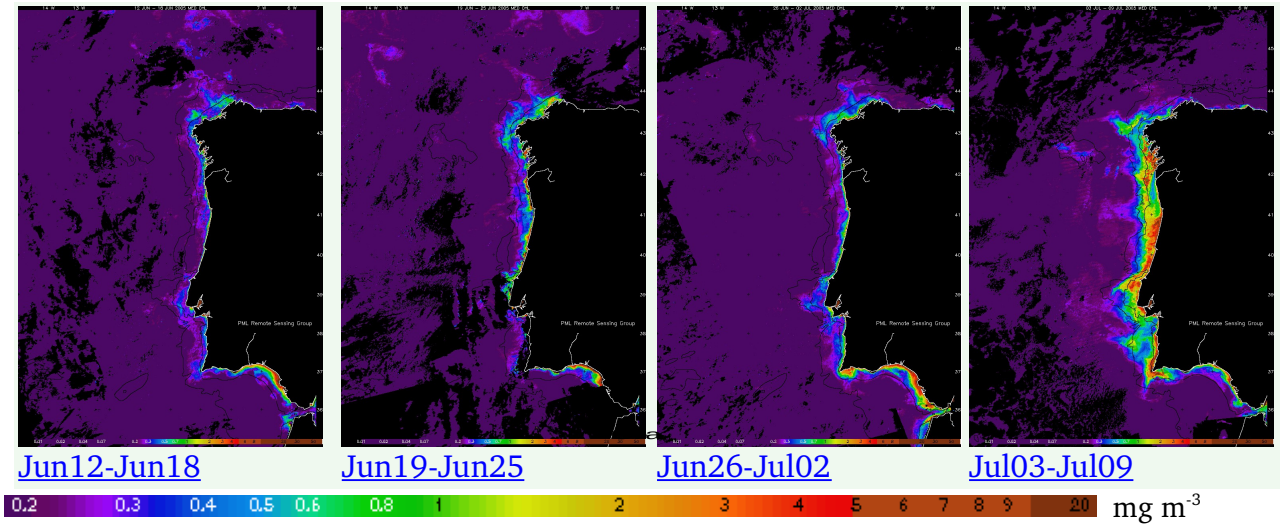


Figure 4.1.2. MODIS Aqua chl-a weekly composites for period of cruise in 2005.

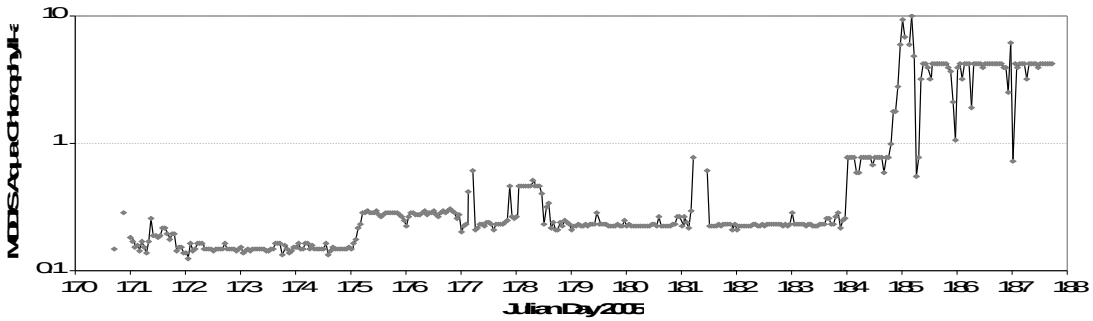


Figure 4.1.3. 'Underway' chl-a derived from MODIS Aqua weekly composite data. Logarithmic scale used on chl-a axis.

Pre-cruise planning data
SeaWiFS chl-a data were processed for previous years to assess the inter-annual variability and likelihood of observing upwelling during the cruise (Figure 4.1.4).

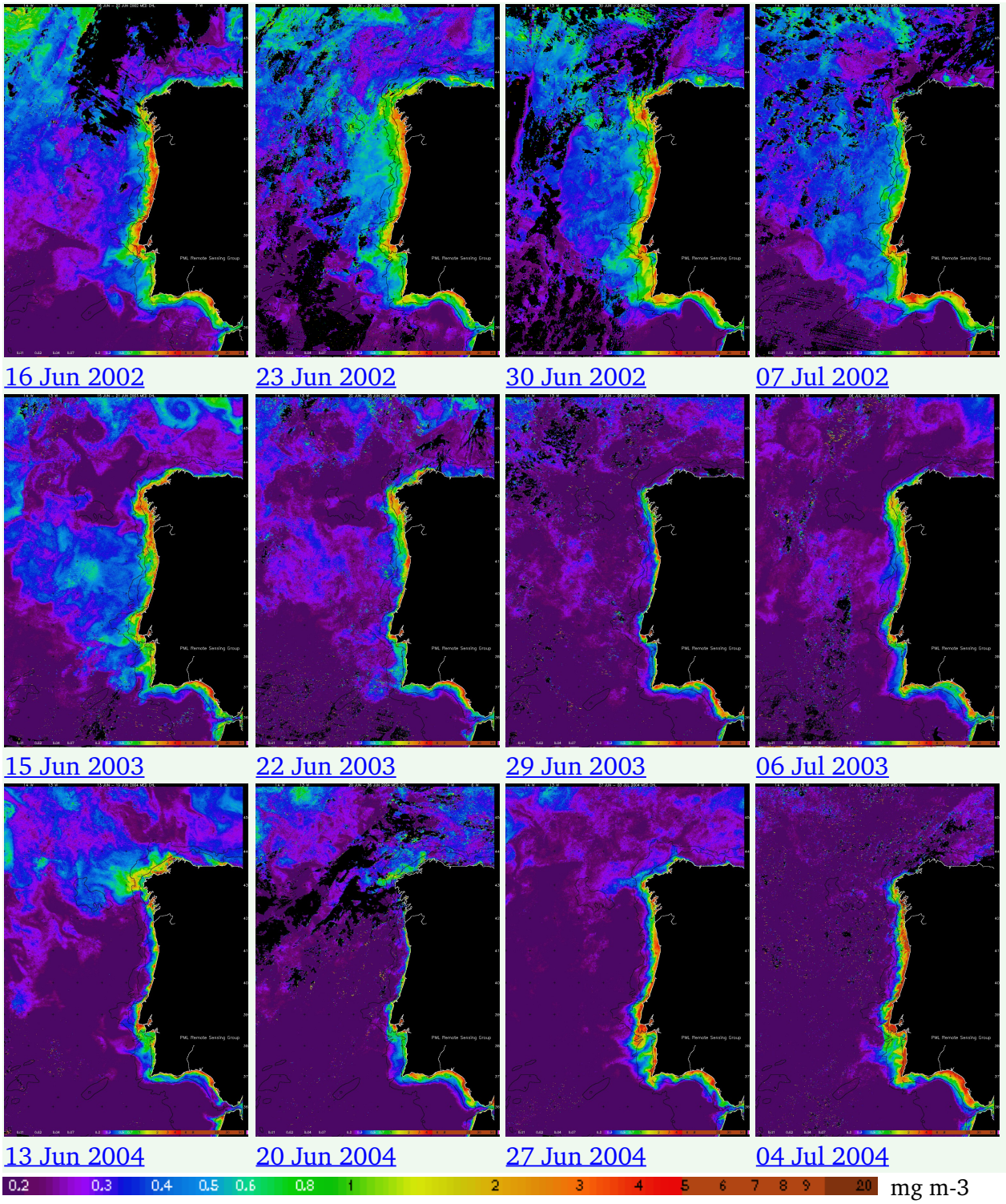


Figure 4.1.4. SeaWiFS chl-a weekly composites for period of cruise in previous years

Weekly SST maps from 1993 to 1997 have been visually analysed to determine the times during the year when upwelling and filaments occurred within the OMEX II-II region off Vigo (figure 4.1.5). Each coloured horizontal line in this figure represents the dates and duration of one such period. Different colours represent different years, and results are presented separately for upwelling and filaments, and for the Finisterre and Vigo regions. This graph summarises the inter-annual variability of the Galician upwelling season during five years. The data from previous years may be used with caution to estimate the likelihood of observing upwelling or filaments during certain months, which may assist in planning the times, locations, and activities of cruises.

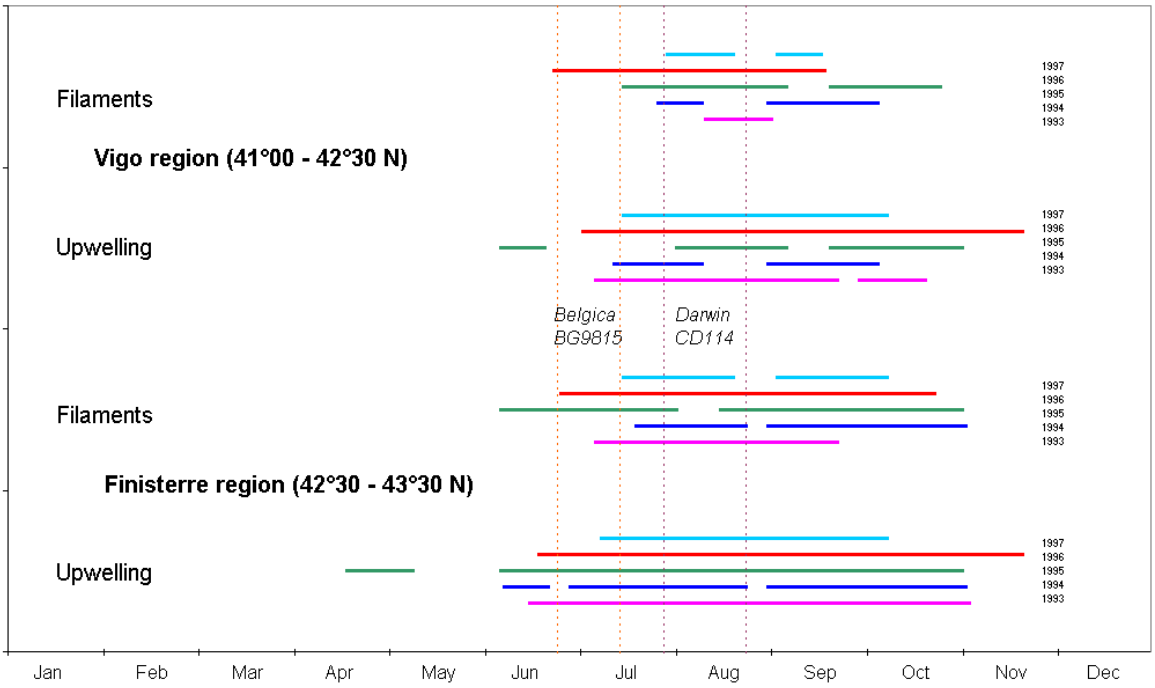
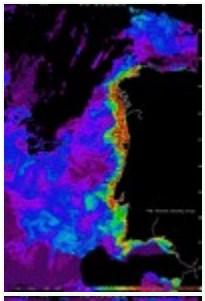
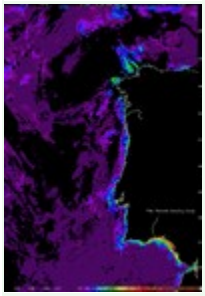


Figure 4.1.5. Duration of upwelling and filaments in OMEX II-II box

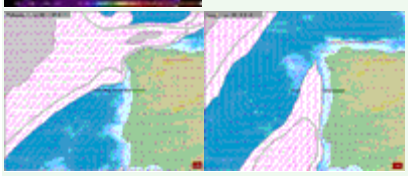
EO data sent to ship in near-real time
There follows a summary of EO and met data processed in near-real time and e-mailed to Charles Darwin to assist in cruise planning. This is based on the cruise EO web page at:
http://www.npm.ac.uk/rsdas/projects/pml_cruise/cd172_jun05/



08 Jun 2005 MODIS chl-a 3-day composite: Showing significant upwelling and some filaments.

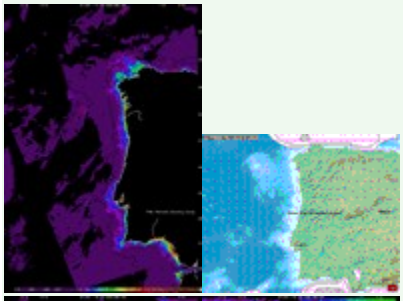


14 Jun 2005 MODIS chl-a 3-day composite: Much lower abundance due to downwelling (southerly) winds.

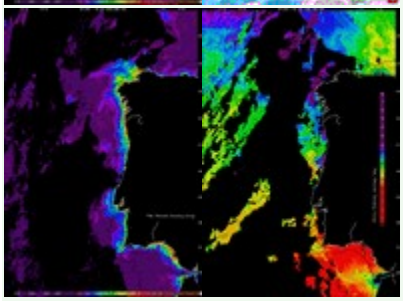


15-17 June 2005 Modelled wind: There are currently southerly winds along the Iberian coast, causing the drop in upwelling intensity seen in the chl-a maps below. However this is forecast to change to upwelling (northerlies) tomorrow as seen in the second plot for midnight Friday morning. See below for how to read wind maps. A longer range forecast shows northerly 15 knots

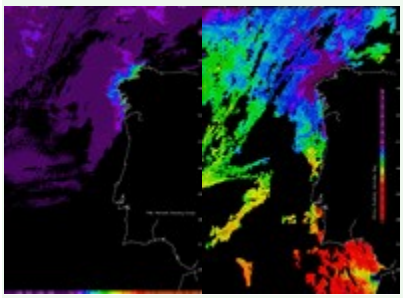
along the coast for Saturday morning (19 June), strengthening to 20 knots on 20 June, 20-25 knots on 21 June, before dropping back to 5-10 knots from 22-24 June, still northerly.



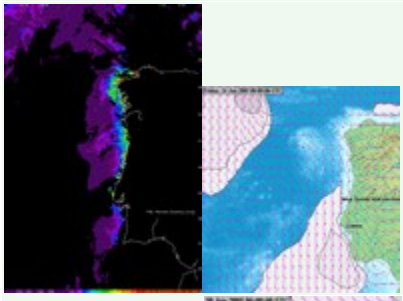
17 June 2005 MODIS chl-a 3-day composite: Some signs of upwelling restarting, though the winds (northwesterly 5 knots) are not as strong as forecast.



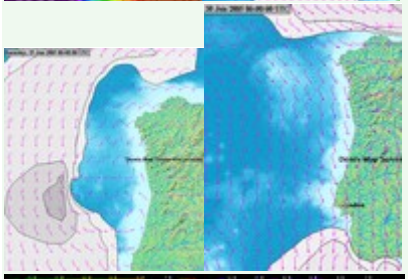
18 Jun 2005 MODIS Aqua NASA chl-a 3-day composite: Looking at the previous upwelling cycle and today's SST image, it appears the upwelling is restarting, and that it will be strongest and most persistent around Finisterre and around 41 15 to 42 00 N. If we get upwelling off Vigo it may be weaker and closer to coast. Also shows 20 Jun AVHRR SST 3-day composite.



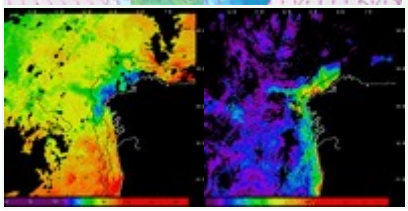
21 Jun 2005 1403 UTC MODIS Aqua chl-a: Unfortunately cloudy just over the suggested region (41 15 to 42 00 N), but there is a hint on the latest MODIS-Aqua image that there is some enhanced abundance in that area, apart from the higher concentration around Finisterre. The model forecasts a change to southwesterly winds by Thursday morning, if so you may have to go nearer to Finisterre for your high productivity station. Also shows 21 Jun AVHRR SST 3-day composite.



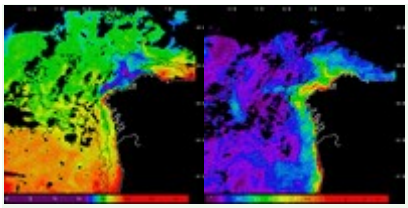
22 June 2005 13:07 MODIS Aqua chl-a: A good single pass image shows most of the coastline, highlighting areas of upwelling. The Thursday morning forecast shows southwesterly winds, but fortunately this just seems to be a blip, as the Friday morning forecast (shown here) gives northerlies again. So hopefully the upwelling will not be affected.

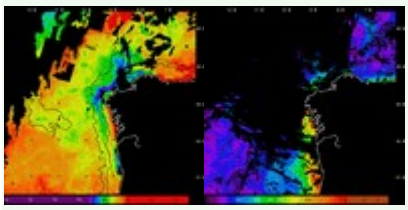


25-27 June 2005: The met forecasts show a low pressure system persisting around the area of interest until around Wednesday. Later in the week winds should return to northerlies.



28-29 June 2005: Quite a lot of cloud cover over the region of interest during the earlier part of the week, so not many useful images. Looks like the winds should change back to northerlies from 30 June through the rest of the week.





1st July 2005: The winds should by staying northerly for the next week according to the metoc forecast. So we are keeping an eye out for upwelling developments. Today's SST shows a channel of slightly cooler water from 41.5N-43N along the coast.

2-4th July 2005: After disruptions to the processing of MODIS images over the weekend we now have a reasonable aqua image. This shows an increase in chlorophyll concentrations along the coast. The SST image from the weekend also shows the coastal waters cooling down. Wind speeds on Monday were in the region of 20-30 knots (pim on 4th states 28knots northerly winds at ~41.5N, 9W) providing some difficulties to sampling. Met wind map forecast shows slightly lower wind speeds through rest of the week.

Cruise support log
17 Jun PIM: Sent 17 Jun MODIS Aqua Chl composite + wind maps.
20 Jun PIM: Sent 18 Jun MODIS Aqua Nasa chl comp, 20 Jun SST comp, wind, etc.
21 Jun PIM: Sent 21 Jun 1403 MODIS Aqua chl, 21 Jun SST comp, wind.
22 Jun ROHU: Sent 22 Jun AVHRR SST 3-day comp, wind (f) friday 24th Jun 0000,
22 Jun 13:07hr MODIS Aqua chlor-a.
23 Jun ROHU: Sent 23 Jun AVHRR SST 3-day comp, 23 Jun MODIS Aqua chl 3day comp.
24 Jun ROHU: Sent 24 Jun AVHRR SST 3-day comp, 24 Jun MODIS Aqua chl 3day comp,
25 Jun 6am wind map forcast.
29 Jun ROHU: Sent 29 Jun MODIS Aqua 3-day comp
29 Jun ROHU: Sent 29 Jun 13:56hrs MODIS Aqua image
29 Jun ROHU: Sent 1 Jul 12:12hrs AVHRR SST image , 01 jul05 13:01 MODIS Aqua chlor image
29 Jun ROHU: Sent 2 Jul 11:50hrs AVHRR SST image
03 Jul JAMS: Sent 03 jul 04:24 AVHRR SST image
04 Jul ROHU: Sent 03 jul 14:25 Aqua Nasa image. (sent for morning transmission)

4.2 SYNOPSIS OF SCIENTIFIC RESULTS – Chris Gallienne

As stated in section 1, we planned to examine the gradients in major nutrient concentrations and cycling, production and consumption of key biogases and variability in biological communities between near-surface (<<2m) and bulk surface (2-10m) water, and between productive and oligotrophic waters along this transect. We also planned also to examine the influence of these gradients in physical, biological and photochemical processes at or near the surface micro-layer on the transport of heat and bio-gases across the air-sea interface.

Station CTD profiles
During the cruise, a total of six stations were occupied, beginning on oligotrophic waters and working our way towards more productive waters nearer to the coast where we expected upwelling to develop. In the following sections, stations and days are indicated as, for example '2.3', meaning the third day on station 2. CTD profiles are available for at least one main daily CTD cast for each day spent at each of these six stations. Profiles of temperature are shown in figure 4.2.1.

Temperature profiles
Prograssively calmer conditions during our occupation of stations 1&2 resulted in a high degree of statification. At station 1 a progressive warming and shallowing of the mixed layer is evident from figure 4.2.1, with sea surface temperature (SST) around 17.5°C and mixed layer depth reducing from 50m to around 20-25m. Station 2 is highly stratified – mixed layer depth ~10m – and SST is 18°C. Conditions during the three days' occupation of this station were very calm, allowing the development of a visible surface biogenic 'slick'. Station 3, though in much shallower depth, shows a similar profile to those on the last days on station 1, and conditions began to freshen at this time. The development of the heterotrophic microbial community, together with the presence of large aggregations of dead diatom biomass in surface zooplankton net casts suggest that these stations had been placed in a previous, decayed bloom. Station 4 was only 4nm offshore, and shows a progressive deepening of the mixed layer from ~15m to ~28m, probably due to freshening wind conditions, followed by restratification. A survey south of station 4 showed a drop in temperature, possibly indicating the onset of upwelling. Station 5 was placed at the temperature minimum along this transect, after a 'quick and dirty' nitrate profile with the CTD showed elevated nitrate levels in the surface waters. The temperature profile is similar to station 4, but with a 2°C reduction in SST. A further survey the following night offshore of station 5 showed a further sharp reduction in surface temperature and an approximately threefold increase in the signal from the underway fluorometer. Station 6 was occupied here, and mixed layer depth was found to be around 28m with SST further reduced to 14°C. Satellite imagery for this and the previous day confirmed onset of upwelling (see figures 4.1.2 & 4.1.3). During the three days we occupied this last station, warming and stratification increased surface temperature to 16°C and reduced mixed layer depth to <20m.

Attenuance profiles
The CTD fluorometer has produced values which are near-meaningless and not open to calibration by any method. Until HPLC data are available for all casts, we have relied upon a proxy for chlorophyll to make comparative assessments of station profiles. Figure 4.2.2 shows attenuance values from the CTD transmissometer, which provide a reasonable proxy for particle concentration and for chlorophyll concentration in the water column (Gordon & Morel, 1983; Loisel & Morel, 1998). The profile for station 1 shows a small deep chlorophyll maximum (DCM) shallowing with stratification. The profiles for stations 2 and 3 indicate a larger but reducing DCM beneath the mixed layer at around 30m. The indicated chlorophyll concentrations on stations 4 and 5 are further reduced, and the DCM indistinct. The proximity of station 4 to the mouth of the Vigo estuary probably invalidates the relationship between attenuance and chlorophyll due to the presence of terrigenous particulates. At station 6, the indicated DCM doubles in strength and shallows to ~10m, as the system responds to the upwelling of cooler, nutrient-enriched water.

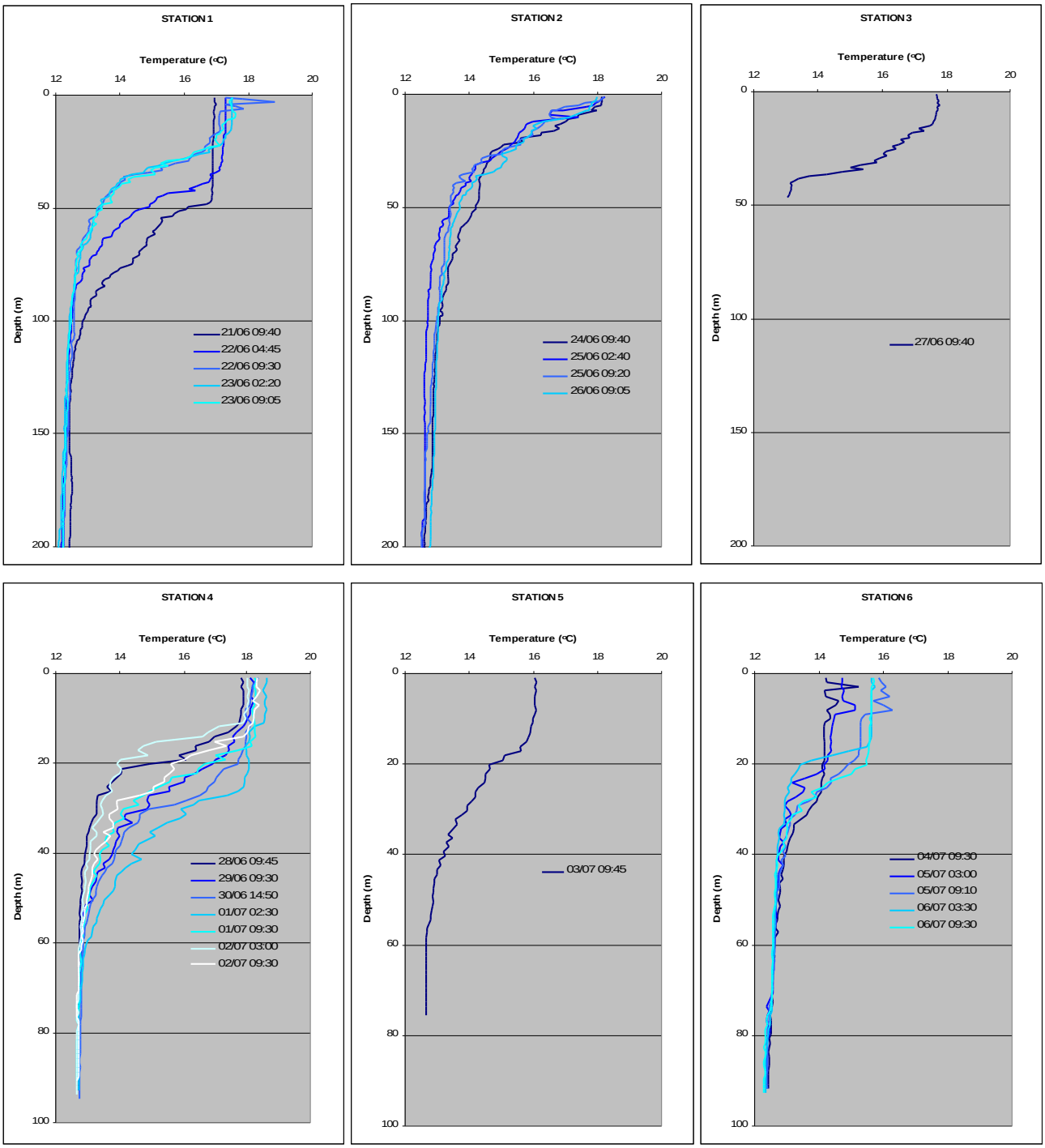


Figure 4.2.1 CTD Profiles of temperature for stations 1-6

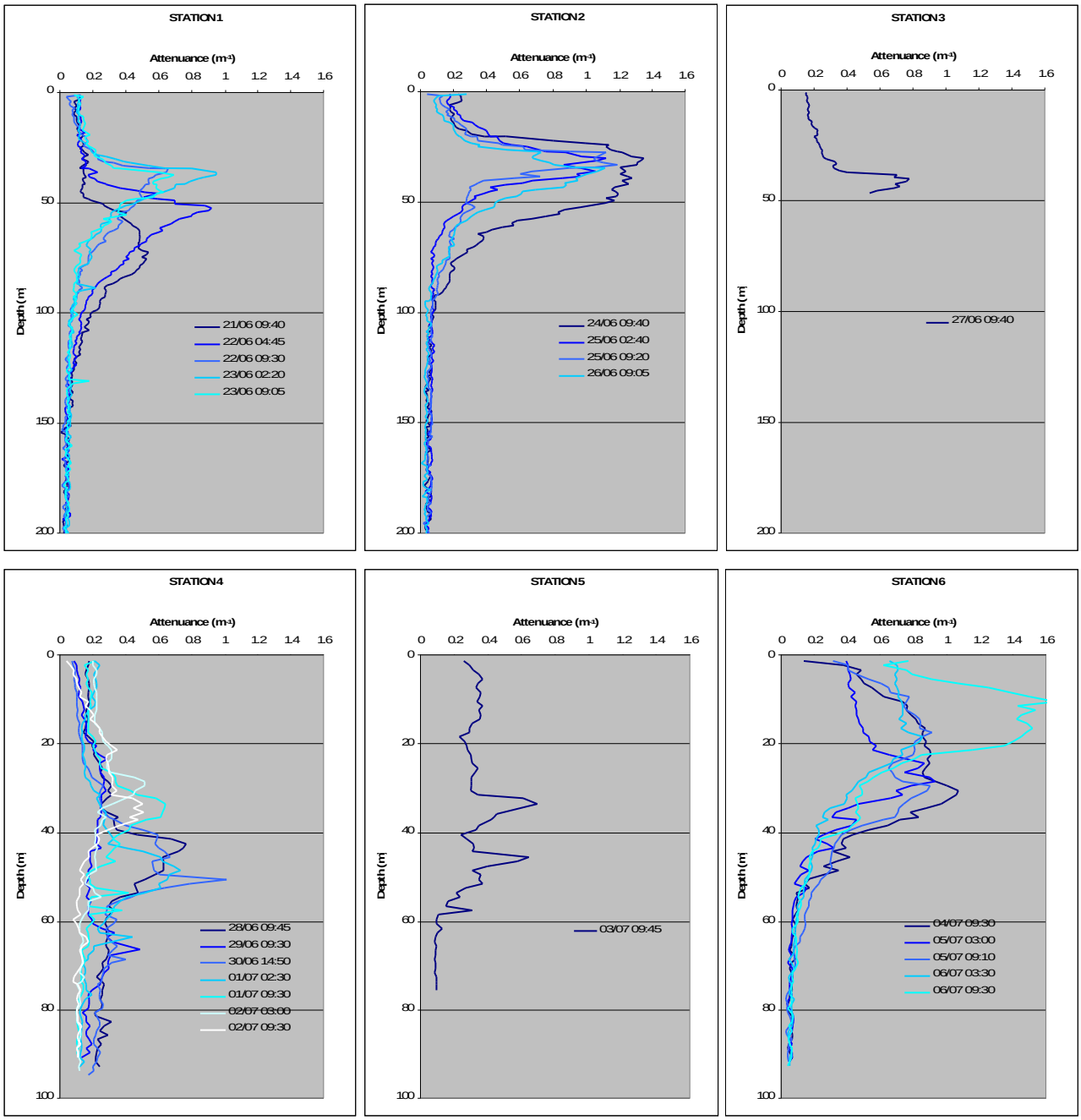


Figure 4.2.2 Profiles of attenuance from CTD Transmissometer as a proxy for chlorophyll (see text).

Primary and heterotrophic bacterial production (section 5.4)
Primary production showed a generally increasing trend from offshore oligotrophic values around 0.5gCm^{2}d^{-1} through to around 1gCm^{2}d^{-1} at station 4 near the coast, and to around 2gCm^{2}d^{-1} at station 6 as upwelling commenced. Heterotrophic bacterial production (HBF) was highest at station 3, providing support for our suspicion that this station represented a 'dead' bloom. The difference in HBF between the microlayer and bulk water was highly variable, there being little or no difference at station 2 day 1 (2.1), but microlayer values were 5 times higher than in bulk water on the following day (2.2), when surface slicks were visible. Considerable variability was also experienced between different sampling methods, however. For example, at station 3 HBF values from Garrett Screen (GS) samples were 3-4 times higher than those from the MLSD.

Coloured dissolved organic matter (CDOM) (section 5.2)
Measured values for CDOM were generally higher in microlayer samples compared to bulk water values, and very high on station day 2.2. Values from GS samples were always higher than from the MLSD.

Microbial communities (section 5.7)
Analytic flow cytometry (AFC) measurements of the microbial communities showed generally little variation between microlayer and bulk waters, as has been found by other studies in this area. However, during station days 2.1 and 2.2 a visible surface slick formed, and AFC values showed an enrichment in the microlayer community of between 5 and 10 times the bulk water values. AFC values between sampling devices were generally consistent, although values for bacterial and virus-like particles (VLPs) were consistently a little higher in GS sample compared to those of the MLSD. Values for autotrophic paricles were more variable.

Microzooplankton (section 5.5)
Through the three days on station 2, there was a large and increasing enrichment of autotrophic dinoflagellates in the microlayer, from 44 to over 900, very much higher than previously reported in other studies. Ciliate enrichment of ciliates was much smaller (2) on day one, and decreased to less than 0.1 as the microlayer developed.

Pigments & MAAs (section 5.6)
Pigment data indicated that a microlayer was generally present throughout the cruise, but was particularly marked on days 2.2 and 2.3, when the chlorophyll 'a' values in the microlayer were 47 and 45 times higher than at 25cm. The pigment distribution in these samples indicated that the microlayer community was dominated by dinoflagellates. Photoprotective (UV absorbing) compounds (MAAs) showed very high ratios between microlayer and bulk waters, the ratio being around 500:1 on station day 2.3, while the ratio for chlorophyll 'a' was around 50:1.
Measured values for chlorophyll 'a' showed considerable variability between the two microlayer sampling methods. The largest discrepancy was on the station day 2.2, where this time MLSD sample values were much higher than those for GS.

Biogases (section 5.8)
Studies of changes in microbial communities and enhanced nutrient availability and productivity in upwelling regions suggest that they may be ‘hotspots’ of DMSP/DMS and biogenic volatile halocarbon production and hence, sea to air flux of these climate-active gases. During the present study, bacterial turnover of DMSP in the microlayer was initially similar to that in bulk waters, but as the surface slick developed at station 2 bacterial community was more developed in the microlayer, and turnover rates increased. Very little difference was detected in concentrations of dissolved DMS between bulk and microlayer waters, possibly 'damped' by sampling methods which of necessity involved mechanical agitation of the samples. Generally, and interestingly, DMS showed a decrease in concentration closely related to the water temperature and increased particulate content of the water as we moved from oligotrophic to more coastal waters, and as upwelling developed. This appears to indicate that upwelling events themselves may reduce DMS sea-to-air flux in the area, rather than enhance it.

Intercomparison of microlayer sampling methods
The NSSD was very useful in providing a sampling gradient through the top 2 metres of the water column at fairly high resolution (20-30cm). The comparison between the two microlayer sampling devices (MLSD, GS) proved interesting. There was often considerable variability between the two sampling methods, but not clearly in favour of either method. Primary productivity, microzooplankton abundance (on station 2) and CDOM values were consistently higher in GS samples than from the MLSD. The microbial community AFC counts were generally consistent

between devices, although bacterial and VLP counts were a little higher from the GS samples. Chlorophyll 'a' values from HPLC pigment analysis also showed considerable variability between these two sampling methods. The largest discrepancy was on the station day 2.2, but MLSD sample values were very much higher than those for GS. It is not intuitively obvious why these differences should appear, and further experimentation would be required to attempt to tease out the causes. Clearly, mechanical agitation of the samples was worse using the MLSD, which probably accounts for there being little difference in concentrations of dissolved DMS between bulk and microlayer waters when significant differences existed in DMSp concentrations.

Summary

We hypothesised that gradients in biological activity from bulk waters to the air-sea surface interface, and from oligotrophic to highly productive waters would have an important influence in the transfer of heat and material across that interface. We assumed, in particular, that an upwelling event with its associated enhancement of biological processes would provide a 'hot spot' in production and air/sea fluxes of biogenic gases such as DMSP/DMS. Our stations 2 & 3 appear to have been placed in a decayed bloom, and showed the highest values in microlayer heterotrophic production and turnover of DMSP. Data analysis is far from complete, but our initial findings seem to suggest that whilst surely associated with upwelling blooms, many of these processes may chiefly occur not during an upwelling event, but during the biological succession which follows, in which flagellates begin to dominate the community. In the present study, the highest concentrations and turnover of biogenic gases and in-cell photoprotective compounds in microlayer and near-surface samples were found during the period between upwelling events when breakdown and decay predominates.

We were fortunate during this cruise in the number of days calm enough for deloyment of the near-surface and microlayer samplers, and even more fortunate in that on one station we were able to monitor and sample the development of a very pronounced microlayer with a biogenic slick visible from the ship. We have obtained some very interesting, and in some cases, unique measurements of the gradients in biological properties and processes in this layer. As data processing and analysis is completed over the coming months, we expect to publish our results. We believe these will include some completely new insights into theses gradients, properties and processes in the near-surface and microlayer of the oceans.

SECTION 5 – SCIENTIFIC METHODS AND PRELIMINARY RESULTS

5.1 PHYSICAL PROCESSES AND TURBULENCE - Ricardo Torres

Introduction and objectives
A set of measurements were routinely taken during CD172 to enable the description and interpretation of the physical oceanographic conditions during the experiments. The aim is to quantify the upper layer physical variability mainly in terms of local currents and hydrography (water temperature structure in particular) and to characterise the turbulence regime in the upper layer.

Two instruments were used to that end, an Acoustic Doppler Current Profiler (ADCP) and a turbulence probe. During the cruise, data from the 150 Hz RDI narrow band Vessel-mounted Acoustic Doppler Current Profiler (VMADCP) were collected throughout. Data was collected with RDI DAS software and output as RDI pingdata. Navigation information from the TRIMBLE 4000 GPS was merged with ADCP data in real-time with the use of the user exit program UE4 from the University of Hawaii. The software also ensures that the data acquisition PC is always synchronised with the navigation time. The period of data collection was between 2005/06/12 11:38:02 to 2005/07/03 10:11:00 uninterrupted except during the port call in Vigo. During this period stations 1, 2 and 4 were sampled. After station 4, the ADCP stopped working.

DAS software was set to acquire data with the following main parameters:

- Bottom tracking when possible
- Heading compensation
- 120s averaging interval for ensembles until 15 June 06:52:50 and 240s from then onwards
- 40 bins of 4m
- blank beyond transmit was set to 8m
- Use of 3 beam solution

From previous experience on this vessel (CD156) it was known that pings from Beam 3 were of significantly worse quality than the other beams. On average, Beam 3 recorded less than 50% good pings (sometimes as low as 5% in over 300 ensembles) compared to over 90% recorded by the other Beams. This can cause error velocity estimates to be higher than expected and as a consequence reasonable data could be lost. The origin of Beam 3 problems was not identified and it was decided not to use the error velocity as a quality control parameter as means of diminishing the number of data loss and the 3 beam solution was enabled. As a consequence, data quality increased. The average number of pings processed by DAS was 220 pings per ensemble.

Ashtech ADU-GPS needed for correcting the ship's gyrocompass was recorded throughout the cruise and was applied to the entire dataset.

Pulling from the experience of the previous cruise (CD156) we knew that the build up of air pressure in the ADCP pool caused Spectral Width, Signal and Frequency errors in all four beams. Therefore the ADCP pool was purged regularly in order to reduce errors.

The ADCP stopped working on July 4 5:30AM. The PC stopped working for unknown reasons and had to be changed with the spare one. However the COMS ports on the new PC were different and it would not accept the navigation stream. It did not matter however because the ADCP was giving

errors in all Beams. We purged the ADCP pool twice but it didn't improve matters. After extensive tests the ADCP showed failure in the AMP/RECV section for Beam 3 in the out of band test which we were expecting. However, this time not even with the 3 Beam solution would the ADCP work. The unit was unavailable for the reminder of the cruise.

The ADCP data were processed onboard using the Common Oceanographic Data Access System (CODAS), developed at the University of Hawaii by Eric Firing and Ramon Cabrera with subsequent updates by Julie Ranada (Firing *et al.*, 1995). The system consists of several iterative C and matlab programs to carry out editing, calibration, navigational correction and plotting of the ADCP database. The principal objectives of the editing stage are to identify and flag bins showing erroneous data caused by interference from physical objects, such as the winch wire during a CTD cast or air bubbles caused by rough weather.

Velocities relative to the ship must be adjusted for orientation of the transducer relative to the gyro compass and for any inaccuracy in the relative geometry of the four beams. With accurate navigation information available during large changes in ship's velocity, amplitude and angle errors can be computed from the ADCP. The method used was bottom track, which compares the acceleration over the ground, measured with the ADCP, to the acceleration over the ground, calculated from navigation. The calibration consists in the calculation of the amplitude and phase (angle) correction factor to the bottom track velocities to be used subsequently in the Gyro correction. The amplitude factor correction was found to be 1.01 ($\pm$0.006) and the phase was -3.5° ($\pm$0.4).

The final step in processing ADCP data is introducing the navigation data, which are used to calculate the ship's velocity and absolute water velocities. The absolute reference layer velocity is the sum of the ship's speed over the ground obtained from the navigation data, and the average relative water velocity in the reference layer, measured by the ADCP. This layer is calculated with reference bins between 5 to 16. The data used in this interval have a percentage good over 30. Once the reference layer is obtained the data are interpolated and smoothed. Profile positions are then recalculated from the smoothed velocities. The final estimate of true velocities is made by adding the difference profile from the reference layer velocity, to the final absolute reference layer velocities.

The steps followed in this process were:

1. Obtain the ship velocity relative to the reference layer.
2. Calculate the absolute ship velocity.
3. Smooth and interpolate the data to the ADCP ensemble times.
4. Update the database.

Preliminary Results

ADCP data from stations 1, 2 and 4 are presented in figures 5.1.1-3. The top figure corresponds to the progressive vector from 3 bin depths and the bottom figure represents the time evolution with depth of both velocity components (U in the upper panel and V in the lower panel).

During station 1 (figure 5.1.1) we were in a strongly tidal environment with southwards residual currents at the surface, weakening with depth. Maximum currents were of the order of 30cms^{-1}.

Station 2 (figure 5.1.2) showed a different scenario. The surface bin showed indications of surface intensified inertial oscillations possibly due to the sudden drop in wind while deeper levels showed a tidally modulated weak residual northward current (2cms^{-1}); an indication of the absence of active upwelling.

Station 4 (figure 5.1.1) was sampled during downwelling conditions and the progressive vector

indicates a relatively stronger northward flow (~7cms^{-1}) than in previous stations, with little difference with depth and weak tidal modulation.

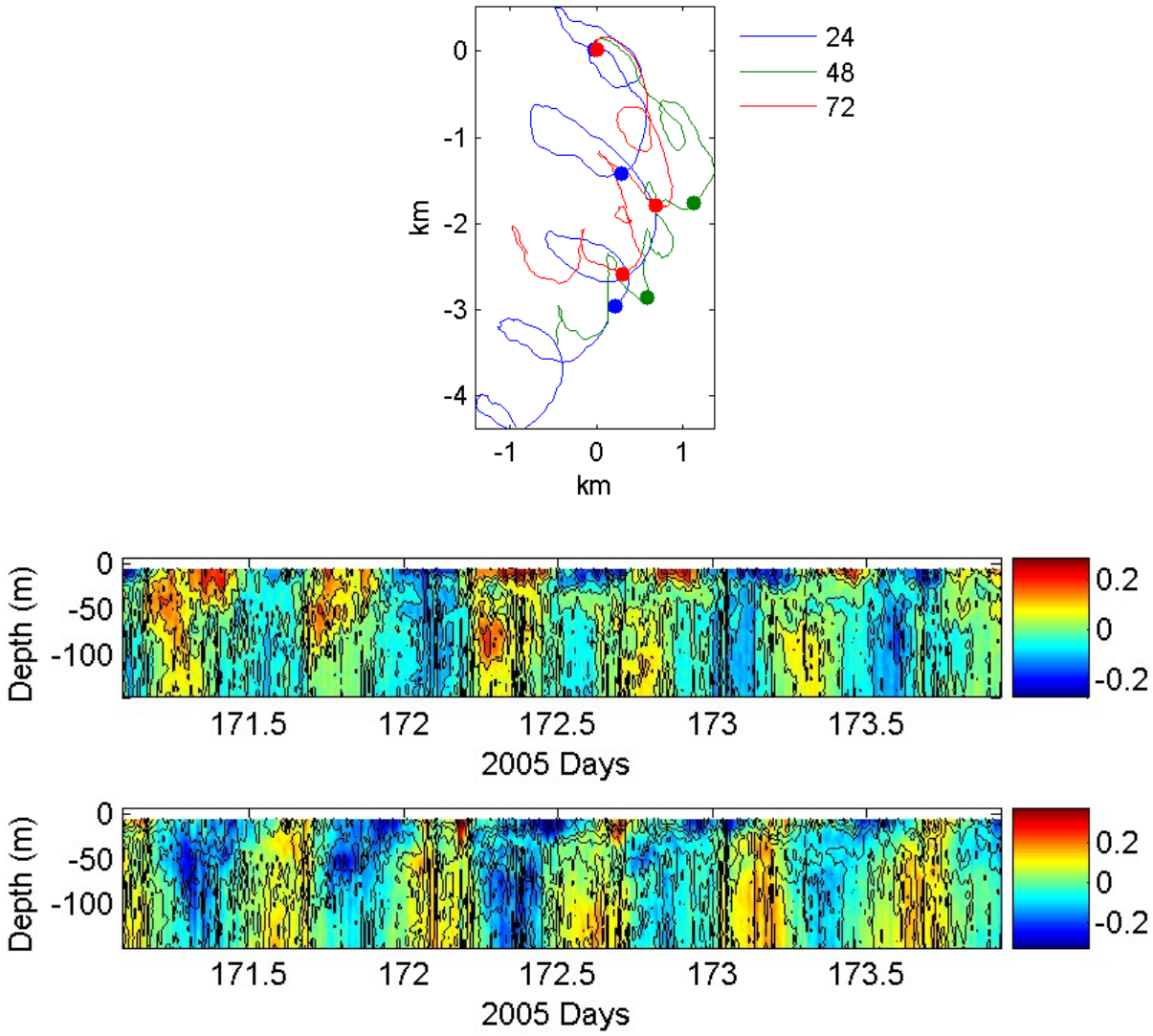


Figure 5.1.1 Station 1 top) ADCP progressive vector from bins at 3 depths relative to the station position and bottom) time evolution of the U (upper panel) and V (lower panel) components with time while on station.

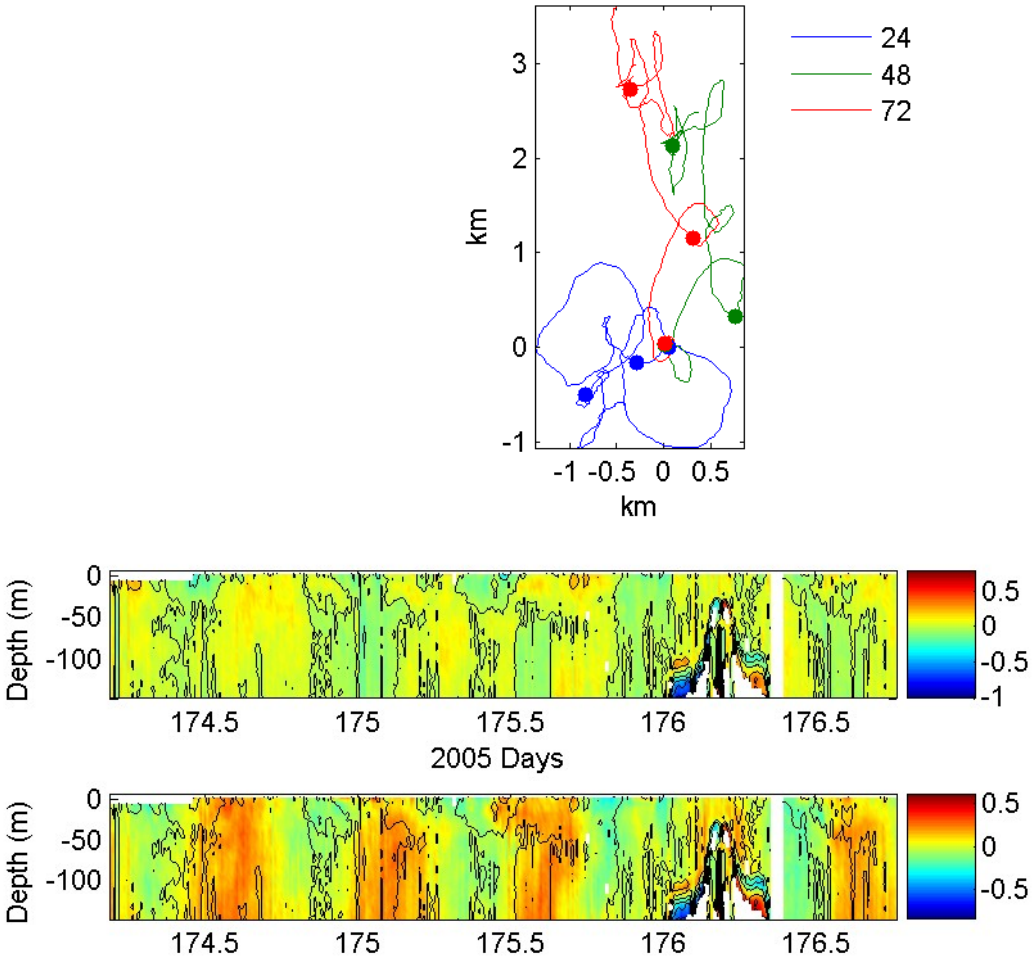


Figure 5.1.2 Station 2 top) ADCP progressive vector for 174- 176 from bins at 3 depths relative to the station position, and bottom) time evolution of the U (upper panel) and V (lower panel) components with time while on station. 176- 176.4 corresponds to port call in Vigo.

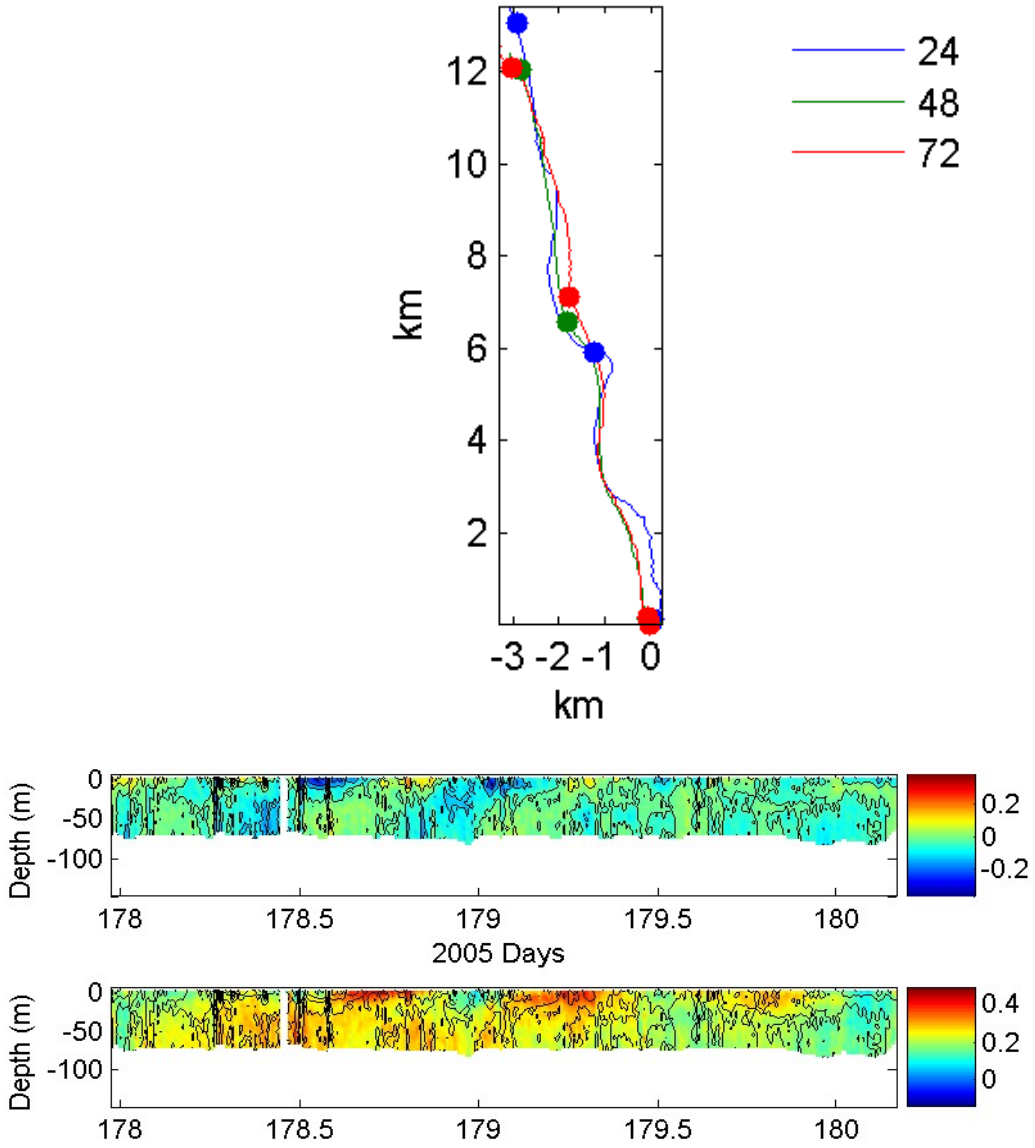


Figure 5.1.3 Station 4 top) ADCP progressive vector from bins at 3 depths relative to the station position and bottom) time evolution of the U (upper panel) and V (lower panel) components with time while on station.

Self-contained autonomous microprofiler (SCAMP)
The Self-contained autonomous microprofiler (SCAMP) is a portable, lightweight microstructure free fall profiler designed to measure extremely small scale (order 1 mm) fluctuations of electrical conductivity and temperature in water. These data can be used to infer the levels of dissipation of turbulent kinetic energy; in-situ fluxes of heat and salt; and the microstructure behaviour of these parameters.

Our SCAMP has sensors for temperature, conductivity (i.e. salinity), light (PAR), turbidity, fluorescence and depth (pressure). The temperature and conductivity are fast response sensors that are capable of providing 1 mm scale resolution while the others sample at a scale of 1cm at a nominal fall speed of $10cms^{-1}$.

This was the first time we had used SCAMP and there was much to learn and get used to. Deployment is preferably done from a small boat as the measurements require sampling through undisturbed waters. From a large Research Vessel like the Charles Darwin the deployment takes place by hand from the deck and has to be carefully coordinated with the bridge in order to avoid both the ship's wake and the ever-present risk of drifting over SCAMP during release and/or recovery.

During the cruise we managed to take 45 casts of which 60% provide some reliable data. Most of the cast were taken in station 1 while other casts were performed in station 2 and 4. The most challenging part of SCAMP operation is to correctly gauge the amount of ballast and buoyancy so that the profiler sinks at a constant velocity through the area of interest. SCAMP is rated to 100m but we generally achieved depths of 60-70m. The reasons for bad profiles ranged from highly variable fall speed due to swell to sampling through the ship's wake.
On the 24th June the accurate conductivity sensor in SCAMP started to misbehave due to flooding of the instrument. SCAMP was dismantled and the two boards from the Fast Conductivity and Accurate sensors were rinsed and bathed in distilled water and coated with moisture displacement and finally alcohol.

We next tried SCAMP on 26th June only to realised it had flooded again. The same steps as before were taken. During the following trial on the 27th June SCAMP flooded once more. This time we bathed the entire unit overnight and dried it thoroughly with heat gun and covered it with connect moisture displacement. Afterwards it was rinsed with methanol making sure it got into all the fuses covered with plastic tubing. All sensors were extracted and the inside dried with the gun. We carefully inspected all the o rings until we were sure everything was in good condition.
We had onboard a previous model of SCAMP that we borrowed from NOC. We changed the casing with NOC's one and it seemed tighter. We tested for leaks and nothing was leaking. A bucket test indicated that all T sensors gave different values. The fast conductivity sensors did not work and was disconnected.

SCAMP continued to work until the 29th June when it flooded again and we decided to clean it up and store it. Bench tests with the spare SCAMP were unsuccessful as the correct configuration file for that unit wasn't provided with the instrument. Although communication with the instrument was established it never recorded any data.

Processing of the available data was done with a combination of SCAMP's own processing software and a refined spectrum estimation method (Lomb's method) that allows for uneven data distribution (i.e. variable fall speed). The basic steps of post processing involve calculation of SCAMP fall speed, computation of derived parameters like salinity, density, Thorpe scales, and buoyancy frequency. Fast Fourier Transform (FFT) analysis is used to calculate the variance spectrum of the temperature gradient assuming a constant fall speed. When deviations to this

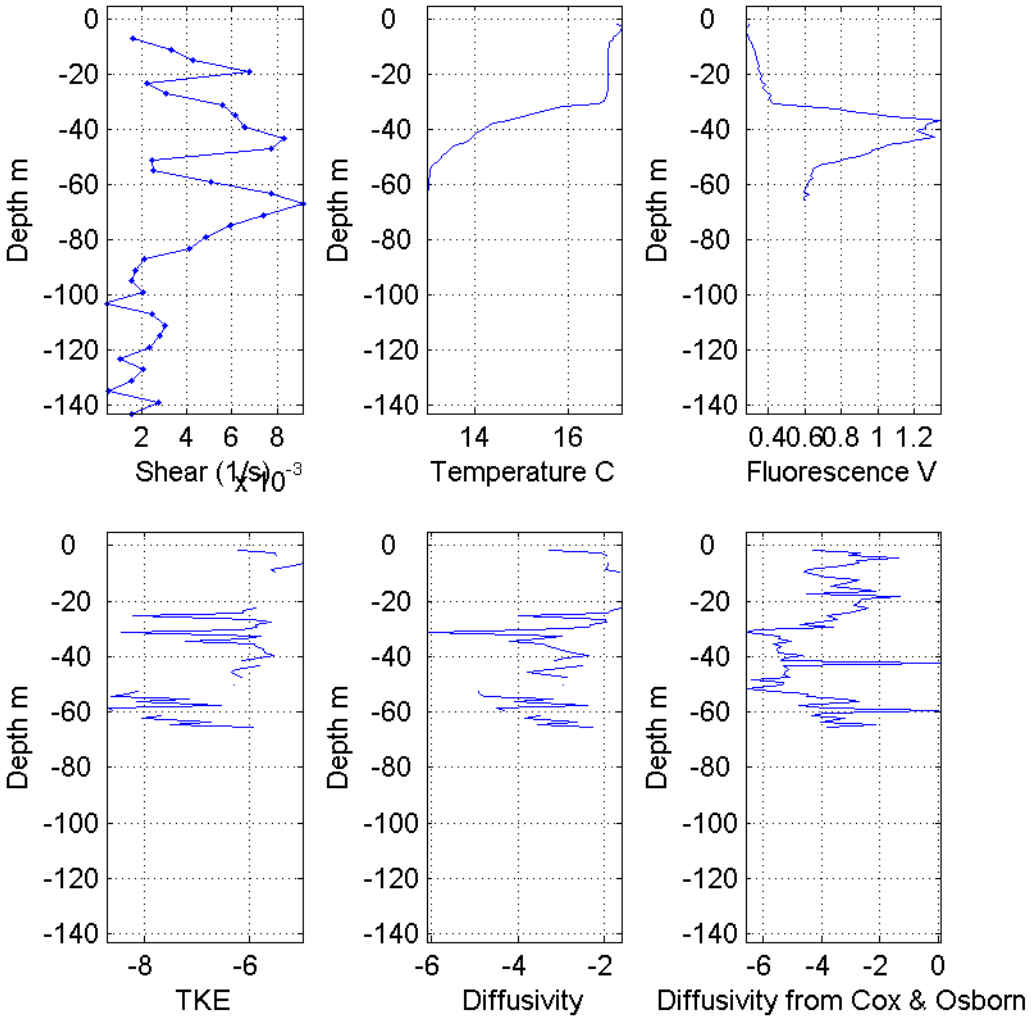


Figure 5.1.4 SCAMP cast 9. 21 June 19:23 Station 1

assumption happen we used an alternative power spectral analysis method, the Lomb method, which is potentially more applicable to such data as it does not require measurements to be evenly spaced. From the variance spectrum we then estimate the Batchelor wavenumber and turbulent dissipation.

Examples of SCAMP results are presented in figures 5.1.3 and 5.1.4 for stations 1 and 4, respectively. The vertical shear as estimated from the ADCP together with the raw temperature and fluorescence profiles are shown in the top panel while the derived turbulent related quantities are in the bottom panel. Gaps in the data are due to high statistical uncertainties in the data.

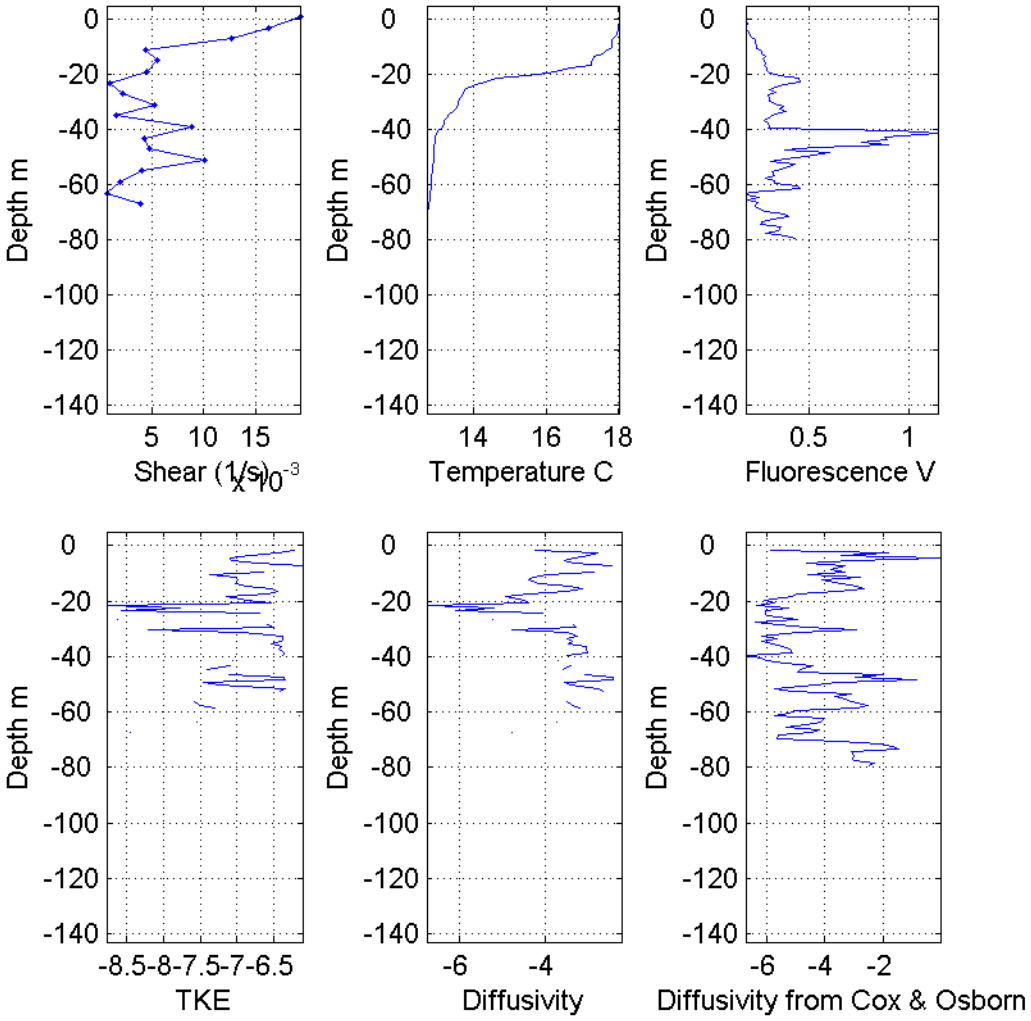


Figure 5.1.5 SCAMP cast 44. 28 June 18:00. Station 4

5.2 APPARENT AND INHERENT OPTICAL PROPERTIES OF THE WATER COLUMN, PHOTOPHYSIOLOGY AND PHOTO-OXIDATION OF COLOURED DISSOLVED ORGANIC MATERIAL - Gavin H. Tilstone.

Introduction

The optical properties of material suspended in sea water such as phytoplankton, coloured dissolved organic material (CDOM) and detrital material impacts the biological activity deeper in the water column and the recycling of nutrients within the surface layer through the microbial loop. Determination of the inherent optical properties (IOPs) is also essential to understanding the optical signal detected by satellites and for the development of novel algorithms and products from satellite data. Though the inherent optical properties in the euphotic zone have been well characterized in European shelf and coastal seas, the impact of IOP's on phytoplankton photosynthesis in the microlayer and on microlayer processes in general, remains largely unstudied. Light absorption by CDOM, for example, plays a number of roles in natural waters, including nutrient cycling, trace gas production and control of light penetration in the water column (Goldstone et al. 2004; White et al. 2003). CDOM photobleaching can result in a deeper penetration of light at all wavelengths in the water column, which can consequently affect phytoplankton photosynthesis (Cullen and Neale 1994; White et al. 2000) and may result in increased biogenic gas production, especially dimethyl sulfide (DMS, Toole and Siegel 2004).

Methods

The inherent (IOP) and apparent optical properties (AOP) and phytoplankton photo-physiology were determined in the microlayer on discrete samples and in the water column using in situ profilers to study the impacts of VIS and UV irradiance on the coupling between the photoxidation of CDOM and phytoplankton photosynthesis. IOP's were determined from ac9 and from discrete samples using the hyperspectral spectrophotometric measurements of CDOM. AOP and UV profiles were also measured up to six times a day. Discrete samples were also taken from the microlayer and near-surface samplers and from the Garrett screen samplers for the determination of IOP's.

Optical and photo-physiological profiles

An optical profiling rig was deployed from the crane on the starboard quarter (outboard reach 4-6 m) positioned stern-to-sun to avoid ship shadow and lowered at ~0.5ms^{-1} through the water column to a depth > 1% light level. The optical rig (Fig. 5.2.1) housed the following sensors: The UV and visible AOP spectra were measured using SATLANTIC Ed and Lu and TRIOS UV optical sensors. The total and dissolved spectral absorption and attenuation coefficients were measured using a WETLabs ac-9 and the volume scattering function was measured at one channel using a WETLabs ECO-VSF1. A Chelsea Technologies Ltd. FAST^{tracka} was mounted horizontally on the top of the rig with depth sensor and 2π PAR (400-700 nm) sensor. The excitation source was a bank of LEDs with peak emission at 478nm, configured for 100 saturation flashes of duration 1.1μs with 2.8μs interval between flashes. The fluorescence signal was detected at 668nm; 8 sequences were averaged per acquisition. The instrument gain was fixed at 1 for the high chlorophyll inshore stations which prevented data loss due to gain switching and was set to auto-ranging at the offshore stations for the low signals in the surface waters. Blanks of 0.2μm filtered seawater were run periodically in both the light and dark chambers at all gains. All data were processed using FRS software (Chelsea Technologies Ltd, modified at PML).

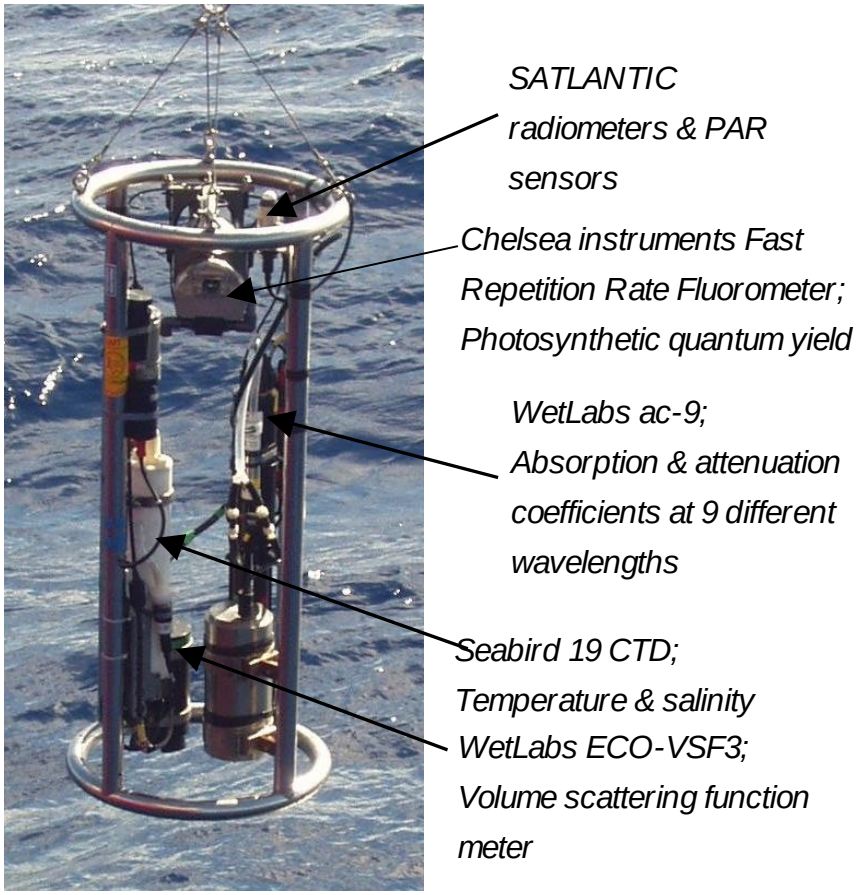


Fig 5.2.1. Optical rig showing sensors deployed to measure the apparent and inherent optical properties and photo-physiological characteristics of the water column.

Optical data was also collected using a freefalling optical profiler built at the Plymouth Marine Laboratory (PML) utilising a Satlantic Incorporated 7 band Irradiance head and a 7 band Radiance head. The seven wavelengths are comparable with the SeaWiFS sensor and are as follows, 412, 443, 490, 510, 555, 620, and 683nm. The freefall was deployed from the stern of the ship and left to fall independently through the water column at a rate of 0.5m/s. Data was collected from the irradiance head orientated towards the surface and the radiance head measuring up welling light. Ancillary data including the depth and the tilt and roll of the instrument are also recorded live to a computer on deck via a cable. The PML freefall also has the capability of being used as a surface buoy with the irradiance head being held out of the water with the addition of an extra buoyancy ring. In this form it collects the surface reflection data for satellite validation.

Phytoplankton and suspended particulate absorption coefficients
Samples were collected from 3 to 6 depths at every station for the determination of absorption coefficients of total particulate and detrital material. Between 500 and 2000ml of sea water was filtered onto GF/F filters which were then flash frozen in liquid nitrogen. Absorption coefficients was measured at the laboratory on a Perkin Elmer Lambda 800 spectrophotometer retro-fitted with an integrating sphere using the methods of Tassan & Ferrari (1995) within one month of the samples being collected.

Chromophoric dissolved organic material
Seawater from CTD and microlayer sampler casts was filtered through 0.2μm filters using pre-ashed glassware. The first and second 150 ml of filtered water was discarded. The absorption properties of the third sample were determined spectrophotometricaly in a 25 cm cuvettes from 200 to 900 nm on an Avantes optical fibre spectrophotometer using bi-distilled seawater as system blank. Replicate samples were also spiked with 0.05 NaN_3 to preserve the samples which were analysed on a Perkin Elmer lambda 800 spectrophotometer in 10 cm UV quartz cuvettes.

Suspended particulate material
Between 1.5 & 4 litres of seawater was filtered through pre-washed, pre-ashed, pre-weighed 0.7μm filters in triplicate. After filtration the filters were washed with distilled water on the ground glass filtration frits. The filters are oven dried at 65°C for 24 hrs after which they are stored in a dessicator before weighing on an electro-balance to determine the total suspended particulate material concentration. A blank filter was also included to calculate the handling error.

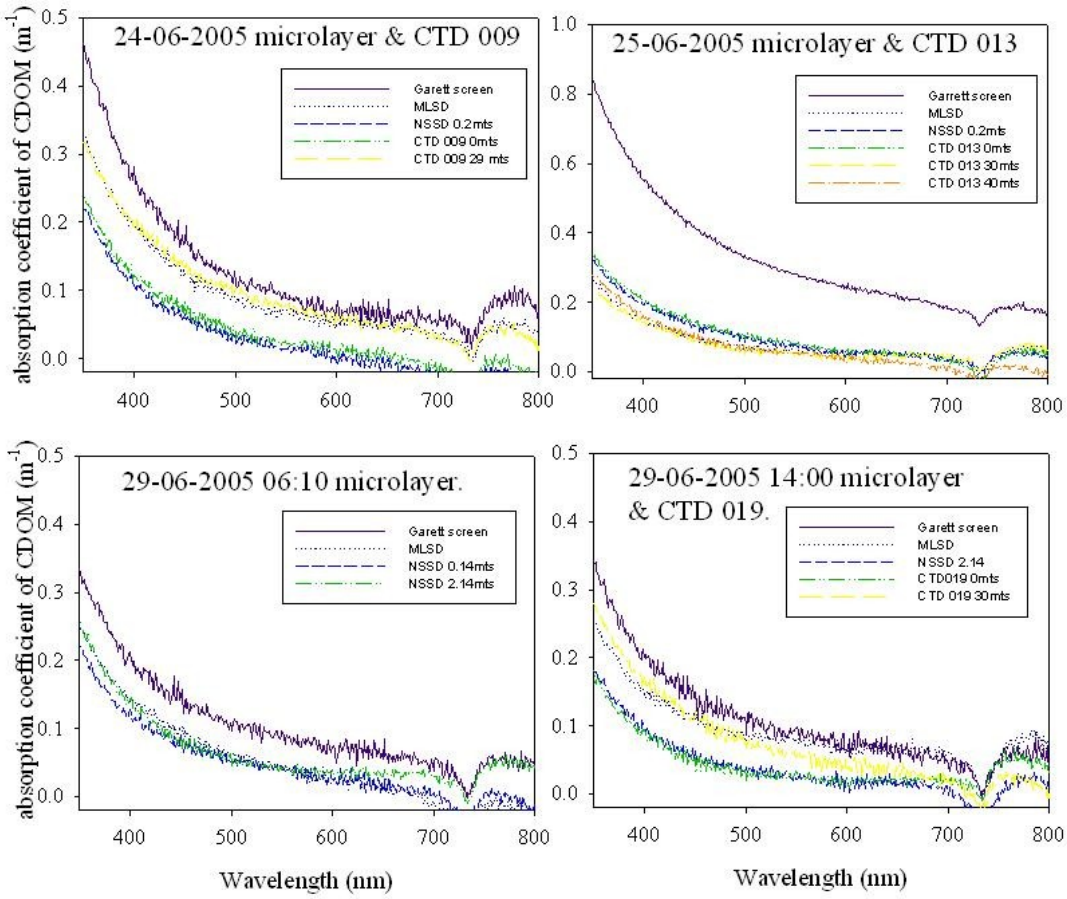


Fig 5.2.2. Absorption coefficients of coloured dissolved organic material (CDOM) in microlayer and CTD samples. (Note: no off-set correction applied and scale change on 25-06-2005).

Preliminary Results
The absorption coefficients of CDOM samples taken using both the microlayer sampling devices and conventional niskin bottles are given in Fig 5.2.2. Higher CDOM absorption coefficients were found in the Garrett screen samples, although the difference was not as marked on 29-06-2005 at 14:00 GMT indicating the possible photo-oxidation of CDOM in the microlayer**.** The highest CDOM absorption coefficients were measured in the garett screen sample on 25-06-2005 at station 2, 12

nautical miles from the portugese/Spanish border where CDOM at 350nm was >0.8 m^{-1}. All other samples taken on this day from either microlayer or niskin bottles were <0.4 m^{-1}. On all sampling days there was a high co-variation between the 2.14 mt NSSD sample and those from the surface CTD bottle as was expected. There was no difference between CDOM values from deeper samples compared with those from the surface. On all days CDOM from the deep samples co-varied with CDOM values from the MLSD samples. Using the NSSD sampler, CDOM values were higher at 2.14 mts compared to 0.14 mts which again may indicate photo-oxidation in the surface layer.

5.3 NUTRIENTS AND PHOTOAMMONIFICATION – Malcolm Woodward

Introduction - Aims of Experiment
The aims of the experiment are to investigate photoammonification rates from seawater CDOM found within highly productive upwelling waters and open ocean CDOM samples. Where CDOM will be less photodegraded within the upwelling waters and will provide higher rates of ammonium production during natural irradiation, in comparison to open ocean waters where CDOM is highly photodegraded leading to lower rates of ammonium production.

Samples were to be taken at 4 stations along the cruise transect (2 in upwelling and 2 further along the transect), where samples were to be taken at the same depths throughout the cruise (within the mixed layer between 10 and 20 metres) to show rates going from high to lower along the transect. 4 irradiation experiments -- x2 within upwelling and x 2 elsewhere along transect. Amount of sample needed per experiment: separate CTD as need 12 L of water per experiment.

Methods
Day before experiment collect water and filter same day. Filtration is carried out gravimetrically by attaching silicon tubing to sample bottle and 0.2 μm cartridge filter and allowing water to flow downwards through both into a clean collection vessel. Back flush filter with MQ for 15 minutes after filtration.

Experimental set-up:
Set up irradiation trays in a sunny spot on the ships deck making sure they are tied down with bungee ropes and attach the sea water tap to the trays, adjusting the flow rate to ensure that all samples are kept at a constant temperature. Attach plastic tubing to the uncapped end of the quartz irradiation flasks and hang them over the side of the irradiation box, this will allow for expansion within the tubes. Leave samples to irradiate over local solar noon (ideally 1.5 hours before noon and then 1.5 hours after) for a total of 3 hours irradiation. Take out samples and their respective dark controls at arranged intervals (e.g. every 0.5 hours) and analyse ammonium content and CDOM absorbance, taking samples also for DOC analysis (acidify and store in freezer). Throughout the experiment make sure the ships PAR sensor is recording data and also set up UV sensor and record data. If there is any opportunity to cut out wavelengths using mylar and llumar plastic films as filters to cover one irradiation tray and compare it to uncovered samples then carry out an experiment using these films to investigate wavelength dependence reaction.

Preliminary results
Results are not yet available as analysis of samples is proceeding.

5.4 PRIMARY PRODUCTION & HETEROTROPHIC BACTERIAL PRODUCTION - Joanna Dixon

Aims

1.To provide level 1 rates of primary production and heterotrophic bacterial production from predawn CTD casts.
2.To investigate the fine scale variability in heterotrophic bacterial production in the top 2 m of the water column (NSSD)
3.To assess the relationship between heterotrophic bacterial production in the sea surface micro layer (as sampled by Garrett screens and MLSD) and near surface seawater (as sampled by the NSSD)
4.To investigate the effects of macro and micro nutrient additions on rates of nitrification, primary production and heterotrophic bacterial production

Methods

Water was collected from each pre-dawn CTD casts from depths equivalent to 97%, 55%, 33%, 20%, 7% and 1% of surface irradiance for determination of rates of primary production and heterotrophic bacterial production. In addition bacterial production was also determined from approximately 6 depths from all other routine CTD casts and all deployments of the NSSD, MLSD and Garrett screens (please refer to the tabulated list for all samples collected).

Carbon fixation:

Rates of carbon fixation were estimated from the incorporation of ^{14}C-bicarbonate. Approximately 60 ml aliquots of seawater samples in polycarbonate bottles (3 x colourless & 1 x black) were spiked with 10 μCi $NaH^{14}CO_3$ and incubated in the on deck system. Incubations were terminated after 24 hr by sequential filtration through 2.0 and 0.2 μm polycarbonate filters. The filters were subsequently placed in a desiccator with fuming HCl for 10 minutes before being dried and stored in a dessicator overnight prior to measurement in a liquid scintillation counter.

Rates of Nitrification:

Rates of bacterial oxidation of ammonium was estimated by the incorporation of ^{14}C-bicarbonate in the dark with and without the presence of the nitrification inhibitor allylthiourea (ATU). Approximately 250 ml amber polycarbonate bottles were filled with water from ~33% light level (3 replicate bottles for each treatment), spiked with 10 μCi $NaH^{14}CO_3$ and incubated in the dark at in situ temperature for ~12 hours. ATU was added to 3 bottles at a final concentration of 10 mg l^{-1}. Incubations were terminated by sequential filtration through 2.0 and 0.2 μm polycarbonate filters which were dried over silica gel desiccant before analysis by liquid scintillation counting.

Bacterial production:

Incorporation of L-[4,5-^{3}H]Leucine into bacterial protein in seawater samples was determined following the method of Smith and Azam (1992). 1.7 ml seawater samples were inoculated with 25 nM ^{3}H Leucine (7 μl) (as determined by a Vmax experiment carried out on 19/06/05) and incubated in the dark at in situ temperature for 1 hr. Samples were terminated with 100 μl TCA (5% final concentration) and incorporated ^{3}H extracted following procedures outlined in Smith & Azam 1992 before being measured by liquid scintillation counting.

Macro and micro nutrient addition experiments:

Rates of carbon fixation and heterotrophic bacterial production were measured after addition of Co (5 nM), Zn (10 nM) and Fe (3 nM) and incubation for 4 days (Station 1 only). Rates of bacterial nitrification were measured after the addition of ammonium (1.7 μM), phosphate (100 nM), Fe (3 nM), Cu (10 nM), Co (5 nM) and Zn (10 nM) after incubation for ~12 hours (Stations 1, 2 & 4).

Preliminary Results

Measurements of primary production confirm that we were initially in a more oligotrophic area in typical summer stratified conditions where integrated rates (to 1% of surface irradiance) of primary production were between 0.41-0.65 gC m^{-2} d^{-1} at stations 1 and 2. These rates progressively increased to between 0.95-0.99 g C m^{-2} d^{-1} at station 4 and up to 2.0 gC m^{-2} d^{-1} at station 6; which was more reflective of upwelling conditions (Figure 5.4.1). Integrated rates of heterotrophic bacterial production followed similar patterns with low rates between 0.44-1.2 μmol leu m^{-2} h^{-1} at stations 1 and 2, with rates increasing to between 2.5-3.9 μmol leu m^{-2} h^{-1} at station 4, before decreasing to 0.87 μmol leu m^{-2} h^{-1} at the maximum primary productivity station 6. The highest rate of 5.9 μmol leu m^{-2} h^{-1} occurred at station 3 where we were sampling a decaying old phytoplankton bloom.

The relationship between heterotrophic bacterial production in the sea surface micro layer (as sampled by either Garrett screens or MLSD) and near surface (<2m) seawater (average of depths sampled by the NSSD) was highly variable both in time and space. For example, at station 2 on the first day of sampling there was no statistical difference in HBP between MLSD and bulk seawater samples. However 24 hours later at the same station HBP measured in MLSD water was 5 times higher than bulk. There was also significant differences between HBP measured in sampled collected by the MLSD and the Garrett screens. For example at our most nearshore station (station 3) HBP measured in Garrett screens samples was approximately 3.7 times higher than samples from the MLSD or average NSSD.

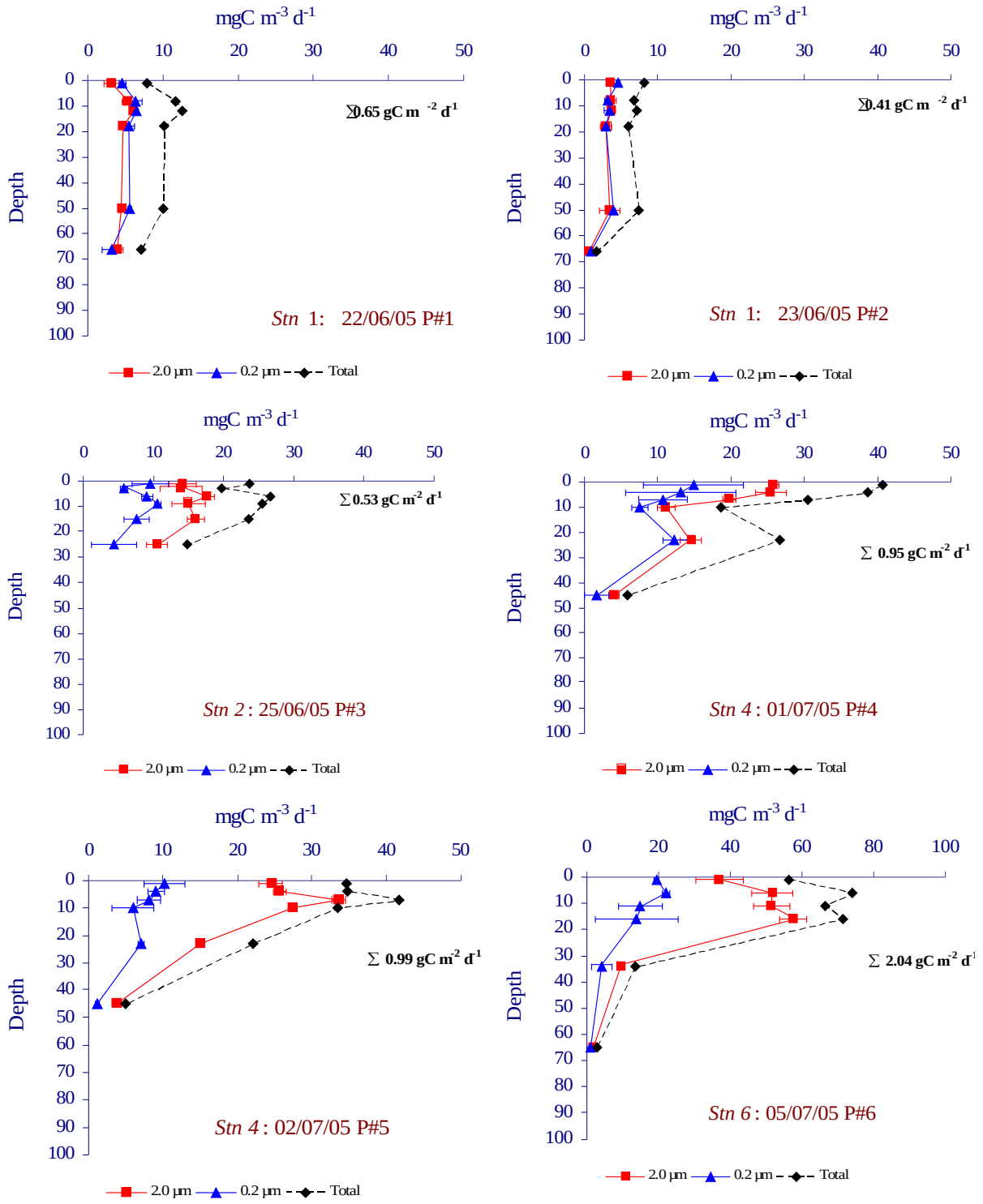


Figure 5.4.1. Depth profiles of rates of primary production where total depth integrated rates of carbon fixation are indicated by ∑ in each profile.

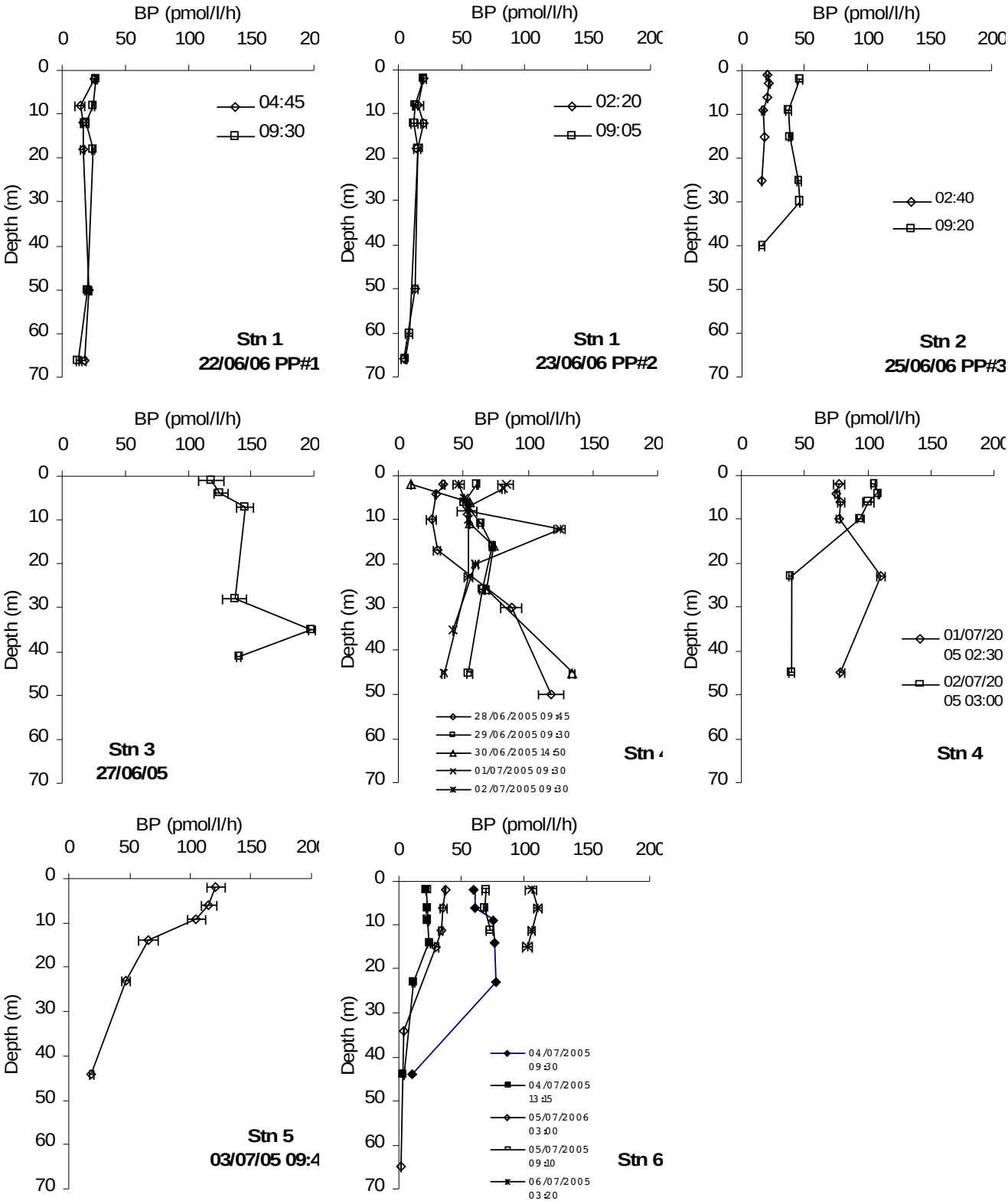


Figure 5.4.2. Depth profiles of rates of heterotrophic bacterial production

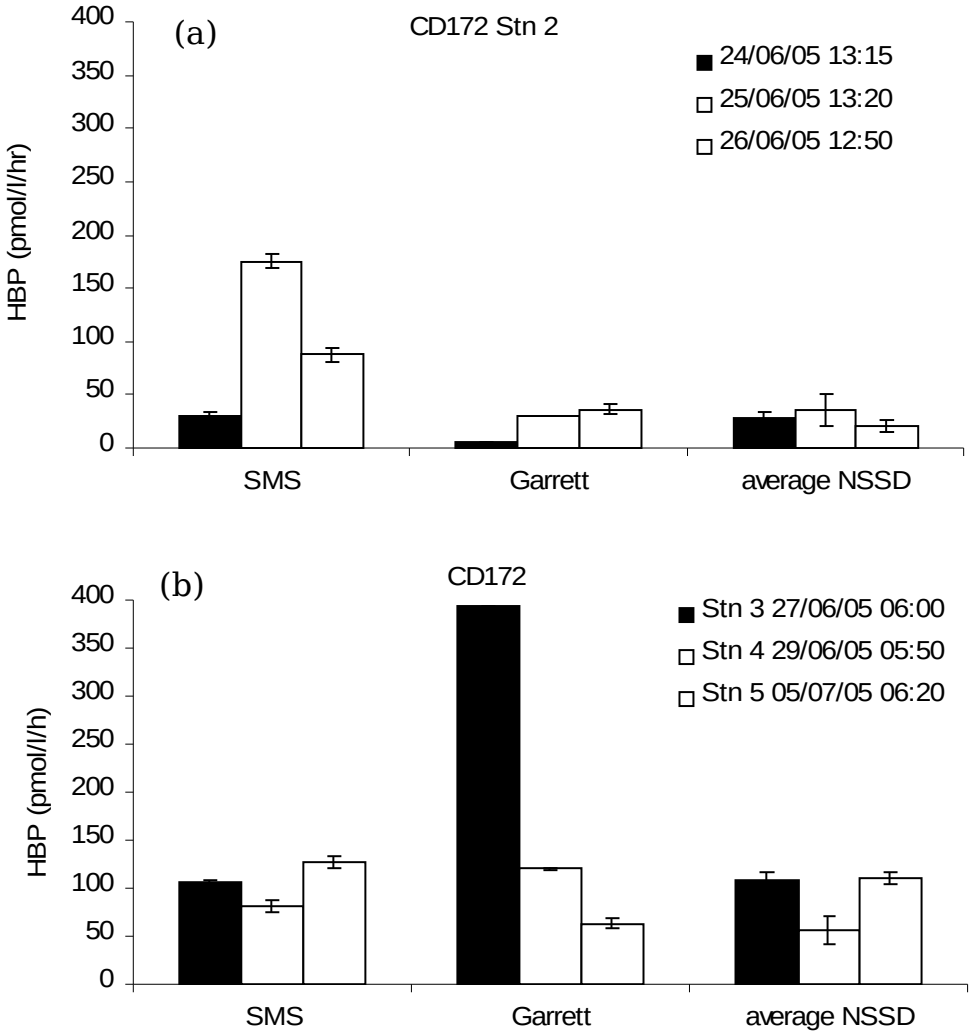


Figure 5.4.3. Heterotrophic bacterial production measured in samples collected by the surface micro-sampler (MLSD), Garrett screens and average of the depths sampled in the top 2 m by the NSSD. (a) daily variation at station 2 sampling ~13:00 hrs and (b) variation between stations 3-5 from the pre-dawn sampling.

5.5 MICROZOOPLANKTON BIODIVERSITY - Elaine Fileman and Claire Widdicombe

Introduction
The microzooplankton are a heterogenous group of organisms between 2 and 200μm in size which form a vital link in the planktonic food web between small bacteria, phytoplankton, and larger metazoans and fish. The aim of this work is to test the hypothesis that species diversity is higher in the surface microlayer than in underlying water. We aim to determine whether there are major differences in the abundance, biomass, species composition and diversity of microzooplankton between the communities of the surface microlayer and the underlying water. Changes in diversity will be compared to phytoplankton distribution and size structure and to predator abundance.

Methods
Water samples were collected daily from CTD casts and using the NSSD, Garrett screen and the MLSD. To determine the abundance and biomass of microzooplankton, 250ml samples were fixed in 2% Lugol's solution and stored cool and in the dark. Concentrated sub- samples of these samples were to be analysed by inverted microscopy in the lab. For determination of heterotrophic nanoflagellate abundance and biomass, between 30 and 100 ml of water sample was fixed with 1% final concentration glutaraldehyde. Cells were stained with DAPI for 4 minutes, counterstained with proflavin and concentrated onto 0.8μm black polycarbonate filters, using a backing filter to enhance even distribution of cells. Filters were mounted onto a glass slide with a small drop of immersion oil between the filter and coverslip. Slides were then frozen and will be analysed by Image Analysis in the lab. Additional water samples were collected for the determination of abundance and diversity of rarer species including tintinnids. 10L water samples, collected using either the near-surface zooplankton pump or the CTD, were gently reverse filtered through a 20μm mesh down to a final volume of 250ml which was then fixed in 2% Lugols solution and stored cool and in the dark until analysis by inverted microscopy and FlowCAM.

Preliminary results
Most results are not yet available as analysis of samples is proceeding, but table 5.5.1, below, contains a summary of microscope cell counts for all three days on station 2.

Table 5.5.1 Station 2 microplankton cell abundance (ml^{-1})
(Key: GS - Garrett screen; NSSD - Near surface sampler, 25cm depth; MLSD - Microlayer sampling device; EF - enrichment factor – average of GS & MLSD / NSSD)

	24th June				25th June				26th June			
	GS	NSSD	MLSD	EF	GS	NSSD	MLSD	EF	GS	NSSD	MLSD	EF
Ciliates	5.44	2.12	3.08	2.009	7.04	31	3.12	0.1639	1.28	11.04	0.2	0.0670
Heterotrophic dinos	2.6	1.44	1.2	1.319	7.36	25.52	0.92	0.1622	0.24	6.04	0.12	0.0298
Autotrophic dinos	46.50	1.28	66.40	44.09	5.08	28.28	3395	60.11	4681	3.4	1538	914.5
Flagellates	4060	3568	3009	0.990	4179	4536	5776	1.097	18178	3126	7781	4.152
Diatoms	32.25	24.99	2.92	0.703	16.12	8.16	2.88	1.164	1.48	7.12	1.32	0.1966
Misc Other	0.16	0.16	0.08	0.75	0.16	0.52	0	0.1538	0.16	0.84	0.16	0.1905

Two trends stand out in this data. First, the large and increasing enrichment of autotrophic dinoflagellates in the microlayer, from 44 to over 900 (much higher than previously reported in other studies). Second, the far smaller and reducing enrichment of ciliates and heterotrophic dinoflagellates, from ~2 to less than 0.1 over the three days as the microlayer developed.

Generally, and averaged over the three days, the Garrett Screen abundances were 3 to 6 times higher than those from the MLSD, except for autotrophic dinoflagellates and flagellates, where they were broadly comparable, though still a little higher in the Garrett Screens.

MESOZOOPLANKTON BIODIVERSITY, PIGMENTS & PHOTOPROTECTION – Ruth Airs and Delphine Bonnet

5.6.1 MESOZOOPLANKTON BIODIVERSITY - Delphine Bonnet

Introduction
Although the Surface Micro Layer (SML) is known to be a site of intense biological activity, the food-web structure and the dynamics of the SML are not well known. Both micro- and meso-zooplankton have been shown to be abundant in the SML and through their grazing activity play an important role in the cycling of biogases.

There are a number of scientific questions which could be addressed on this cruise:

- Are there major differences in the species composition (microbial, autotrophic, microzoo- & mesozooplankton) and diversity between the communities of the SML and the underlying water? We propose to test hypothesis that species diversity is higher in the SML than in underlying water.
- Is the SML enriched in bulk biomass or in particular species? Do these species exhibit pronounced diel patterns in their activity related to fluctuations in light and chemical conditions?
- Zooplankton/microzooplankton/phytoplankton – what are the predator prey interactions at the sea-surface microlayer? What are the implications for higher trophic levels e.g. fish larvae and cycling of biogases.
- How stable are the SML communities spatially and temporally? Is there patchiness of prey as well as patchiness of predators?

Considerable evidence indicates that small increases in UV-B radiation can inhibit photosynthesis, growth or reproduction in a variety of marine species. However, neustonic plankton occur at the sea surface where the UV-B radiation is greater than in the water column. Therefore they should be adapted to high levels of UV-B radiation (eg. They should contain pigments offering screening protection, MAAs, transparent cells, DNA radiation repair mechanisms, etc). This raises two further questions:

- What are the specific adaptation strategies of the populations inhabiting the SML?
- How does UVR affect growth and digestion in zooplankton populations of the SML?

Methods
See section 3.

Biodiversity
Rationale:
The mesozooplankton composition at the surface layer of the ocean is changing. Most of later development stages of copepods are migrating vertically at night to the surface waters to feed. However during the day, the composition of the surface layer has not been very much studied. Some key groups like the Pontellids are know to live exclusively in the surface layer and copepod juveniles due to their limited capacity of mobility are very abundant at the surface of the ocean.

Aims: To determine the composition and biomass of the mesozooplankton in the first meter of the water column and (ii) to look at its change during a transect from a heterotrophic to an oligotrophic area.

Methods
We will be collecting neuston with a floating WP2 net. Juvenile stages will be collected with a surface pump. Samples will be collected day and night and fixed in formalin for count and identification. Additional samples will be filtered on GF/F for biomass measurement (Carbon/Nitrogen analysis).

Pigments UV protecting, MAAs
Rationale:
Over the past 10-15 years, solar ultraviolet B (UV-B, 290-320 nm) levels have increased significantly at mid-latitude areas of the Northern and Southern Hemispheres. These increases in UV-B are linked to reductions of stratospheric ozone. Early life stages of crustacean zooplankton and ichthyoplankton present in the first metre of coastal water columns are susceptible to UV-B radiation. To counteract the negative effects of ultraviolet radiation (UVR), aquatic organisms may display one or more strategies: (1) avoidance (i.e. deep distribution); (2) photoprotection through the use of "sunscreen" compounds, such as mycosporine-like amino acids (MAAs) or carotenoid pigments, and (3) enzymatic repair of the damage.

Aims:
Our aims are (i) to identify which kind of carotenoid pigments and MAAs are present in the zooplankton and (ii) to determine qualitative and quantitative changes in carotenoid pigments and MAAs according to the species and the depth of the sampling.

Methods
We will be collecting neuston with a floating WP2 net and will focus on some key species (especially Pontellids if present). Juvenile stages will be collected with a surface pump. We are planning a day/night as well as a surface/depth comparison for the juveniles (juveniles would be then collected from the water of the CTD). The organisms will be starved for several hours before being frozen for HPLC and LC-MS measurements (Collaboration with Ruth Airs).

Trophic interaction
Rationale:
MAAs and carotenoid pigments are not synthesized by the zooplankton and their accumulation in the organisms requires a dietary source; for example some dinoflagellates have been shown to be rich in MAAs. We would like to determine and quantify the diet of copepod nauplii in the surface layer in relation to their photoprotection strategy.

Aims:
Our aims are (i) to identify the diet of nauplii from grazing experiments (incubations) and (ii) to estimate the trophic relationships within the first levels of the food web (stable isotopes- Collaboration with Andy Rees).

Methods
We will be collecting neuston with a floating WP2 net. Juvenile stages will be collected with a surface pump. Nauplii collected from the surface pump at dawn and will be picked up and incubated with surface water screened on a 200 µm mesh (grazing experiment). Sub-samples of the incubation water at the beginning and at the end of the experiment will be fixed in 2% Lugol to determine predation pressure on phyto- and microzooplankton. Water collected from the surface pump system as well as mesozooplankton from both the pump system and net will be size-fractionated and filtered on GF/F filters. Filters will be frozen for later stable isotopes analysis.

5.6.2 PHOTOSYNTHETIC PIGMENTS - Ruth Airs

Introduction

Chlorophyll *a* is widely used as an indicator of phytoplankton biomass, and the distribution of photosynthetic pigments (chlorophylls and carotenoids) can be used to determine phytoplankton composition according to pigment fingerprint profiles characteristic of different phytoplankton classes. Furthermore, pigment alteration products can be used to gauge the health of the primary producer community.

The aims of this work were to sample from pre-dawn and daytime CTD casts to enable vertical profiles of the water column pigment distribution to be constructed. Also, where weather conditions permitted, to determine the pigment composition at the microlayer and near surface.

Experimental Approach

Sampling

Details of all of the samples collected are given in the Appendix. Water samples from the mixed layer were collected by CTD to examine depth profiles. When weather conditions permitted, the microlayer and near surface were sampled using the Garrett Screen, surface microlayer sampler and near surface sampling device.

Sample work-up

Water samples were filtered through 25 mm GF/F filters, flash frozen in liquid nitrogen and stored at -80ºC or in liquid nitrogen prior to analysis. Pigments were extracted from the sample filters into 2 ml 90% acetone containing an internal standard apo-carotenoate (Sigma) using an ultrasonic probe (30 sec, 50W). Extracts were centrifuged to remove filter and cell debris (5 min at 4000 rpm, followed by 3 min at 14,000 rpm) and analysed using reverse-phase C8 HPLC gradient elution (based on Barlow et al. 1997) using an Agilent 1100 HPLC system with Chemstation software. The HPLC was calibrated using a suite of standards (DHI, Denmark) and pigments in samples identified using retention time and spectral match using photo-diode array spectroscopy (Jeffrey et al. 1997).

Preliminary Results

Microlayer and Near-surface

The chl-a concentrations determined from microlayer samples demonstrate discrepancies between the sampling methods used (Garrett Screen and Microlayer Sampler; Fig. 5.6.3). The largest discrepancy was evident for samples taken on the second day at Station 2, but the data do not demonstrate either sampling method to produce consistently higher levels of chl-a. It was assumed that if sampling conditions caused either of the sampling methods to under-perform, this would result in a dilution of the microlayer sample and hence a reduction in the observed chl-a concentration. Therefore, for each sampling event, data from the sampling method that gave the highest chl-a concentration were used.

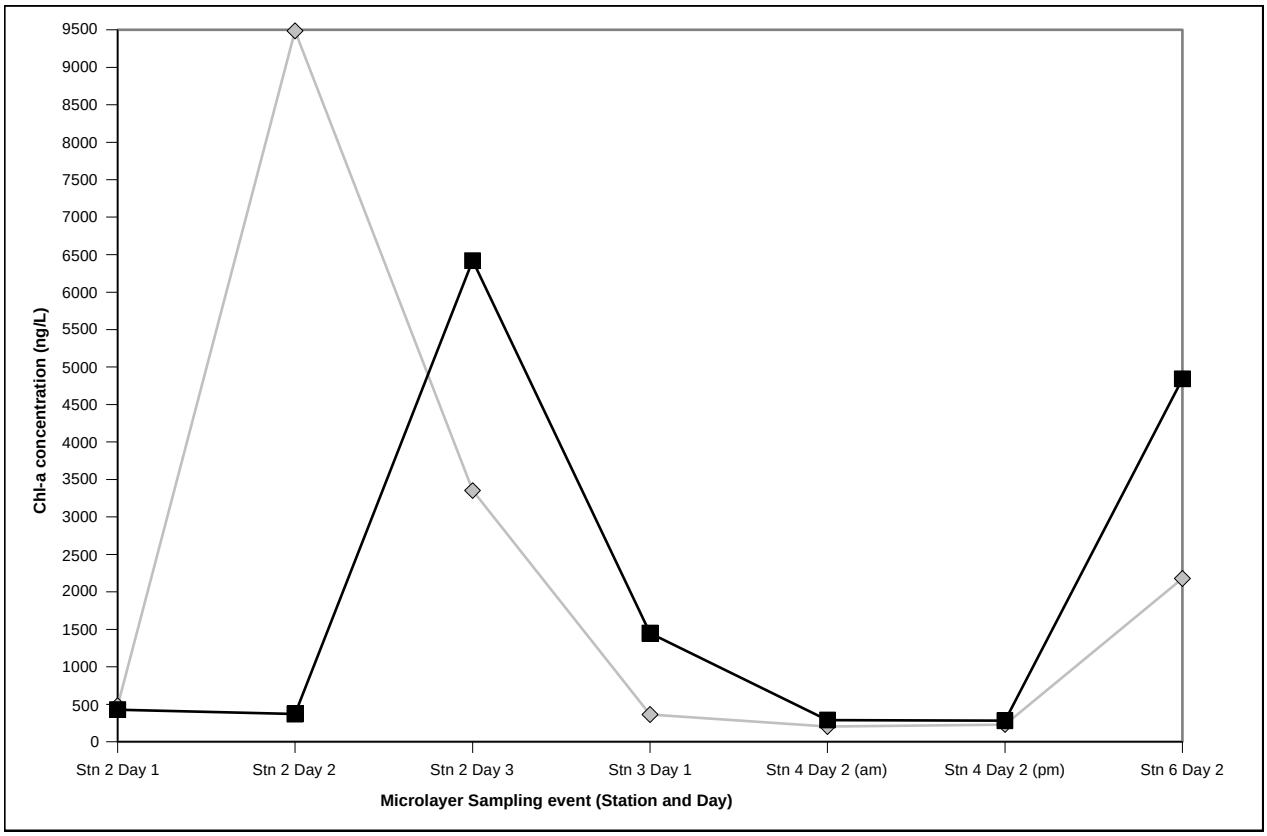


Figure 5.6.3. Microlayer Chl-a concentration in samples collected using the Garrett Screen (black) and Microlayer Sampling Device (MLSD, grey).

The Chl-a depth profiles between the surface and 182 cm (Fig. 5.6.4) demonstrate a higher concentration at the sea-air interface on the second and third days at station 2, the first day at station 3, the fifth day at station 4 and the second day at station 6. Microlayer formation was most pronounced on days 2 and 3 at station 2, with Chl-a concentrations at the sea-air interface 47 and 45 times higher than those detected at 25 cm, respectively. The pigment distribution of the microlayer at station 2 (data not shown) indicates the phytoplankton were dominated by peridinin-containing dinoflagellates.

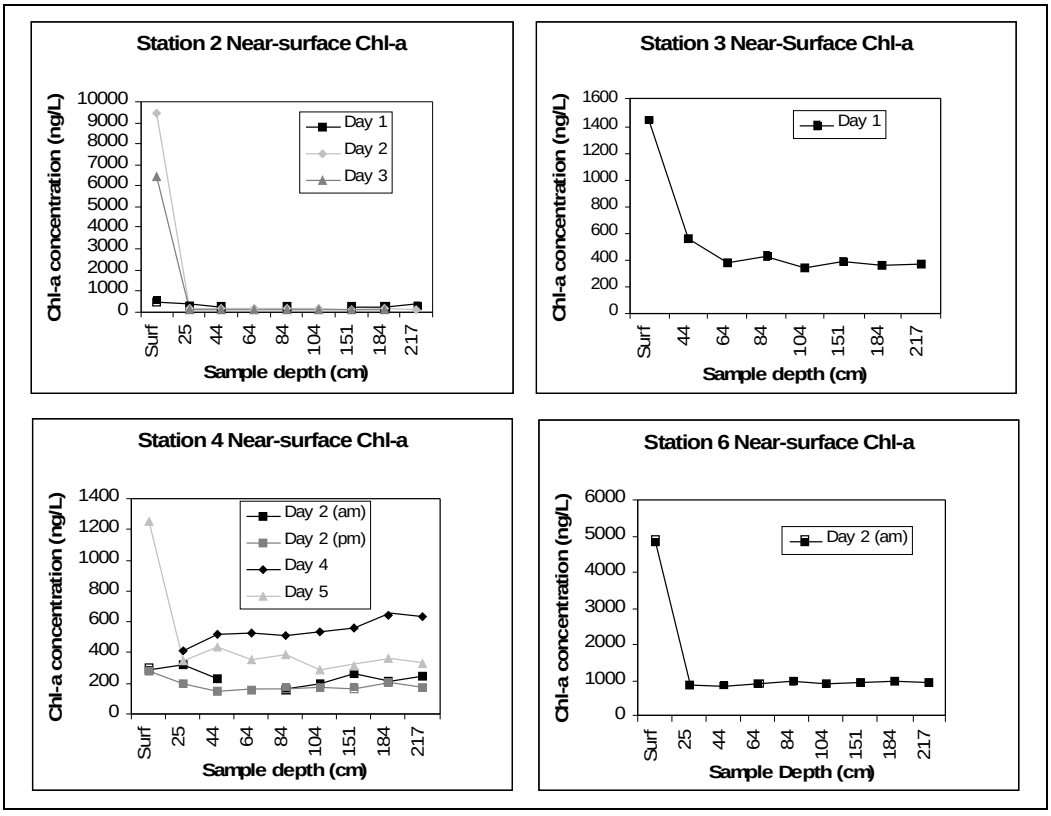


Figure 5.6.4. Chl-a profiles of the microlayer and near-surface depths sampled at stations 2, 3, 4 and 6 (On depth scale, 'surf ' = highest of the two microlayer samples).

5.6.3 PHOTOPROTECTION: UV Absorbing compounds - Ruth Airs and Delphine Bonnet

Introduction
The UV-absorbing mycosporine-like amino acids (MAAs) are biosynthesised by some autotrophic eukaryotes and prokaryotes to protect against deleterious effects of UV radiation. The abundance and distribution of MAAs in phytoplankton varies, but are most abundant and diverse in surface bloom forming species. There have been few studies measuring the distribution and abundance of MAAs in the marine environment. Additionally, little is known about the abundance and distribution of UV absorbing compounds in microlayer communities.

Heterotrophic organisms are unable to synthesise MAAs de novo, but can accumulate them from their diet. Photoprotection strategies are likely to be important for surface dwelling zooplankton.

The aims of this work were to determine the abundance and distribution of MAAs in particulate material sampled from the microlayer and near-surface, and the profiles of these compounds with depth across a transect from an oligotrophic region to an upwelling region, and to relate the profiles to phytoplankton composition. Also to investigate the photoprotective strategies of surface-dwelling zooplankton and their interaction with phytoplankton by determining the MAAs and carotenoid composition of key species sampled both during the day, and at night.

Experimental Approach
Sampling
Details of the samples collected are given in the Appendix. Water samples from the mixed layer were collected by CTD to examine profiles of MAAs with depth. When weather conditions permitted, the microlayer and near surface were sampled using the Garrett Screen, surface microlayer sampler and near surface sampling device.

Surface zooplankton were collected using a neuston net (200μm mesh size) towed during 10 minutes. Tows were performed both during the day and at night (pre-dawn). Following the neuston net tows, surface water samples for phytoplankton pigments and MAAs were collected using a surface pump (e.g. pumping 40 to 50 cm below the surface).

Sample-work-up
Zooplankton were sorted according to groups or species. For several calanoid copepods, sex and late stage of development were identified. Organisms were incubated in filtered sea water for several hours to empty their gut. Groups of few individuals (varying according to the size of the organisms) were frozen in liquid nitrogen and stored at -80°C prior to pigment and MAA analysis. Simultaneously, organisms were placed individually or in small groups in tin cups and frozen at -30° C for later carbon and nitrogen analysis (Carbo Erba) so that MAA and pigment measurements could be expressed per unit of biomass rather than per individual. *Trichodesmium* colonies sampled at Station 2 using the surface pump were isolated and gently filtered onto 25 mm GF/F filters for pigment and MAA analyses.

Water samples were filtered through 25 mm GF/F filters, flash frozen in liquid nitrogen and stored either at -80ºC or in liquid nitrogen prior to analysis. Phytoplankton pigment analyses were performed as described in section 3.7.2. MAA analyses were performed as follows: MAAs were extracted from filters or zooplankton into 1 ml (0.5 ml for zooplankton) 75% acetonitrile using an ultrasonic probe (30 sec, 40W). Extracts were incubated at 45ºC for 2 hours and then centrifuged to remove filter and/or cell debris (3 min at 14,000 rpm). Extracts were analysed using HPLC (Agilent 1100 Series). Separations were perfomed using a Luna-amino column (250 x 4.6 mm; Phenomenex, UK) protected by a SecurityGuard™ (Phenomenex) cartridge containing the same phase as the analytical column. The mobile phase comprised acetonitrile and 0.1 M ammonium

carbonate (pH 10) in the following composition: Solvent A: 85% acetonitrile, 15% 0.1M ammonium carbonate pH10; solvent B: 25% acetonitrile, 75% 0.1 M ammonium carbonate pH10. Starting composition = 100% A. Isocratic hold at 100% A for 10 mins. Gradient elution from 100% A to 100% B over 35 minutes. Total run time 45 mins. 10 minutes re-equilibration time between runs. Flow rate 1.0 ml/min. HPLC response factors for individual MAAs were determined from pure compounds isolated by preparative HPLC from phytoplankton cultures and quantified using UV/vis spectrometry and published extinction coefficients.

MAA and pigment analyses for *Trichodesmium* samples were performed on a single filter as follows: GF/F filters containing *Trichodesmium* colonies were extracted into 2 mL 100% methanol by sonication (30 secs; 40W). A 0.5 mL portion of the methanol extract was taken for pigment analysis by HPLC as described in section 3.8.1. A second 0.5 mL portion of the methanol extract was blown to dryness under N_2(g), re-dissolved in 0.5 mL 75% acetonitrile and analysed for MAAs as described above. Following the methanol extraction, the *Trichodesmium* filter paper residues were re-extracted in 1 mL 75% acetonitrile and analysed according to our standard MAA extraction protocol (see above). The *Trichodesmium* MAAs per filter were calculated using the MAA content of both the methanol and acetonitrile extracts.

Zooplankton samples for photoprotective-carotenoid analysis were preserved at -80ºC for analysis using high resolution HPLC and LC-MS/MS according to Airs et al. (2001).

Preliminary Results

Microlayer and Near-surface

Preliminary data analysis of MAA abundance and distribution from microlayer and near surface samples from the third day at Station 2 revealed shinorine and palythene concentrations in the microlayer were 500 times higher than those at 25 cm. Concentrations of mycosporine-glycine and shinorine in the microlayer reached over 0.1 mg/L. On the third day of sampling at Station 2, the molar ratio of shinorine to Chl-a was approximately 50. Although MAA surveys of individual marine organisms are widespread, few studies have determined the abundance of MAAs in natural phytoplankton assemblages. One such study in the Western English Channel revealed a maximum total MAA concentration of approximately 8 μg/L (Llewellyn and Harbour, 2003).

Zooplankton

Initial analyses of UV-absorbing mycosporine-like amino acids in zooplankton revealed distribution differences among stations, time of the sampling, species and between sex and stage of development of the same species. For example, female *Centropages* sampled during the day at Station 5 contained a higher relative amount of mycosporine-glycine (Fig. 5.6.5a), which exhibits an absorption maximum at 310 nm, whereas male *Centropages* sampled at the same time contained a higher relative amount of MAAs with absorption maxima at 334 nm (porphyra and shinorine; Fig. 5.6.5b). In contrast, *Acartia clausii* females, also sampled during the day at Station 5 exhibited a distribution of MAAs characterised by high relative amounts of mycosporine-glycine, palythine (λmax 320 nm), porphyra and shinorine (Fig. 5.6.5c). A final comparison of absolute quantities of photoprotective compounds will be expressed per unit of carbon body weight to permit comparison between zooplankton species biomass (eg. Table 5.6.1).

Table 5.6.1

Species	Nitrogen weight ± stdev (ug N ind^{-1})	Carbon weight ± stdev (ug C ind^{-1})
Centropages C5	1.25 ± 0.11	4.64 ± 0.45
Centropages Males	3.17 ± 0.61	11.64 ± 2.00
Centropages Females	3.55 ± 1.64	13.43 ± 5.83

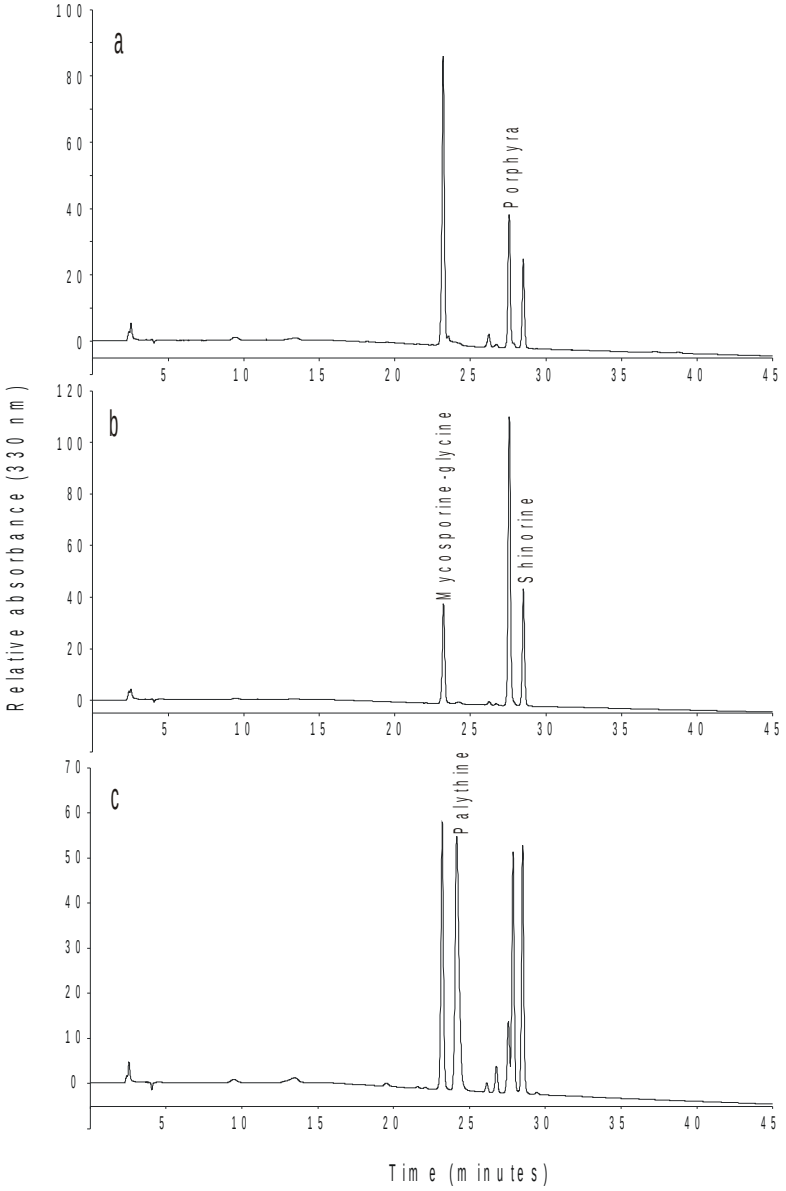


Figure 5.6.5. HPLC chromatogram detected at 330 nm of zooplankton MAA extracts from (a) 23 *Centropages* females (b) 16 *Centropages* males and (c) 30 *Acartia clausi* females, sampled during the day at station 5.

5.6.4 CHLOROPHYLL PHOTODEGRADATION - Ruth Airs

Introduction
The role of photochemical processes during the degradation of phytoplankton and detritus in the euphotic layer of the ocean has received little attention to due lack of adequate tracer compounds. Phytoplankton cells in a poor state of health are particularly prone to the effects of photodegradation. Recent research shows that the photodegradation of phytogenic material may be significant in organic matter budgets and fluxes particularly in unproductive and warm waters.

The overall aim of this work was to investigate the biogeochemical consequences of the photodegradation of phytoplankton. More specifically to estimate the amount of chlorophyll photodegraded with depth in upwelling and oligotrophic waters. This work will help us to understand the role of photochemical processes in the transformation of photosynthetically fixed carbon in the extreme upper ocean.

Experimental Approach
Sampling
Particulate material was collected by large volume filtration using stand alone pumps (SAPs). Details of SAP deployment are given in Appendix 4. After deployment, the 293 mm GF/F's were retrieved from the SAP pumps, visually inspected and cut into sections (47 mm diameter) using a spherical filter cutter. Filters were stored frozen (-80ºC) for analysis post-cruise.

Sample work-up
Following hydrolysis to retrieve isoprenoid components, we will use GC-EIMS to determine the ratio of phytol to phytyldiol, a specific photooxidation marker of the chlorophyll phytyl chain. Phytol and phytyldiol will be quantified using calibration curves generated from pure standards. We will use the results together with the published chlorophyll side-chain photodegradation index (CPPI) to estimate the proportion of photodegraded chlorophyll. Intact pigments will be extracted from selected filters and analysed by high resolution HPLC (Airs et al., 2001) to relate the abundance of chlorophyll alteration products to the proportion of photodegraded chlorophyll.

5.7 COMPOSITION AND METAGENOMICS OF THE MICROBIAL COMMUNITY - Willie Wilson & Claire Evans

Introduction

Microbes form the base of the marine foodweb and are the drivers of ocean biogeochemistry. The sea-surface microlayer (SML) is a poorly understood microbial environment (Agogue et al. 2005) and in particular little is known about the vironeuston. Studies have reported enriched abundances of autotrophic and heterotrophic microbes as well as virus-like-particles (VLP) in the SML compared with underlying waters (e.g. Joux et al. 2006) however, studies have indicated that microbe concentrations may be also lower at the sea surface (Bell and Albright 1982). We aim to determine the variation in composition and abundance of the microbial community over varied spatial scales within the water column in productive upwelling waters as well as open ocean regions. Phytoplankton groups, heterotrophic bacteria and viruses will be enumerated using flow cytometry and DNA will be isolated in order to assess the diversity of the communities present. We aim to sample from all CTD casts and all deployments of the NSSD and microlayer sampling devices.

Methods

Samples for flow cytomtery were collected in 250 ml polycarbonate bottles and stored in the refrigerator until analysis. All samples were analysed on a FACScan flow cytometer with the standard filter set up using FACSFlow as the sheath fluid. Flow rates were determined daily using fluorescence beads and used to calculate concentrations of the organisms analysed. Freshly collected seawater was used for the analysis of phytoplankton groups which were distinguished on the basis of their autofluorescence signatures. For enumeration of bacteria and viruses samples were fixed in final concentration 0.5% glutaraldehyde for 30 min before being snap frozen and stored at -80 ˚C until analysis back at the lab. Bacterial samples were analysed according to methods adapted from Marie et al (1999) using the fluorescent nucleic acid stain SYBR Green I. Defrosted samples were diluted by a factor of 10 with TE buffer (10 mM Tris, 1 mM EDTA adjusted to pH 7.5) which had been pre filtered through a VivaFlow 200 (Sartorius) equipped with a polyether sulfone (PES) 30 kDa module and then autoclaved. The diluted samples were mixed with SYBR Green I at a final concentration of 10^{-4} and maintained at room temperature for a 15 min staining period. Virus samples were enumerated according to the method of Brussaard (2003) again using SYBR Green I. Samples were defrosted and diluted by a factor of 100 with TE buffer (prepared as above). The samples were then mixed with SYBR Green I at a final concentration of 5 x10^{-5} and incubated at 80 ˚C for 10 min in the dark and then cooled for 5 min prior to analysis. For both bacteria and viruses data acquisition was triggered on green fluorescence and side scatter. For DNA isolation 10L samples were passed through 0.2 μm Sterivex filters which were then sealed at both ends using blue tack and snap frozen immediately. To determine community diversity 18S rDNA DGGE/sequence analysis will be performed for the phytoplankton,16S rDNA DGGE/sequence analysis will be performed for the bacteria and for viruses the Major Capsid Protein (MCP) and DNA polymerase diagnostic markers will be employed.

Preliminary Results

To date all the flow cytomtery has been completed and worked up and it is anticipated that the samples for community diversity will be analysed over the following two years. The photosynthetic community was dominated by the picoplankton and of these the most significant groups were the *Synechococcus* and Picoeukaryotes, with the former being numerically dominant at most stations. As has been indicated during other studies of this area (e.g. Moran et al. 2002) *Prochlorococcus* and the Nanoeukaryotes were also present. Numbers of bacteria and VLPs observed were typical of those generally reported for similar geographical location and season. Concentrations of all components of the microbial community were generally found to be similar in the SML to those observed in the underlying waters at a depth of 0.25 m. However, at station 2 from the 24th to the 26th of June a 'slick' developed on the sea surface and the concentration of all the microbial groups examined

increased in the SML (Figure 5.7.1a, b.). During this time microbial concentrations were higher at the SML when compared with the underlying waters yielding the maximum enrichment factors observed (Figure 5.7.1c.). It is interesting to note that enrichment factors for all the viral groups detected increased in parallel with the cellular microbial community indicating that they were able to respond rapidly to an increase in their hosts confirming the vironeuston are an active and dynamic component of the SML. When comparing the concentrations of microorganisms in waters collected from the SML by the Garrett screen sampler with the surface microlayer sampler it was found that bacteria and VLPs were almost always consistently higher in the former (Figure 5.7.2a, b.). Whereas, for the autotrophic community much more variation in concentrations yielded was observed between the two sampling devices (Figures 5.7.2c, d.).

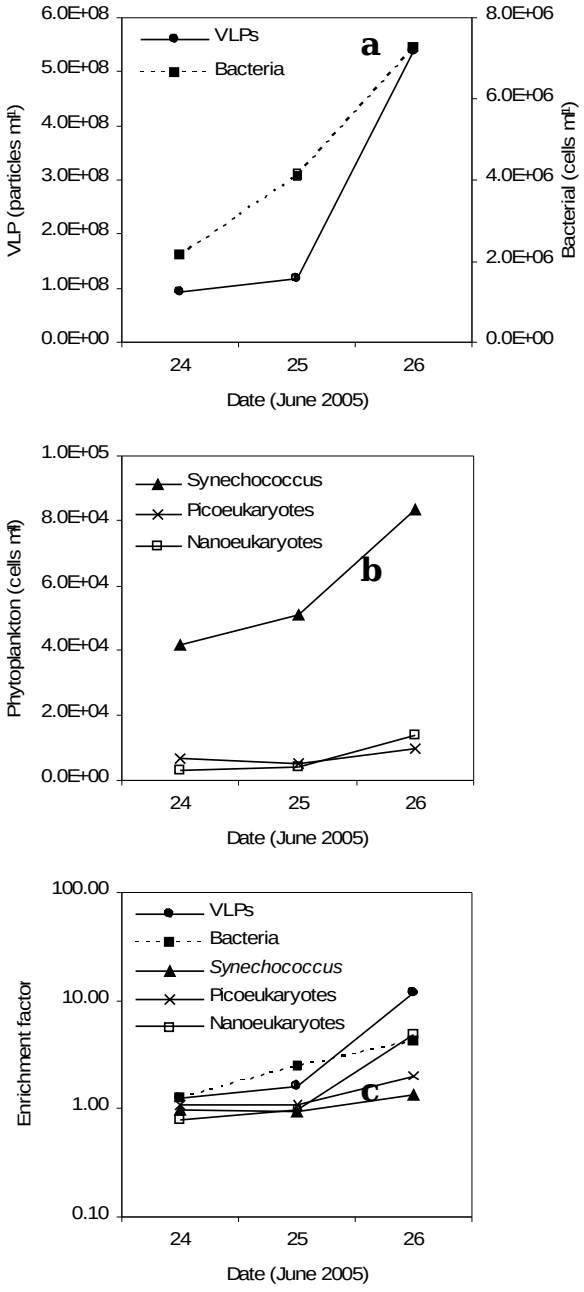


Figure 5.7.1. Changes in the concentration of (a) Virus Like Particles (VLP) and bacteria, (b) the phytoplankton community and (c) the enrichment factors in the sea surface microlayer measured over three consecutive days using the Garrett screen sampling device.

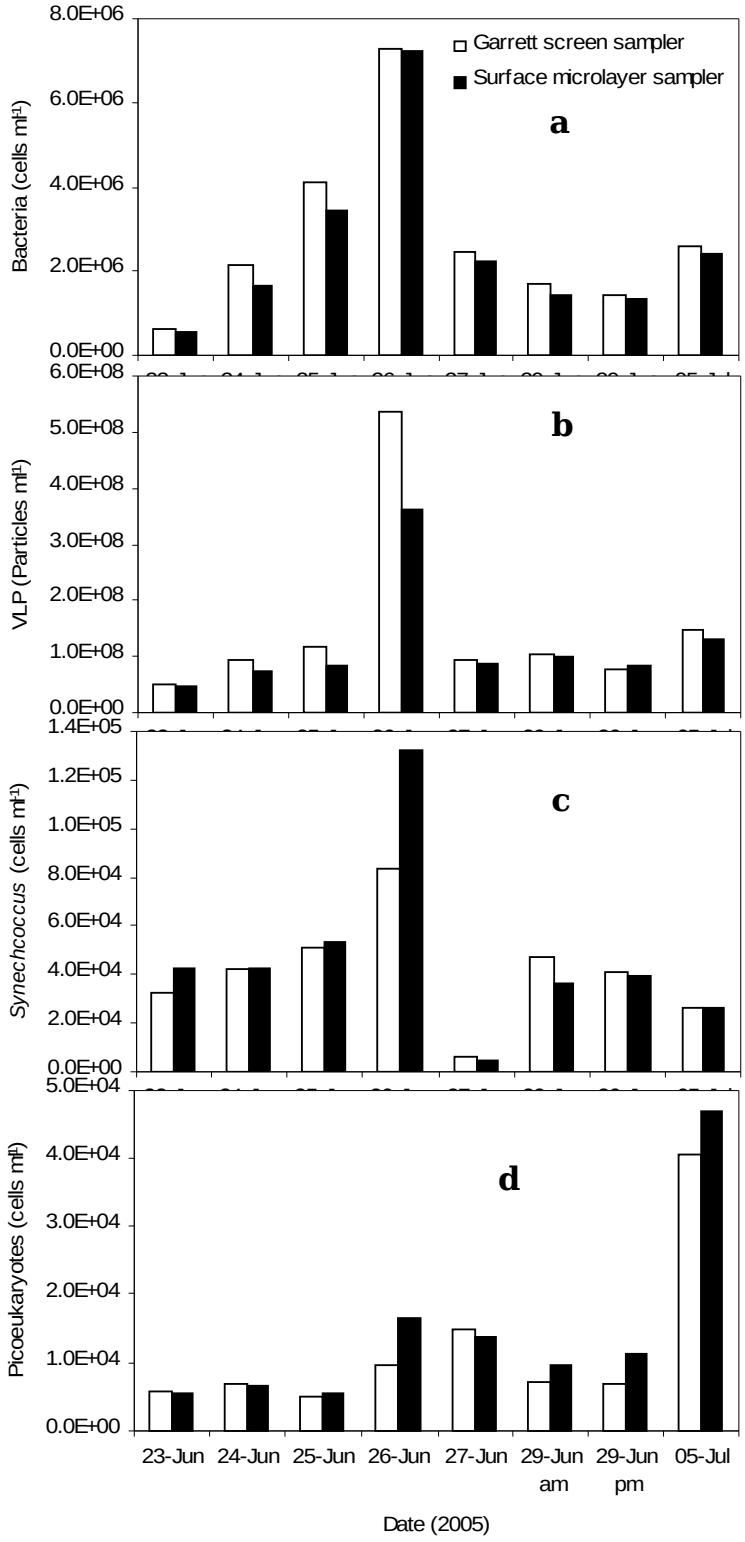


Figure 5.7.2. Comparison of the concentration of (a) bacteria, (b) virus-like-particles (VLP), (c) *Synechococcus* and (d) Picoeukaryotes in the sea surface microlayer as sampled by the Garrett screen sampling device and the microlayer sampling device.

Metagenomic analysis of virus-driven nutrient regeneration

Underlying rationale:

Marine phytoplankton are central players in nutrient cycling and energy transfer and their mortality has important biogeochemical and ecological consequences. The main non-predatory loss route for primary production by phytoplankton is virus-induced cell lysis. As much one-quarter of the photosynthetically-fixed organic carbon is recycled back to the dissolved fraction by viral lysis of phytoplankton, bacteria and grazers through a process termed the 'viral shunt' (carbon is shunted from transfer to secondary consumers). There is a dearth of information on what actually happens after the cell lysis event. Clearly a large amount of dissolved organic matter (DOM) will be released following the virus-induced demise of a phytoplankton bloom. However, we know very little about the microorganisms that utilise the resulting DOM or what nutrient cycling pathways are utilised in the remineralisation process. We plan to conduct a metagenomic characterisation of the microbial communities that arise as a consequence of the viral shunt and to try and determine the molecular basis of the DOM cycling pathways these communities utilise.

Methods

An adapted version of the Stable Isotope Probing (SIP) technique (Radajewski et al. 2000) was used where the radioisotope ^{14}C Sodium bicarbonate was incubated with the natural plankton community. Over the course of the cruise 3 experiments were set up using waters collected from the predawn CTD cast at station 1 on the 22nd of June, station 2 on the 25th of June and at station 4 on the 1st of July. The experiments were run for 3 days and each day three aliquots were removed and filtered fractionated through a 3 μm and 0.2 μm polycarbonate filters. One litre of filtrate was then concentrated using a vivaflow ultrafiltration system equipped with a 30 kDa polyether-sulphone membrane filter. Liquid scintillation was performed on all the filters and the concentrates generated as well as whole water. Flow cytometry for the autotrophic community was performed on the fresh filtrate/concentrate generated from each filtration/concentration steps, in addition samples were fixed and frozen for later analysis of the heterotrophic bacterial and viral communities.Samples for the isolation of DNA from the microbial community were also collected by filtration on to 0.2 μm Sterivex capsule filters and an aliquot of concentrate was reserved for viral DNA isolation. ^{14}C-labelled DNA will be isolated from each fraction for the following analysis:

Phytoplankton: 18S rDNA DGGE/sequence analysis to determine the diversity of the active phytoplankton community.

Bacteria: (a) 16S rDNA DGGE/sequence analysis to determine the diversity of the active bacteria community. (b) Construction of a metagenomic library of the active bacteria community.

Viruses: (a) Major Capsid Protein (MCP) and DNA polymerase diagnostic markers to determine diversity of the virus community. (b) Construction of a metagenomic library of the active virus community.

Samples will be collected to generate a phytoplankton community expressed sequencing tag (EST) database. We plan to use the cruise largely to test this methodology, use results for downstream environmental microarray projects and leverage for future proposals. We are hoping to get funding from the SOLAS programme to support much of the downstream work resulting from this cruise. Downstream analysis will include spotting metagenomic libraries or key gene clusters (from both virus and bacteria libraries) onto microarray slides to produce a 'microbial loop chip'. This chip will then be used to compare phenotypic diversity of microbial communities over temporal and spatial sampling regimes (eg. annual cycle at L4 in the English Channel) using a transcriptomics approach.

The experiments will be conducted in parallel with a recently funded NERC project to characterise the composition, nutritional quality, role and fate of DOM constituents released following viral lysis of phytoplankton. This will provide invaluable background information upon which to base the metagenomic approach.

Results
All liquid scintillation and flow cytometric samples have been analysed and worked up. Liquid scintillation of the fractionated samples revealed that the label was taken up by the microbial community during all experiments. However, the label could not be detected within the viral fraction above background levels indicating that viral induced mortality was not significant for the microbes present in the waters examined. It is anticipated that the samples for DNA will be isolated over the coming 2 years.

5.8 VOLATILES AND BIOGASES - Dimethylsulphide and halocarbons - Stephen Archer, Malcolm Liddicoat and Denise Cummings.

Introduction

Elevated productivity and shifts in microbial community composition associated with enhanced nutrient availability in upwelling regions suggest that they may be 'hotspots' of DMSP/DMS and biogenic volatile halocarbon production and hence, sea to air flux of these climate-active gases. Several previous studies measuring DMSP and DMS concentrations in the Iberian and NW African upwelling regions support this suggestion, although very little is known about halocarbon concentrations in these waters. In addition, it has become increasingly apparent that in order to estimate rates of air-sea exchange of these climate-active compounds, it is important to understand key processes in the sea-surface microlayer that may affect the exchange process. With these points in mind, we aimed to:

1.determine the standing stocks of reduced sulphur and halocarbon compounds in the region in relation to upwelling and non-upwelling conditions.
2.determine whether vertical gradients of these compounds exist in the near surface and microlayer
3.quantify the bacterial turnover rates of reduced sulphur compounds in surface layers in comparison to the underlying water column
4.characterise the bacterioplankton community and identify the taxa responsible for reduced sulphur metabolism in the surface layer verses the underlying water column

Methods

1.DMS(P) analyses: purge and cryo-trap gas chromatography with pulsed flame photometric detection (PFPD). Samples from CTD casts (~6 depths), NSSD, garret screens and MLSD were analysed.
2.Halocarbon analyses: purge and cryo-trap gas chromatography with electron capture detection (ECD). Depth profiles from CTD casts (6+ depths) and NSSD were analysed regularly.
3.Reduced sulphur turnover: 35S-methionine and 35S-DMSP were used at tracer concentrations to determine bacterial turnover rates of these compounds. Dissolved methionine *in situ* concentrations were determined using an isotope-dilution approach. Dissolved DMSP concentrations were determined by GC-PFPD following sample filtration using a syringe pump at 5 ml min^{-1} through GF/F filters and purging to remove DMS. DMSPd was then converted to DMS by alkaline hydrolysis. Separate sub-samples from the incubations were fixed in 1% paraformaldehyde and stored at -80ºC for flow cytometric sorting of defined sub-populations of bacteria. Samples were also fixed and frozen in the same way for FISH analysis of bacterial taxonomy.

Preliminary Results

Halocarbons:

No preliminary results are available yet for the halocarbon work.

DMS(P) concentrations:

We have accumulated an interesting dataset on (1) the variation in DMS(P) concentrations in relation to the pattern of upwelling events in the region (e.g. figure 5.8.1) and (2) some rare measurements of near-surface DMS(P) gradients, particularly during the calm conditions that allowed an obvious microlayer to develop at station 2 (e.g. figure 5.8.2).

We were able to compare bacterial turnover of DMSP and methionine and cell-specific turnover rates of defined sub-populations of the bacterioplankton in the microlayer and underlying water during the 3-4 days of calm weather 23-26 June. Initially bacterial composition was similar between the microlayer and underlying water and if anything, cell-specific turnover and assimilation rates were reduced in microlayer. However, as the calm period progressed, the

bacterial composition became more distinct in the microlayer and turnover and cell specific rates changed in relation to the underlying communities. We are still waiting for FISH analysis of these samples to be carried out at NOC and this will throw more light on the compositional changes in the microlayer.

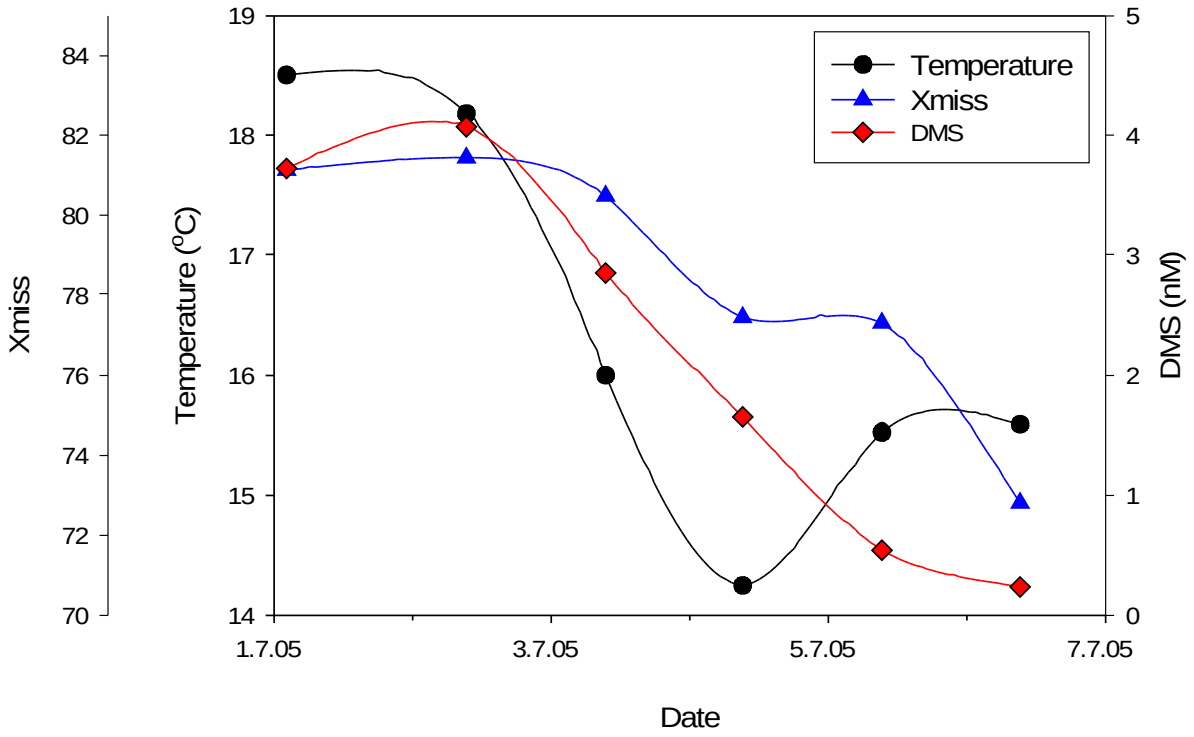


Figure 5.8.1. Temporal sequence prior to and during the upwelling event of: temperature, transmisometery and DMS concentrations all averaged at 10m. Interestingly, DMS shows a decrease in concentration closely related to the water temperature and increased particulate content of the water i.e. upwelling events themselves may reduce DMS sea-to-air flux in the area, rather than enhance it.

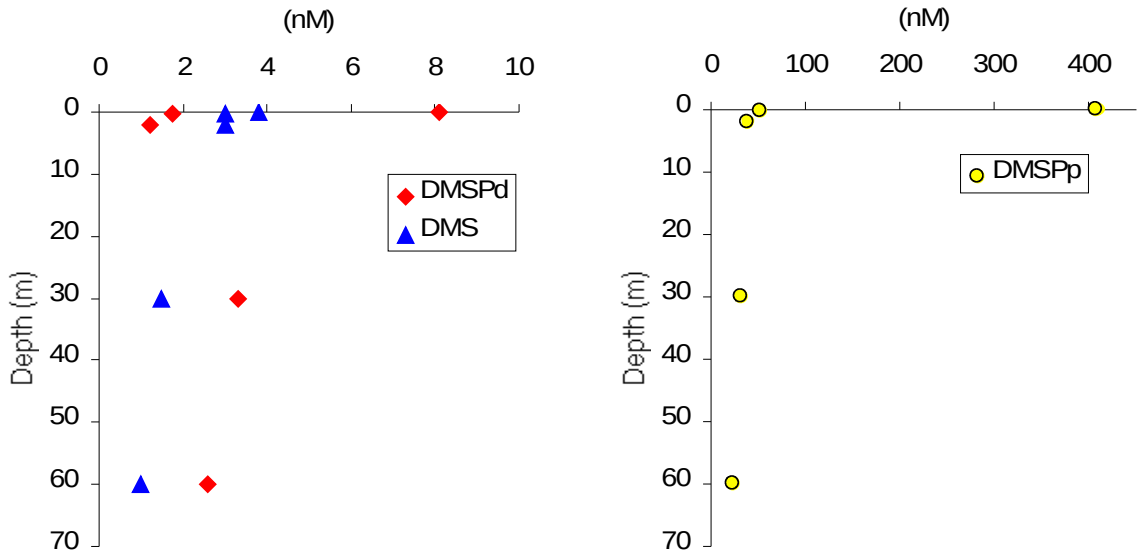


Figure 5.8.2. Depth profiles, including microlayer samples of the concentrations of DMS, DMSPd and DMSPp on the 26.6.05 after 3-4 days of calm weather and distinct microlayer formation. The sampling methods probably obscure any enhanced DMS in the microlayer but both dissolved DMSP and particulate DMSP occur at elevated concentrations with potentially important implications for DMS sea to air flux.

5.9 NITROGEN CYCLING - Darren Clark

Introduction
N-cycling (measured as ammonium regeneration and nitrification) in the marine environment makes a strong contribution to the support of marine primary production. Ammonium regeneration provides 'regenerated' N in the form of NH_4^+ while nitrification provides 'new' N in the form of NO_3^-. Previous studies (Clark et al., 2006a, b) have demonstrated that both of these processes occur in the surface ocean, in contrast to earlier studies which suggested that nitrification was constrained to the deeper, darker layers of the ocean due to light inhibition. Primary production supported by both nitrate and ammonium are related in the f-ratio and this has been used as a measure of exportable production (as sedimenting particles or as biomass to higher trophic levels). However, in the presence of significant ammonium regeneration and nitrification rates in the euphotic zone, isotope dilution will lead to underestimations of N-assimilation values during short term ^{15}N deck incubations and bias f-ratio determinations. Further, the influence of diel variations in N-assimilation kinetics (Clark et al, 2002; Flynn et al., 2002), ammonium regenerations rates (due to vertically migrating zooplankton) and nitrification rates (due to differential but incomplete light inhibition of ammonium and nitrite oxidation; Clark et al. 2006c) would lead to complex interactions for f-ratio determinations. Further, in a transect from upwelling to oligotrophic marine environments, the dominant source of N supporting primary production is likely to shift from nitrate to ammonium, which would be reflected in the f-ratio. The object of this study was to examine the diel variance in ammonium regeneration, nitrification and N-assimilation rates and to asses what impact the affect of isotope dilution has upon f-ratio determinations as the system shifts from one supported by nitrate (new production) to one supported by ammonium (regenerated production).

Methods.
Methods used in the study have been described previously (Clark et al., 2006 a,b).

Results.
PON concentrations in samples increased from oligotrophic into upwelling stations. Simultaneously, raw ^{15}N enrichment data suggested light and N-source dependant changes, in line with expectations. These data will be combined with ambient concentration data to calculate N-assimilation rate and f-ratio values. Nitrification and regeneration rate data are being analysed at present (February 06). The complete data set will be available June/July 2006.

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APPENDICES

1.Scientific Log
2.Navigation Log
3.Surface Sampler Log
4.CTD Log
5.SAPS
6.Optical properties
7.Primary and bacterial production
8.Mesozooplankton sampling Log
9.Microzooplankton sampling Log

Appendix 1. Scientific Log

Date	Time (GMT)	Stn. No.	Event No.	Event	Lat.	Lon.	Comments
21/06	02 :30	1	1	Neuston Net 1	42 00.30	10 30.07	10mins 2kts
	02:50	1	2	Neuston Net 2			
	03:20	1	3	Zooplankton Pump	42 01.81	10 30.25	
	04:28	1	4	SAPS	42 00.02	10 30.25	
	07:28	1	5	Turbulence Probe	42 00.09	10 30.08	
	07:53	1	6	Turbulence Probe			Aborted
	09:40	1	7	Daily CTD	42 00.19	10 29.88	CTD02
	10:45	1	8	Neuston Net 1	42 00.48	10 29.93	10mins 2kts
	11:04	1	9	Neuston Net 2	42 01.07	10 29.76	
	11:35	1	10	Zooplankton Pump	42 01.70	10 29.80	
	12:10	1	11	Turbulence Probe	42 02.02	10 30.36	
	12:32	1	12	Turbulence Probe			
	14:11	1	12a	Optics Cast	42 02.20	10 30.70	Broken Bracket
	14:11	1	13	CTD - Nitrification	42 02.47	10 31.14	CTD03 Jo/ Malcolm
	15:06	1	14	Turbulence Probe	42 02.65	10 30.36	
	15:32	1	15	Turbulence Probe	42 02.93	10 30.26	
	18:23	1	16	Turbulence Probe			
	18:42	1	17	Turbulence Probe			
	19:24	1	18	Optics Cast			
	20:19	1	19	SAPS			
22/06	02:35	1	20	Neuston Net 1	41 59.94	10 30.07	10mins 2kts
	02:55	1	21	Neuston Net 2	42 00.53	10 30.01	
	03:30	1	22	Zooplankton Pump	42 01.55	10 29.99	
	04:45	1	23	CTD - pp	42 01.49	10 30.44	CTD04 – (too late)
	05:15	1	24	Optics Cast	41 59.88	10 29.78	
	05:41	1	25	Turbulence Probe	41 59.63	10 29.59	
	06:07	1	26	Turbulence Probe			
	07:38	1	27	Optics Cast	41 59.83	10 29.61	
	08:14	1	28	Turbulence Probe	41 59.87	10 29.59	
	08:40	1	29	Turbulence Probe			Aborted
	08:42	1	30	Turbulence Probe			
	09:30	1	31	Daily CTD	41 59.77	10 29.47	CTD05
	10:45	1	32	Neuston Net 1	41 59.82	10 29.20	10mins 2kts
	11:03	1	33	Neuston Net 2	42 00.27	10 28.95	
	11:41	1	34	Optics Cast	42 00.62	10 28.99	
	12:07	1	35	Turbulence Probe	42 00.67	10 28.95	
	12:28	1	36	Turbulence Probe			
	13:00	1	37	Zooplankton Pump	42 00.29	10 29.67	
	14:00	1	38	RIB, NSSD			
	14:30	1	39	Turbulence Probe			From RIB
	16:16	1	40	Turbulence Probe			Aborted
23/06	18:23	1	41	Turbulence Probe			OK
	01 :07	1	42	Neuston Net 1	41 59.85	10 30.03	10mins 2kts
	01:33	1	43	Neuston Net 2	42 00.42	10 30.02	
	01:50	1	44	Zooplankton Pump	42 00.83	10 30.15	
	02:20	1	45	CTD - pp	42 00.86	10 30.64	CTD06
	04:25	1	46	Turbulence Probe	41 59.96	10 30.51	
	08 :10	1	47	Turbulence Probe	41 59.73	10 29.77	
	09 :05	1	48	Daily CTD	41 59.93	10 29.77	CTD07
	10:05	1	49	Neuston Net 1	42 00.25	10 29.50	10mins 2kts
	10:25	1	50	Neuston Net 2	42 00.75	10 29.43	
	12:00	1	51	Turbulence Probe	42 00.28	10 29.72	
	12:20	1	52	Turbulence Probe			
	12 :53	1	53	Zooplankton Pump	42 00.15	10 29.92	
	13:20	1	54	Optics Cast	41 59.32	10 30.37	
	13:50	1	55	Optics Cast			

Date	Time (GMT)	Stn. No.	Event No.	Event	Lat.	Lon.	Comments
	14:20	1	56	RIB, NSSD, MLSD	41 59.30	10 30.37	
	14:37	1	56a	Turbulence Probe			From RIB
	16:30	1	57	Turbulence Probe	41 59.73	10 29.87	
	18 :51	1	58	Turbulence Probe			
	19 :27	1	59	Optics Cast	41 59.70	10 30.00	
	20:02	1	60	Optics Cast			
	22:40	1	60a	CTD – 10m	41 59.70	10 30.00	CTD08 – Darren
24/06	05:27	2	61	Neuston Net 1	41 43.75	09 19.48	10mins 2kts
	05:45	2	62	Neuston Net 2	41 44.32	09 19.69	
	06:18	2	63	Zooplankton Pump	41 43.85	09 19.66	
	06:44	2	64	Turbulence Probe	41 43.06	09 19.61	
	07 :10	2	65	Turbulence Probe			
	07 :30	2	66	SAPS	41 43.10	09 19.80	
	09 :40	2	67	Daily CTD	41 43.00	09 19.40	CTD09
	10:45	2	68	Neuston Net 1	41 44.38	09 19.62	10mins 2kts
	11:00	2	69	Neuston Net 2	41 45.04	09 20.04	
	11:16	2	70	Zooplankton Pump	41 43.99	09 19.49	
	13:15	2	71	RIB, NSSD, MLSD	41 44.65	09 19.82	
	16:15	2		BOAT DRILL			
	17:22	2	72	CTD - Nitrification	41 43.89	09 19.13	CTD10
	17:56	2	73	Optics Cast	41 43.51	09 19.37	
	18:26	2	74	Optics Cast			
	19:00	2	74a	SAPS			
	22:40	2	75	CTD – 10m	41 43.80	09 19.94	CTD11 – Darren
25/06	01:05	2	76	Neuston Net 1	41 44.38	09 19.62	10mins 2kts
	01:30	2	77	Neuston Net 2	41 45.04	09 20.04	
	01:45	2	78	Zooplankton Pump	41 43.99	09 19.49	
	02:40	2	79	CTD - pp	41 44.01	09 19.48	CTD12
25/06	03:38	2	80	Optics Cast	41 44.32	09 18.96	
	04:05	2	81	Optics Cast			
	07:16	2	82	Optics Cast	41 43.74	09 19.47	
	07:52	2	83	Optics Cast			
	09:20	2	84	Daily CTD	41 44.00	09 19.60	CTD13
	10:19	2	85	Optics Cast	41 43.95	09 20.12	
	10:39	2	86	Optics Cast			
	11:10	2	87	Neuston Net 1	41 43.49	09 20.12	10mins 2kts
	11:27	2	88	Neuston Net 2	41 43.93	09 20.66	
	12:05	2	89	Zooplankton Pump	41 43.45	09 19.60	
	13:20	2	90	RIB, NSSD, MLSD	41 44.60	09 19.60	
	14:43	2	91	Optics Cast	41 43.59	09 19.58	
	15:12	2	92	Optics Cast			
	18:!8	2	93	Optics Cast			
	18:48	2	94	Optics Cast			
26/06	08:54	2	95	Optics Cast	41 43.08	09 20.30	
	09:16	2	96	Optics Cast			
	09:41	2	97	Daily CTD	41 44.60	09 19.60	CTD14
	10:40	2	98	Neuston Net 1	41 42.50	09 20.75	10mins 2kts
	10:55	2	99	Neuston Net 2	41 42.97	09 20.37	
	11:35	2	100	Zooplankton Pump	41 43.93	09 19.67	
	11:50	2	101	Optics Cast	41 43.93	09 19.69	
	12:24	2	102	Optics Cast			
	12:50	2	103	RIB, NSSD, MLSD	41 43.60	09 19.60	
	15:10	2	104	Optics Cast	41 43.81	09 18.83	
	15:40	2	105	Optics Cast			
	18:50	2	106	CTD			CTD15
27/06	01:03	3	107	Neuston Net 1	41 51.36	08 58.25	10mins 2kts
	01:30	3	108	Neuston Net 2	41 50.91	08 58.21	
	01:50	3	109	Zooplankton Pump	41 51.58	08 58.31	
	02:57	3	110	Optics Cast	41 51.42	08 57.98	

Date	Time (GMT)	Stn. No.	Event No.	Event	Lat.	Lon.	Comments
	03:19	3	111	Optics Cast			
	05:00	3	111a	SAPS			
	06:00	3	112	RIB, NSSD, MLSD	41 51.99	08 57.78	
	08:30	3	113	Optics Cast			
	09:40	3	114	Daily CTD	41 51.74	08 57.84	CTD16
	10:25	3	115	Neuston Net 1	41 51.69	08 57.82	10mins 2kts
	10:40	3	116	Neuston Net 2	41 51.08	08 57.98	
	10:55	3	117	Zooplankton Pump			
28/06	01:10	4	118	Neuston Net 1	42 12.63	09 00.77	10mins 2kts
	01:35	4	119	Neuston Net 2	42 12.23	09 00.48	
	02:00	4	120	Zooplankton Pump	42 12.48	09 00.52	
	04:10	4	121	SAPS			
28/06	05:25	4	122	Optics Cast	42 12.55	09 00.51	
	08:30	4	123	Optics Cast	42 12.50	09 00.45	
	09:45	4	124	Daily CTD	42 12.20	09 00.45	CTD17
	10:40	4	125	Neuston Net 1	42 11.98	09 00.46	10mins 2kts
	11:01	4	126	Neuston Net 2	42 11.13	09 00.15	
	11:20	4	127	Zooplankton Pump	42 10.35	08 59.62	
	13:24	4	128	Optics Cast	42 12.20	09 00.68	
	18:40	4	129	SAPS	42 12.45	09 00.62	
	22:30	4	129a	CTD – 10m			CTD18 – Darren
29/06	01:04	4	130	Neuston Net 1	42 12.41	09 00.64	10mins 2kts
	01:27	4	131	Neuston Net 2	42 12.14	09 00.93	
	02:00	4	132	Zooplankton Pump	42 10.41	09 00.71	
	02:20	4	133	Turbulence Probe	42 12.44	09 00.73	
	03:30	4	133a	SAPS	42 12.14	09 00.93	
	04:47	4	134	Optics Cast	42 10.51	09 00.78	
	05:50	4	135	RIB, NSSD, MLSD	42 12.85	09 00.32	
	08:30	4	136	Optics Cast	42 12.00	09 00.00	
	09:30	4	137	Daily CTD	42 12.89	09 00.12	CTD19
	10:40	4	138	Neuston Net 1	42 12.98	09 00.12	10mins 2kts
	11:00	4	139	Neuston Net 2	42 12.69	09 00.96	
	11:20	4	140	Zooplankton Pump	42 12.31	09 00.52	
	13:40	4	142	RIB, NSSD, MLSD	42 12.49	09 00.68	
	15:04	4	143	Optics Cast	42 12.52	09 00.57	
	16:40	4	143a	SAPS	42 12.54	09 00.52	
	18:14	4	144	Optics Cast	42 12.57	09 00.47	
30/06	12:10	4	145	Optics Cast	42 12.42	09 00.66	
	12:40	4	146	Neuston Net 1	42 12.60	09 00.70	10mins 2kts
	13:00	4	147	Neuston Net 2	42 13.07	09 01.04	
	13:28	4	148	Zooplankton Pump	42 12.48	09 00.51	
	14:50	4	149	Daily CTD	42 12.51	09 00.53	CTD20
	16:22	4	149a	Optics Cast	42 12.51	09 00.73	
	22:30	4	150	CTD	42 12.51	09 00.81	CTD21
01/07	01:05	4	151	Neuston Net 1	42 12.49	09 00.60	10mins 2kts
	01:30	4	152	Neuston Net 2	42 12.86	09 00.70	
	01:43	4	153	Zooplankton Pump	42 12.38	09 00.55	
	02:30	4	154	CTD	42 12.57	09 00.61	CTD22
	03:25	4	155	Optics Cast	42 12.64	09 00.66	
	07:43	4	156	Optics Cast	42 12.80	09 00.62	
	08:27	4	157	Optics Cast	42 12.80	09 00.62	Freefall
	09:30	4	158	Daily CTD	42 12.80	09 00.62	CTD23
	10:05	4	159	Optics Cast	42 12.86	09 00.38	
	10:45	4	160	Optics Cast			Freefall
	11:05	4	161	Neuston Net 1	42 12.76	09 00.29	
01/07	11:30	4	162	Neuston Net 2	42 12.17	09 00.61	
	11:54	4	163	Zooplankton Pump	42 12.40	09 00.52	
	12:50	4	164	RIB, NSSD, GS	42 12.40	09 00.52	
	14:15	4	165	Optics Cast	42 12.41	09 00.59	

Date	Time (GMT)	Stn. No.	Event No.	Event	Lat.	Lon.	Comments
	15:12	4	166	Optics Cast	42 12.40	09 00.54	
	17:15	4	167	Optics Cast	42 12.36	09 00.67	
	17:54	4	168	Optics Cast	42 12.31	09 00.37	
	22:30	4	169	CTD	42 12.00	09 00.33	CTD24
02/07	01:20	4	170	Neuston Net 1	42 12.53	09 00.61	10mins 2kts
	01:42	4	171	Neuston Net 2	42 12.82	09 00.65	
	02:20	4	172	Zooplankton Pump	42 12.37	09 00.65	
	03:00	4	173	CTD - pp	42 12.37	09 00.84	CTD25
	04:00	4	174	SAPS	42 12.38	09 00.74	
	05:05	4	175	Optics Cast	42 12.41	09 00.88	
	07:30	4	176	Optics Cast	42 12.36	09 00.74	
	08:21	4	177	Optics Cast	42 12.41	09 00.85	
	09:30	4	178	Daily CTD	42 12.40	09 00.60	CTD26
	11:20	4	179	Optics Cast	42 12.42	09 00.90	Free-Fall Probe lost
	13:20	4	180	RIB, NSSD, GS	42 12.37	09 00.84	
	18:00	4	181	SAPS	42 12.27	09 00.65	
	18:30	4	182	Shallow CTD	42 12.28	09 01.09	CTD27 – 15m
	23:15	5	183	CTD Q&D Nitrate	41 46.66	09 01.09	CTD28 – test station
03/07	01:28	5	184	Neuston Net 1	41 48.88	09 01.18	10mins 2kts
	01:35	5	185	Neuston Net 2	41 47.01	09 01.26	
	02:10	5	186	Zooplankton Pump	41 46.75	09 00.99	
	07:10	5	187	Optics Cast	41 46.77	09 00.97	
	09:45	5	188	Daily CTD	41 46.88	09 00.59	CTD29
	10:20	5	192	Optics Cast	41 46.97	09 01.06	
	10:55	5	189	Neuston Net 1	41 47.04	09 01.35	10mins 2kts
	11:18	5	190	Neuston Net 2	41 47.01	09 01.41	
	11:45	5	193	Zooplankton Pump	41 46.71	09 01.09	
	15:10	5	194	Optics Cast	41 46.73	09 01.04	
	19:00	5	195	SAPS	41 46.73	09 01.01	
04/07	09:30	6	196	Daily CTD	41 47.21	09 06.64	CTD30
	11:03	6	197	Neuston Net 1	41 47.05	09 06.53	10mins 2kts
	11:31	6	198	Neuston Net 2	41 47.25	09 06.54	
		6		Zooplankton Pump			Cancelled
	13:15	6	199	CTD	41 46.93	09 06.58	CTD31
	15:00	6	200	CTD	41 47.96	09 06.70	CTD32
	18:00	6	201	Shallow CTD	41 46.87	09 06.79	CTD33
05/07	01:18	6	202	Neuston Net 1	41 46.99	09 06.62	10mins 2kts
	01:43	6	203	Neuston Net 2	41 47.29	09 06.62	
	02:31	6	204	Zooplankton Pump	41 47.01	09 06.67	
05/07	03:00	6	205	CTD - pp	41 47.02	09 06.71	CTD34
	06:20	6	206	RIB, NSSD, MLSD	41 47.00	09 06.80	
	07:11	6	207	Optics Cast	41 46.99	09 06.54	
	09:10	6	208	Daily CTD	41 46.95	09 06.74	CTD35
	10:04	6	209	Optics Cast	41 46.94	09 06.75	
	11:03	6	210	Neuston Net 1	41 47.17	09 06.79	10mins 2kts
	11:36	6	211	Neuston Net 2	41 47.22	09 06.68	
	12:06	6	212	Zooplankton Pump	41 46.96	09 06.58	
	13:20	6	213	CTD	41 47.01	09 06.55	CTD36
	15:19	6	214	Optics Cast	41 46.78	09 06.73	
	17:09	6	215	Optics Cast	41 47.08	09 06.68	
	17:30	6	216	SAPS	41 47.08	09 06.68	
06/07	01:20	6	217	Neuston Net 1	41 46.84	09 06.53	10mins 2kts
	02:03	6	218	Neuston Net 2	41 46.96	09 06.58	
	03:20	6	219	CTD	41 46.94	09 06.54	CTD37
	04:13	6	220	Optics Cast	41 47.01	09 06.55	
	07:18	6	221	Optics Cast	41 46.94	09 06.52	
	09:30	6	222	Daily CTD	41 47.06	09 06.62	CTD38
	10:14	6	222a	Optics Cast	41 47.06	09 06.50	
	11:03	6	223	Neuston Net 1	41 47.32	09 06.61	10mins 2kts

Date	Time (GMT)	Stn. No.	Event No.	Event	Lat.	Lon.	Comments
	11:29	6	224	Neuston Net 2	41 46.99	09 06.61	
	12:18	6	225	Zooplankton Pump	41 46.98	09 06.67	
	13:08	6	226	Optics Cast	41 46.98	09 06.59	
	15:35	6	227	Optics Cast	41 46.97	09 06.75	
	16:45	6	228	SAPS	41 46.92	09 06.80	

Appendix 2. Navigation Log

DAY	DATE	TIME	LAT(N)	LON(E)	VN	VE	CMG	SMG	DIST	HEAD
170	19/06/2005	16:00:00	38.6350	-9.3548	-6.90	-6.67	224	9.6	23	224
170	19/06/2005	17:00:00	38.5903	-9.5418	0.81	-9.31	275	9.3	41	281
170	19/06/2005	18:00:00	38.6537	-9.7090	9.23	-2.86	343	9.7	58	345
170	19/06/2005	19:00:00	38.8042	-9.7578	9.73	-0.33	358	9.7	76	359
170	19/06/2005	20:00:00	38.9570	-9.7606	9.57	-0.10	359	9.6	93	1
170	19/06/2005	21:00:00	39.1164	-9.7618	9.91	-0.20	359	9.9	110	3
170	19/06/2005	22:00:00	39.2700	-9.7691	9.54	-0.01	360	9.5	127	4
170	19/06/2005	23:00:00	39.4260	-9.7689	9.08	0.28	2	9.1	145	3
171	20/06/2005	00:00:00	39.5721	-9.7652	8.00	-0.58	356	8.0	161	356
171	20/06/2005	01:00:00	39.7175	-9.7741	7.94	-0.62	356	8.0	177	356
171	20/06/2005	02:00:00	39.8625	-9.7867	8.76	-0.57	356	8.8	193	354
171	20/06/2005	03:00:00	39.9883	-9.7998	7.24	-0.30	358	7.2	207	358
171	20/06/2005	04:00:00	40.1049	-9.8094	6.87	-0.61	355	6.9	220	357
171	20/06/2005	05:00:00	40.2182	-9.8211	6.30	-0.96	351	6.4	233	357
171	20/06/2005	06:00:00	40.3299	-9.8309	7.30	-0.67	355	7.3	245	356
171	20/06/2005	07:00:00	40.4497	-9.8390	6.54	-0.39	357	6.6	259	356
171	20/06/2005	08:00:00	40.5670	-9.8473	7.30	-0.64	355	7.3	272	353
171	20/06/2005	09:00:00	40.6855	-9.8588	7.47	-0.89	353	7.5	285	354
171	20/06/2005	10:00:00	40.7363	-9.8629	-0.02	0.16	99	0.2	291	345
171	20/06/2005	11:00:00	40.7364	-9.8635	0.01	-0.30	272	0.3	291	342
171	20/06/2005	12:00:00	40.7388	-9.8666	0.35	0.29	40	0.5	292	2
171	20/06/2005	13:00:00	40.7486	-9.8738	0.36	-0.43	310	0.6	293	342
171	20/06/2005	14:00:00	40.7713	-9.8832	0.48	0.06	7	0.5	296	349
171	20/06/2005	15:00:00	40.7767	-9.8866	0.31	-0.05	351	0.3	297	349
171	20/06/2005	16:00:00	40.8444	-9.8907	8.43	-0.10	359	8.4	305	360
171	20/06/2005	17:09:40	40.9874	-9.9446	6.72	-3.52	332	7.6	321	338
171	20/06/2005	18:09:40	41.1039	-10.014	7.15	-3.01	337	7.8	336	339
171	20/06/2005	19:09:40	41.2203	-10.091	6.54	-3.26	334	7.3	350	339
171	20/06/2005	20:09:40	41.3377	-10.168	7.14	-3.16	336	7.8	365	339
171	20/06/2005	21:09:40	41.4519	-10.250	7.07	-2.91	338	7.6	379	341
171	20/06/2005	22:09:40	41.5705	-10.317	6.42	-2.79	337	7.0	394	344
171	20/06/2005	23:09:40	41.6822	-10.371	5.97	-1.73	344	6.2	407	346
172	21/06/2005	00:09:40	41.7854	-10.417	7.05	-2.36	341	7.4	419	346
172	21/06/2005	01:09:40	41.8978	-10.467	6.65	-1.81	345	6.9	432	351
172	21/06/2005	02:09:40	41.9992	-10.501	0.50	-0.28	331	0.6	444	22
172	21/06/2005	03:09:40	42.0306	-10.504	1.41	-0.07	357	1.4	447	10
172	21/06/2005	04:09:40	41.9991	-10.499	0.43	-0.14	342	0.5	453	9
172	21/06/2005	05:09:40	41.9999	-10.504	0.50	-0.20	338	0.5	454	8
172	21/06/2005	06:09:40	42.0000	-10.502	0.54	-1.01	298	1.1	455	11
172	21/06/2005	07:09:40	42.0020	-10.500	-0.03	0.02	144	0.0	455	20
172	21/06/2005	08:09:40	42.0026	-10.499	0.41	-0.09	348	0.4	456	11
172	21/06/2005	09:09:40	42.0028	-10.498	0.22	0.14	31	0.3	457	13
172	21/06/2005	10:09:40	42.0040	-10.498	-0.22	-0.21	224	0.3	457	5
172	21/06/2005	11:09:40	42.0220	-10.495	2.67	0.25	5	2.7	460	13
172	21/06/2005	12:09:40	42.0302	-10.501	0.37	-0.30	321	0.5	461	18
172	21/06/2005	13:09:40	42.0345	-10.507	0.70	-0.15	348	0.7	462	16
172	21/06/2005	14:09:40	42.0409	-10.518	0.24	-0.39	301	0.5	464	21
172	21/06/2005	15:09:40	42.0471	-10.523	0.41	-0.35	319	0.5	465	19
172	21/06/2005	16:09:40	42.0437	-10.536	-5.16	0.84	171	5.2	468	164
172	21/06/2005	17:09:40	41.9978	-10.503	1.37	0.21	9	1.4	475	14
172	21/06/2005	18:09:40	42.0169	-10.496	-2.59	2.32	138	3.5	477	151
172	21/06/2005	19:09:40	42.0120	-10.499	0.24	0.00	1	0.2	479	12
172	21/06/2005	20:09:40	42.0127	-10.503	-0.05	-0.23	258	0.2	479	7
172	21/06/2005	21:09:40	42.0129	-10.504	-0.17	-0.22	232	0.3	480	5
172	21/06/2005	22:09:40	42.0227	-10.503	1.21	0.00	360	1.2	481	9
172	21/06/2005	23:09:40	42.0411	-10.504	1.42	0.07	3	1.4	483	11
173	22/06/2005	00:09:40	42.0616	-10.508	1.58	-0.43	345	1.6	485	9
173	22/06/2005	01:09:40	42.0888	-10.517	1.37	-0.40	344	1.4	488	9
173	22/06/2005	02:09:40	42.0437	-10.508	-9.27	1.46	171	9.4	498	166
173	22/06/2005	03:09:40	42.0198	-10.498	2.17	0.28	7	2.2	507	18
173	22/06/2005	04:09:40	42.0228	-10.506	0.65	-0.21	342	0.7	508	7
173	22/06/2005	05:09:40	41.9998	-10.497	0.32	0.21	33	0.4	513	8
173	22/06/2005	06:09:40	41.9963	-10.494	-0.51	0.03	176	0.5	514	3
173	22/06/2005	07:09:40	41.9961	-10.494	0.11	-0.11	314	0.2	514	353

DAY	DATE	TIME	LAT	LON	VN	VE	CMG	SMG	DIST	HEAD
173	22/06/2005	08:09:40	41.9972	-10.493	0.00	0.00	103	0.0	515	353
173	22/06/2005	09:09:40	41.9972	-10.492	-0.37	0.10	165	0.4	515	351
173	22/06/2005	10:09:40	41.9949	-10.489	-0.13	0.24	118	0.3	516	17
173	22/06/2005	11:09:40	42.0071	-10.481	1.48	0.42	16	1.5	517	11
173	22/06/2005	12:09:40	42.0089	-10.484	-0.82	-0.61	217	1.0	519	358
173	22/06/2005	13:09:40	42.0046	-10.497	-0.20	-0.59	251	0.6	520	0
173	22/06/2005	14:09:40	42.0062	-10.511	-1.02	-0.68	214	1.2	522	270
173	22/06/2005	15:09:40	41.9999	-10.522	0.07	-0.18	290	0.2	523	73
173	22/06/2005	16:09:40	42.0008	-10.503	0.91	-0.11	353	0.9	527	9
173	22/06/2005	17:09:40	42.0021	-10.504	-1.53	3.39	114	3.7	529	129
173	22/06/2005	18:09:40	41.9923	-10.500	0.82	-0.01	359	0.8	532	354
173	22/06/2005	19:10:50	41.9891	-10.496	0.13	0.32	68	0.3	533	358
173	22/06/2005	20:10:50	41.9974	-10.493	1.87	0.42	13	1.9	534	355
173	22/06/2005	21:10:50	42.0288	-10.493	1.81	-0.10	357	1.8	537	351
173	22/06/2005	22:10:50	42.0558	-10.494	1.34	-0.31	347	1.4	540	350
173	22/06/2005	23:10:50	42.0783	-10.506	1.18	-0.64	332	1.3	543	351
174	23/06/2005	00:10:50	42.0988	-10.524	1.75	-0.73	337	1.9	546	352
174	23/06/2005	01:10:50	42.0001	-10.500	2.19	-0.05	359	2.2	559	10
174	23/06/2005	02:10:50	42.0142	-10.506	0.19	-0.93	282	1.0	561	358
174	23/06/2005	03:10:50	42.0141	-10.511	-4.12	1.68	158	4.5	563	150
174	23/06/2005	04:10:50	41.9961	-10.505	0.18	-0.05	345	0.2	565	8
174	23/06/2005	05:10:50	42.0002	-10.511	0.07	-0.35	281	0.4	566	354
174	23/06/2005	06:10:50	41.9966	-10.497	-0.27	-0.08	197	0.3	569	90
174	23/06/2005	07:10:50	41.9917	-10.494	1.74	-0.71	338	1.9	570	331
174	23/06/2005	08:10:50	41.9999	-10.499	0.59	0.30	27	0.7	571	354
174	23/06/2005	09:10:50	42.0005	-10.494	0.10	0.16	57	0.2	572	354
174	23/06/2005	10:10:50	42.0066	-10.491	2.11	0.11	3	2.1	573	352
174	23/06/2005	11:10:50	42.0208	-10.489	-0.26	-0.13	207	0.3	574	339
174	23/06/2005	12:10:50	42.0111	-10.490	-1.01	-0.37	200	1.1	576	288
174	23/06/2005	13:10:50	42.0000	-10.500	-0.80	-0.16	191	0.8	577	274
174	23/06/2005	14:10:50	41.9894	-10.506	-0.67	0.02	179	0.7	579	253
174	23/06/2005	15:10:50	41.9780	-10.508	-0.80	0.14	170	0.8	580	232
174	23/06/2005	16:10:50	41.9687	-10.515	-1.34	-0.77	210	1.5	582	223
174	23/06/2005	17:10:50	42.0001	-10.499	2.64	0.77	16	2.7	586	11
174	23/06/2005	18:10:50	41.9999	-10.499	-0.49	0.14	164	0.5	587	64
174	23/06/2005	19:10:50	41.9971	-10.496	-0.26	0.16	148	0.3	588	319
174	23/06/2005	20:10:50	41.9952	-10.498	-0.54	0.30	151	0.6	588	317
174	23/06/2005	21:10:50	41.9972	-10.498	0.47	0.28	31	0.5	589	333
174	23/06/2005	22:10:50	41.9973	-10.496	-0.13	-0.13	224	0.2	590	333
174	23/06/2005	23:10:50	41.9941	-10.315	-0.66	10.08	94	10.1	605	86
175	24/06/2005	00:10:50	41.9995	-10.095	-0.11	9.90	91	9.9	623	89
175	24/06/2005	01:10:50	41.9992	-9.8673	0.42	10.46	88	10.5	642	86
175	24/06/2005	02:10:50	41.9934	-9.6657	1.48	10.04	82	10.2	661	85
175	24/06/2005	03:10:50	41.9452	-9.4688	-7.50	7.26	136	10.4	680	134
175	24/06/2005	04:10:50	41.8226	-9.3264	-9.98	-0.01	180	10.0	698	180
175	24/06/2005	05:10:50	41.7130	-9.3274	9.04	0.80	5	9.1	717	3
175	24/06/2005	06:10:50	41.7311	-9.3280	0.56	-0.62	312	0.8	723	330
175	24/06/2005	07:10:50	41.7214	-9.3239	-0.80	0.00	180	0.8	725	307
175	24/06/2005	08:10:50	41.7182	-9.3282	0.29	-0.19	327	0.3	726	339
175	24/06/2005	09:10:50	41.7214	-9.3296	0.00	-0.05	266	0.1	726	349
175	24/06/2005	10:10:50	41.7223	-9.3326	0.36	0.08	12	0.4	727	346
175	24/06/2005	11:10:50	41.7437	-9.3455	2.32	-1.32	330	2.7	730	339
175	24/06/2005	12:10:50	41.7340	-9.3293	2.19	-5.58	291	6.0	735	292
175	24/06/2005	13:10:50	41.7427	-9.3334	0.30	-0.14	335	0.3	737	357
175	24/06/2005	14:10:50	41.7504	-9.3224	0.05	0.04	38	0.1	738	56
175	24/06/2005	15:10:50	41.7358	-9.3254	-0.42	0.31	144	0.5	741	2
175	24/06/2005	16:10:50	41.7342	-9.3246	0.36	-0.19	333	0.4	742	289
175	24/06/2005	17:10:50	41.7313	-9.3179	-0.77	2.51	107	2.6	744	99
175	24/06/2005	18:10:50	41.7310	-9.3260	-0.32	0.22	146	0.4	746	317
175	24/06/2005	19:10:50	41.7292	-9.3260	2.63	-1.21	335	2.9	747	340
175	24/06/2005	20:10:50	41.7318	-9.3288	0.00	-0.18	270	0.2	748	344
175	24/06/2005	21:10:50	41.7300	-9.3323	-0.09	0.06	147	0.1	749	7
175	24/06/2005	22:10:50	41.7461	-9.3367	2.03	-0.45	347	2.1	751	3
175	24/06/2005	23:10:50	41.7798	-9.3447	2.05	-0.14	356	2.1	754	2
176	25/06/2005	00:10:50	41.7380	-9.3778	-0.69	6.36	96	6.4	762	102
176	25/06/2005	01:10:50	41.7427	-9.3291	2.53	-1.31	333	2.8	768	331
176	25/06/2005	02:10:50	41.7331	-9.3252	0.14	0.32	67	0.3	774	318

DAY	DATE	TIME	LAT	LON	VN	VE	CMG	SMG	DIST	HEAD
176	25/06/2005	03:10:50	41.7374	-9.3178	0.34	0.36	46	0.5	775	227
176	25/06/2005	04:10:50	41.7425	-9.3093	0.46	0.62	53	0.8	776	212
176	25/06/2005	05:10:50	41.7389	-9.3155	-0.64	-0.68	227	0.9	778	243
176	25/06/2005	06:10:50	41.7301	-9.3302	-0.43	0.62	125	0.8	781	266
176	25/06/2005	07:10:50	41.7270	-9.3325	-0.41	0.51	129	0.7	782	246
176	25/06/2005	08:10:50	41.7205	-9.3230	-0.36	0.86	113	0.9	783	253
176	25/06/2005	09:10:50	41.7352	-9.3304	-0.45	-0.38	220	0.6	786	304
176	25/06/2005	10:10:50	41.7247	-9.3310	-0.71	-0.02	182	0.7	787	353
176	25/06/2005	11:10:50	41.7245	-9.3349	1.83	-1.50	321	2.4	788	329
176	25/06/2005	12:10:50	41.7403	-9.3533	-0.42	-0.39	223	0.6	792	324
176	25/06/2005	13:10:50	41.7377	-9.3332	0.08	-0.26	287	0.3	795	9
176	25/06/2005	14:10:50	41.7430	-9.3369	0.37	-0.06	350	0.4	795	24
176	25/06/2005	15:10:50	41.7308	-9.3269	-0.46	-0.10	193	0.5	797	216
176	25/06/2005	16:10:50	41.7276	-9.3267	-0.34	-0.30	221	0.5	798	241
176	25/06/2005	17:10:50	41.7339	-9.3245	-0.18	0.49	110	0.5	799	76
176	25/06/2005	18:10:50	41.7277	-9.3206	-0.67	0.32	154	0.7	801	236
176	25/06/2005	19:10:50	41.7145	-9.3131	-0.67	0.41	149	0.8	803	229
176	25/06/2005	20:10:50	41.7018	-9.3107	-0.49	0.15	163	0.5	804	268
176	25/06/2005	21:10:50	41.6940	-9.3057	-0.31	0.27	139	0.4	806	208
176	25/06/2005	22:10:50	41.7044	-9.3171	1.73	-1.01	330	2.0	808	337
176	25/06/2005	23:10:50	41.7346	-9.3394	1.43	-1.11	322	1.8	812	337
177	26/06/2005	00:10:50	41.8410	-9.3532	9.99	-0.15	359	10.0	824	0
177	26/06/2005	01:10:50	41.9479	-9.1975	6.05	6.81	48	9.1	841	49
177	26/06/2005	02:10:50	42.0564	-9.0587	3.53	3.56	45	5.0	858	38
177	26/06/2005	03:10:50	42.1467	-8.9828	0.75	8.30	85	8.3	871	85
177	26/06/2005	04:10:50	42.2159	-8.8190	6.91	5.66	39	8.9	888	39
177	26/06/2005	05:10:50	42.1774	-8.8709	-7.17	-6.36	222	9.6	900	220
177	26/06/2005	06:10:50	42.0630	-9.0269	-8.37	-5.43	213	10.0	919	214
177	26/06/2005	07:10:50	41.9230	-9.1530	-8.51	-5.62	213	10.2	937	213
177	26/06/2005	08:10:50	41.7799	-9.2842	-8.59	-5.82	214	10.4	957	215
177	26/06/2005	09:10:50	41.7138	-9.3427	-0.66	-0.40	211	0.8	966	264
177	26/06/2005	10:10:50	41.7073	-9.3447	-0.33	0.14	157	0.4	966	281
177	26/06/2005	11:10:50	41.7228	-9.3346	1.74	0.98	29	2.0	969	38
177	26/06/2005	12:10:50	41.7312	-9.3305	0.00	-0.19	271	0.2	971	48
177	26/06/2005	13:10:50	41.7320	-9.3287	0.12	0.51	76	0.5	971	40
177	26/06/2005	14:10:50	41.7407	-9.3227	0.54	0.67	51	0.9	973	21
177	26/06/2005	15:10:50	41.7322	-9.3236	-0.60	0.40	146	0.7	976	181
177	26/06/2005	16:10:50	41.7311	-9.3132	-0.50	-0.42	220	0.7	977	242
177	26/06/2005	17:10:50	41.7297	-9.3180	0.15	0.49	73	0.5	978	309
177	26/06/2005	18:10:50	41.7240	-9.3041	-0.36	0.33	137	0.5	980	216
177	26/06/2005	19:10:50	41.7202	-9.2982	0.69	-1.69	292	1.8	981	321
177	26/06/2005	20:10:50	41.7852	-9.1091	3.90	9.11	67	9.9	998	65
177	26/06/2005	21:10:50	41.8507	-8.9732	5.75	-0.22	358	5.8	1014	359
177	26/06/2005	22:10:50	41.8636	-8.9928	-2.92	-0.10	182	2.9	1022	180
177	26/06/2005	23:10:50	41.8276	-9.0019	1.99	-0.13	356	2.0	1027	359
178	27/06/2005	00:10:50	41.8651	-9.0046	2.44	0.11	3	2.4	1031	1
178	27/06/2005	01:10:50	41.8512	-8.9686	-2.44	0.60	166	2.5	1038	167
178	27/06/2005	02:10:50	41.8615	-8.9675	-0.56	-0.77	234	1.0	1041	217
178	27/06/2005	03:10:50	41.8554	-8.9676	0.49	0.53	47	0.7	1043	131
178	27/06/2005	04:10:50	41.8564	-8.9712	0.10	0.08	38	0.1	1044	176
178	27/06/2005	05:10:50	41.8622	-8.9678	0.15	0.06	21	0.2	1045	181
178	27/06/2005	06:10:50	41.8600	-8.9627	0.19	0.32	59	0.4	1046	187
178	27/06/2005	07:10:50	41.8628	-8.9597	-0.31	-0.10	198	0.3	1047	187
178	27/06/2005	08:10:50	41.8552	-8.9720	-1.49	-0.29	191	1.5	1050	187
178	27/06/2005	09:10:50	41.8550	-8.9632	0.06	0.37	81	0.4	1051	171
178	27/06/2005	10:10:50	41.8632	-8.9633	0.72	0.20	15	0.8	1053	166
178	27/06/2005	11:10:50	41.8448	-8.9693	0.06	-0.25	284	0.3	1056	187
178	27/06/2005	12:10:50	41.9458	-8.9780	10.71	0.09	0	10.7	1068	359
178	27/06/2005	13:10:50	42.1221	-8.9737	10.02	-1.43	352	10.1	1088	349
178	27/06/2005	14:10:50	42.2933	-9.0113	10.00	-1.91	349	10.2	1107	345
178	27/06/2005	15:10:50	42.4416	-9.1191	8.39	-5.52	327	10.0	1126	326
178	27/06/2005	16:10:50	42.5993	-9.1713	10.88	0.62	3	10.9	1145	5
178	27/06/2005	17:10:50	42.7537	-9.2609	10.87	-0.88	355	10.9	1165	351
178	27/06/2005	18:10:50	42.7583	-9.2627	-7.03	0.43	176	7.0	1180	183
178	27/06/2005	19:10:50	42.6434	-9.2308	-6.96	1.77	166	7.2	1193	168
178	27/06/2005	20:10:50	42.5322	-9.1960	-6.56	1.90	164	6.8	1206	166
178	27/06/2005	21:10:50	42.4308	-9.1367	-6.27	2.44	159	6.7	1218	159

DAY	DATE	TIME	LAT	LON	VN	VE	CMG	SMG	DIST	HEAD
178	27/06/2005	22:10:50	42.3279	-9.0774	-5.72	2.87	153	6.4	1230	156
178	27/06/2005	23:10:50	42.2290	-9.0201	-6.09	2.30	159	6.5	1242	159
179	28/06/2005	00:10:50	42.2176	-9.0195	4.63	-2.13	335	5.1	1251	333
179	28/06/2005	01:10:50	42.2103	-9.0127	-1.14	1.00	139	1.5	1259	162
179	28/06/2005	02:10:50	42.2092	-9.0079	-0.36	0.38	133	0.5	1263	177
179	28/06/2005	03:10:50	42.2058	-9.0099	0.44	0.20	25	0.5	1264	178
179	28/06/2005	04:10:50	42.2087	-9.0072	0.26	0.05	11	0.3	1265	193
179	28/06/2005	05:10:50	42.2104	-9.0057	-0.10	0.40	104	0.4	1266	191
179	28/06/2005	06:10:50	42.2057	-9.0096	-1.68	0.28	170	1.7	1267	188
179	28/06/2005	07:10:50	42.2097	-9.0047	-1.62	-1.26	218	2.1	1271	211
179	28/06/2005	08:10:50	42.2062	-9.0067	-0.42	-0.47	228	0.6	1272	205
179	28/06/2005	09:10:50	42.2062	-9.0100	-0.53	0.28	152	0.6	1273	197
179	28/06/2005	10:10:50	42.2044	-9.0073	-0.70	0.25	161	0.7	1274	196
179	28/06/2005	11:10:50	42.1793	-9.0004	-1.34	0.46	161	1.4	1277	183
179	28/06/2005	12:10:50	42.2071	-9.0064	7.16	0.77	6	7.2	1283	4
179	28/06/2005	13:10:50	42.2003	-9.0142	-0.63	-0.29	204	0.7	1285	202
179	28/06/2005	14:10:50	42.2069	-9.0124	-0.04	-0.29	261	0.3	1287	208
179	28/06/2005	15:10:50	42.2072	-9.0119	0.22	0.24	48	0.3	1288	180
179	28/06/2005	16:10:50	42.2085	-9.0088	-1.51	-1.28	220	2.0	1289	202
179	28/06/2005	17:10:50	42.2150	-9.0126	1.15	0.21	10	1.2	1290	209
179	28/06/2005	18:10:50	42.2118	-9.0110	0.48	-0.02	357	0.5	1292	198
179	28/06/2005	19:10:50	42.2134	-9.0110	0.99	0.48	26	1.1	1293	238
179	28/06/2005	20:10:50	42.2287	-9.0180	0.96	0.82	40	1.3	1295	304
179	28/06/2005	21:10:50	42.2086	-9.0122	0.36	-0.32	319	0.5	1299	249
179	28/06/2005	22:10:50	42.2152	-9.0166	0.27	-0.61	294	0.7	1300	246
179	28/06/2005	23:10:50	42.2112	-9.0404	-0.16	-0.93	260	0.9	1302	240
180	29/06/2005	00:10:50	42.2088	-9.0104	0.15	0.24	58	0.3	1305	231
180	29/06/2005	01:10:50	42.2037	-9.0134	-1.92	-1.28	214	2.3	1307	211
180	29/06/2005	02:10:50	42.2076	-9.0120	0.09	0.11	51	0.1	1311	225
180	29/06/2005	03:10:50	42.2076	-9.0124	0.00	-0.24	271	0.2	1311	217
180	29/06/2005	04:10:50	42.2080	-9.0122	0.02	0.03	51	0.0	1312	217
180	29/06/2005	05:10:50	42.2095	-9.0149	0.50	-0.49	316	0.7	1312	274
180	29/06/2005	06:10:50	42.2129	-9.0046	-0.43	0.08	169	0.4	1314	214
180	29/06/2005	07:10:50	42.2118	-9.0018	0.11	0.53	79	0.5	1315	223
180	29/06/2005	08:10:50	42.2083	-9.0106	0.19	0.11	29	0.2	1317	258
180	29/06/2005	09:10:50	42.2142	-9.0067	0.50	1.30	69	1.4	1318	67
180	29/06/2005	10:10:50	42.2163	-9.0054	0.22	-0.62	290	0.7	1319	269
180	29/06/2005	11:10:50	42.2055	-9.0078	-0.93	0.64	145	1.1	1322	168
180	29/06/2005	12:10:50	42.2070	-9.0115	0.39	0.11	16	0.4	1323	246
180	29/06/2005	13:10:50	42.2131	-9.0149	1.28	-0.40	342	1.3	1324	328
180	29/06/2005	14:10:50	42.2203	-9.0102	-0.45	0.35	142	0.6	1325	159
180	29/06/2005	15:10:50	42.2084	-9.0092	-0.32	0.22	145	0.4	1327	181
180	29/06/2005	16:10:50	42.2080	-9.0097	0.00	0.05	85	0.1	1328	231
180	29/06/2005	17:10:50	42.2080	-9.0091	0.37	-0.13	340	0.4	1329	235
180	29/06/2005	18:10:50	42.2097	-9.0076	0.11	-0.11	314	0.2	1329	224
180	29/06/2005	19:10:50	42.2095	-9.0052	0.05	0.05	45	0.1	1330	229
180	29/06/2005	20:10:50	42.2071	-9.0051	0.00	0.03	100	0.0	1330	234
180	29/06/2005	21:10:50	42.2041	-9.0154	0.07	-0.56	277	0.6	1331	235
180	29/06/2005	22:10:50	42.2036	-9.0273	-0.10	-0.42	257	0.4	1332	239
180	29/06/2005	23:12:30	42.2028	-9.0390	-0.98	-1.01	226	1.4	1333	236
181	30/06/2005	00:12:30	42.2101	-9.0232	0.51	0.83	59	1.0	1335	319
181	30/06/2005	01:12:30	42.2058	-9.0289	-0.86	-0.37	203	0.9	1337	198
181	30/06/2005	02:12:30	42.1918	-9.0411	1.17	-0.19	351	1.2	1339	267
181	30/06/2005	03:12:30	42.1947	-9.0277	-2.91	3.10	133	4.2	1342	139
181	30/06/2005	04:12:30	42.1520	-8.9711	-1.37	1.16	140	1.8	1349	153
181	30/06/2005	05:12:30	42.1834	-8.8544	5.95	5.58	43	8.2	1360	37
181	30/06/2005	06:12:30	42.2407	-8.7306	0.18	-0.03	351	0.2	1373	55
181	30/06/2005	07:12:50	42.2407	-8.7306	0.00	0.00	180	0.0	1373	55
181	30/06/2005	08:12:50	42.2407	-8.7306	0.00	0.00	180	0.0	1373	55
181	30/06/2005	09:13:00	42.2407	-8.7306	0.00	0.03	90	0.0	1373	55
181	30/06/2005	10:13:00	42.2333	-8.7831	-2.73	-7.82	251	8.3	1377	251
181	30/06/2005	11:13:00	42.1561	-8.9277	-2.58	-7.77	252	8.2	1393	250
181	30/06/2005	12:13:00	42.2080	-9.0116	0.54	-0.03	357	0.5	1404	324
181	30/06/2005	13:13:00	42.2090	-9.0118	-2.11	0.97	155	2.3	1407	152
181	30/06/2005	14:13:00	42.2120	-9.0101	0.69	-0.26	339	0.7	1409	320
181	30/06/2005	15:13:00	42.2133	-9.0097	-0.88	0.01	179	0.9	1409	222
181	30/06/2005	16:13:00	42.2069	-9.0097	0.00	0.24	90	0.2	1412	319

DAY	DATE	TIME	LAT	LON	VN	VE	CMG	SMG	DIST	HEAD
181	30/06/2005	17:13:00	42.2082	-9.0080	-0.12	-0.02	188	0.1	1412	302
181	30/06/2005	18:13:00	42.2072	-9.0078	-0.15	0.19	128	0.2	1413	327
181	30/06/2005	19:13:00	42.2053	-9.0070	-0.33	-0.02	184	0.3	1413	313
181	30/06/2005	20:13:00	42.2060	-9.0086	0.00	0.27	90	0.3	1414	334
181	30/06/2005	21:13:00	42.2071	-9.0118	0.33	-0.49	304	0.6	1415	331
181	30/06/2005	22:13:00	42.1724	-8.9991	-9.60	1.69	170	9.7	1420	167
181	30/06/2005	23:13:00	42.0225	-8.9587	7.31	-1.02	352	7.4	1438	348
182	01/07/2005	00:13:00	42.1396	-8.9916	5.96	-1.24	348	6.1	1451	351
182	01/07/2005	01:13:00	42.2136	-9.0107	2.71	-0.32	353	2.7	1459	356
182	01/07/2005	02:13:00	42.2087	-9.0104	0.72	0.21	16	0.8	1462	358
182	01/07/2005	03:13:40	42.2116	-9.0112	-0.09	-0.16	240	0.2	1463	357
182	01/07/2005	04:13:40	42.2104	-9.0119	0.20	0.19	44	0.3	1464	23
182	01/07/2005	05:13:40	42.2105	-9.0129	-0.32	-0.15	205	0.4	1464	13
182	01/07/2005	06:13:40	42.1972	-9.0044	-3.90	0.73	169	4.0	1466	152
182	01/07/2005	07:13:40	42.2053	-9.0070	0.09	0.03	19	0.1	1468	323
182	01/07/2005	08:13:40	42.2069	-9.0067	0.46	-0.27	329	0.5	1468	325
182	01/07/2005	09:13:40	42.2135	-9.0098	-0.11	0.23	115	0.3	1470	321
182	01/07/2005	10:13:40	42.2143	-9.0053	0.03	0.19	82	0.2	1470	325
182	01/07/2005	11:13:40	42.2065	-9.0089	-3.08	-1.04	199	3.3	1472	208
182	01/07/2005	12:13:40	42.2078	-9.0091	0.83	-0.47	330	0.9	1475	327
182	01/07/2005	13:13:40	42.2073	-9.0114	-0.02	-0.43	267	0.4	1477	317
182	01/07/2005	14:13:40	42.2059	-9.0116	0.24	-0.50	295	0.6	1479	330
182	01/07/2005	15:13:40	42.2069	-9.0092	0.23	0.16	34	0.3	1480	330
182	01/07/2005	16:13:40	42.2058	-9.0109	0.10	-0.34	286	0.4	1481	327
182	01/07/2005	17:13:40	42.2059	-9.0110	-0.65	-0.34	208	0.7	1481	327
182	01/07/2005	18:13:40	42.2060	-9.0165	0.14	-0.53	284	0.5	1482	334
182	01/07/2005	19:13:40	42.2015	-9.0099	0.74	0.21	16	0.8	1486	355
182	01/07/2005	20:13:40	42.2141	-9.0164	0.96	-0.68	325	1.2	1488	337
182	01/07/2005	21:13:40	42.1997	-9.0053	0.64	-0.58	318	0.9	1492	345
182	01/07/2005	22:13:40	42.2079	-9.0103	1.17	0.36	17	1.2	1493	31
182	01/07/2005	23:13:40	42.0805	-8.9891	-9.19	1.87	168	9.4	1507	163
183	02/07/2005	00:13:40	42.0778	-8.9859	8.08	-0.66	355	8.1	1522	359
183	02/07/2005	01:13:40	42.2045	-9.0103	2.14	-0.32	352	2.2	1536	5
183	02/07/2005	02:13:40	42.2065	-9.0100	1.56	-0.06	358	1.6	1541	1
183	02/07/2005	03:13:40	42.2068	-9.0151	0.39	0.01	2	0.4	1542	354
183	02/07/2005	04:13:40	42.2066	-9.0122	0.13	-0.03	348	0.1	1543	20
183	02/07/2005	05:13:40	42.2066	-9.0154	0.21	-0.05	347	0.2	1543	352
183	02/07/2005	06:13:40	42.2082	-9.0123	-1.19	-0.23	191	1.2	1544	347
183	02/07/2005	07:13:40	42.2058	-9.0131	-0.07	0.31	103	0.3	1545	11
183	02/07/2005	08:13:40	42.2068	-9.0140	0.29	-0.02	355	0.3	1546	357
183	02/07/2005	09:13:40	42.2101	-9.0113	-0.10	0.09	137	0.1	1547	356
183	02/07/2005	10:13:40	42.2082	-9.0074	-0.39	0.19	153	0.4	1547	320
183	02/07/2005	11:13:40	42.2090	-9.0040	-0.53	0.77	125	0.9	1548	322
183	02/07/2005	12:13:40	42.2005	-9.0035	-0.92	-1.89	244	2.1	1550	281
183	02/07/2005	13:13:40	42.2047	-9.0087	-0.53	0.27	153	0.6	1552	327
183	02/07/2005	14:13:40	42.2022	-9.0075	3.00	-1.25	337	3.2	1554	336
183	02/07/2005	15:13:40	42.2478	-9.0354	2.64	-1.11	337	2.9	1560	336
183	02/07/2005	16:13:40	42.2562	-9.0391	-5.93	2.64	156	6.5	1567	150
183	02/07/2005	17:13:40	42.2049	-9.0120	0.14	-0.24	300	0.3	1574	346
183	02/07/2005	18:13:40	42.2043	-9.0172	-0.38	-0.08	192	0.4	1575	350
183	02/07/2005	19:13:40	42.1988	-9.0269	-5.08	-3.16	212	6.0	1576	215
183	02/07/2005	20:13:40	42.0828	-9.1385	-7.32	-4.99	214	8.9	1592	217
183	02/07/2005	21:13:40	41.9591	-9.1444	-8.12	5.36	147	9.7	1609	142
183	02/07/2005	22:13:40	41.8288	-9.0173	-10.55	-0.13	181	10.5	1627	178
183	02/07/2005	23:13:40	41.7779	-9.0198	0.15	-0.59	284	0.6	1638	337
184	03/07/2005	00:13:40	41.7791	-9.0222	-0.26	0.35	126	0.4	1639	354
184	03/07/2005	01:13:40	41.7799	-9.0182	1.81	-1.52	320	2.4	1641	331
184	03/07/2005	02:13:40	41.7793	-9.0166	-0.09	0.11	129	0.1	1645	330
184	03/07/2005	03:13:40	41.7802	-9.0182	0.15	-0.13	319	0.2	1646	332
184	03/07/2005	04:13:40	41.7691	-9.0140	-0.13	-0.71	260	0.7	1649	333
184	03/07/2005	05:13:40	41.7742	-9.0147	0.51	0.09	10	0.5	1650	346
184	03/07/2005	06:13:40	41.7778	-9.0148	0.47	0.23	26	0.5	1651	348
184	03/07/2005	07:13:40	41.7795	-9.0162	0.21	-0.16	322	0.3	1651	347
184	03/07/2005	08:13:40	41.7811	-9.0171	0.11	0.25	66	0.3	1652	351
184	03/07/2005	09:13:40	41.7814	-9.0148	0.26	-0.08	342	0.3	1652	344
184	03/07/2005	10:13:40	41.7820	-9.0170	0.04	-0.19	283	0.2	1652	344
184	03/07/2005	11:13:40	41.7890	-9.0255	-2.96	2.04	145	3.6	1654	129

DAY	DATE	TIME	LAT	LON	VN	VE	CMG	SMG	DIST	HEAD
184	03/07/2005	12:13:40	41.7806	-9.0180	0.56	-0.47	320	0.7	1657	336
184	03/07/2005	13:13:40	41.7790	-9.0188	0.28	-0.17	328	0.3	1658	341
184	03/07/2005	14:13:40	41.7797	-9.0162	-0.16	0.10	148	0.2	1658	345
184	03/07/2005	15:13:40	41.7789	-9.0173	-0.19	-0.03	190	0.2	1659	344
184	03/07/2005	16:13:40	41.7731	-9.0190	-0.45	0.78	120	0.9	1660	0
184	03/07/2005	17:13:40	41.7786	-9.0170	-0.67	0.07	174	0.7	1662	349
184	03/07/2005	18:13:40	41.7782	-9.0148	-0.91	0.17	170	0.9	1663	358
184	03/07/2005	19:13:40	41.7778	-9.0343	-2.44	-6.10	248	6.6	1665	263
184	03/07/2005	20:16:30	41.7611	-9.0898	-0.04	-0.83	267	0.8	1670	340
184	03/07/2005	21:16:30	41.7571	-9.1010	0.07	-0.50	278	0.5	1671	342
184	03/07/2005	22:16:30	41.7593	-9.1098	1.02	-0.55	332	1.2	1673	345
184	03/07/2005	23:16:30	41.7677	-9.1241	0.54	-0.74	306	0.9	1674	343
185	04/07/2005	00:16:30	41.7775	-9.1417	0.01	-1.01	271	1.0	1676	341
185	04/07/2005	01:16:30	41.7890	-9.1637	1.12	-0.86	322	1.4	1679	342
185	04/07/2005	02:16:30	41.8028	-9.1823	0.69	1.43	64	1.6	1682	33
185	04/07/2005	03:16:30	41.8130	-9.1533	0.74	1.05	55	1.3	1684	26
185	04/07/2005	04:16:30	41.8291	-9.1261	1.53	1.29	40	2.0	1687	26
185	04/07/2005	05:16:30	41.8502	-9.1065	1.13	0.18	9	1.1	1690	4
185	04/07/2005	06:16:30	41.7612	-9.0241	3.12	1.60	27	3.5	1705	19
185	04/07/2005	07:16:30	41.7853	-9.0215	1.62	-2.97	299	3.4	1707	307
185	04/07/2005	08:16:30	41.7713	-9.1150	-8.93	0.04	180	8.9	1720	179
185	04/07/2005	09:16:30	41.7839	-9.1106	-0.17	-0.20	229	0.3	1723	354
185	04/07/2005	10:16:30	41.7834	-9.1071	-0.53	0.51	136	0.7	1724	1
185	04/07/2005	11:16:30	41.7923	-9.1124	2.16	-0.65	343	2.3	1725	342
185	04/07/2005	12:16:30	41.7756	-9.1093	0.44	0.42	44	0.6	1730	349
185	04/07/2005	13:16:30	41.7820	-9.1098	0.10	0.01	7	0.1	1731	337
185	04/07/2005	14:16:30	41.7832	-9.1106	0.20	-0.46	293	0.5	1732	334
185	04/07/2005	15:16:30	41.7822	-9.1106	0.43	-0.16	340	0.5	1733	338
185	04/07/2005	16:16:30	41.7811	-9.1092	0.21	0.01	4	0.2	1734	343
185	04/07/2005	17:16:30	41.7820	-9.1116	0.14	-0.31	294	0.3	1734	339
185	04/07/2005	18:16:30	41.7808	-9.1141	0.19	0.04	11	0.2	1735	352
185	04/07/2005	19:16:30	41.7847	-9.1150	0.56	0.04	4	0.6	1736	352
185	04/07/2005	20:16:30	41.7891	-9.1159	0.12	0.01	3	0.1	1737	351
185	04/07/2005	21:16:30	41.8055	-9.1237	1.40	-0.53	339	1.5	1739	353
185	04/07/2005	22:16:30	41.8230	-9.2562	1.68	-6.61	284	6.8	1750	292
185	04/07/2005	23:16:30	41.8281	-9.3608	-7.89	-0.80	186	7.9	1763	181
186	05/07/2005	00:16:30	41.7892	-9.2358	-0.44	8.55	93	8.6	1778	89
186	05/07/2005	01:16:30	41.7828	-9.1106	2.07	0.30	8	2.1	1789	19
186	05/07/2005	02:16:30	41.7766	-9.1121	4.13	0.88	12	4.2	1794	16
186	05/07/2005	03:16:30	41.7837	-9.1130	-0.11	0.41	106	0.4	1795	13
186	05/07/2005	04:16:30	41.7807	-9.1106	-0.08	0.14	121	0.2	1795	357
186	05/07/2005	05:16:30	41.7819	-9.1126	-0.65	0.20	163	0.7	1797	215
186	05/07/2005	06:16:30	41.7738	-9.0996	-0.37	0.54	124	0.7	1798	30
186	05/07/2005	07:16:30	41.7832	-9.1090	-0.28	0.08	164	0.3	1802	321
186	05/07/2005	08:16:30	41.7842	-9.1090	-0.04	0.05	130	0.1	1802	332
186	05/07/2005	09:16:30	41.7824	-9.1129	-0.19	-0.42	246	0.5	1803	337
186	05/07/2005	10:16:30	41.7825	-9.1130	0.01	-0.06	276	0.1	1803	338
186	05/07/2005	11:16:30	41.7929	-9.1141	1.50	-0.02	359	1.5	1805	9
186	05/07/2005	12:16:30	41.7828	-9.1096	0.22	-0.12	332	0.2	1809	345
186	05/07/2005	13:16:30	41.7832	-9.1093	-0.27	-0.05	190	0.3	1811	340
186	05/07/2005	14:16:30	41.7835	-9.1141	-0.73	-0.08	186	0.7	1812	345
186	05/07/2005	15:20:40	41.7797	-9.1123	-0.29	-0.10	199	0.3	1815	355
186	05/07/2005	16:20:40	41.7846	-9.1093	0.59	-0.53	318	0.8	1816	348
186	05/07/2005	17:20:40	41.7850	-9.1117	0.05	-0.14	289	0.1	1816	5
186	05/07/2005	18:20:40	41.7839	-9.1109	0.10	0.00	2	0.1	1817	2
186	05/07/2005	19:20:40	41.7846	-9.1134	-0.25	-0.53	245	0.6	1818	358
186	05/07/2005	20:20:40	41.7882	-9.1138	1.17	0.23	11	1.2	1819	355
186	05/07/2005	21:20:40	41.7928	-9.1129	0.56	-0.14	346	0.6	1820	356
186	05/07/2005	22:20:40	41.8066	-9.1127	2.81	-1.32	335	3.1	1822	342
186	05/07/2005	23:20:40	41.8365	-9.1347	1.69	-0.72	337	1.8	1826	341
187	06/07/2005	00:20:40	41.8678	-9.1572	2.19	-1.29	330	2.5	1830	339
187	06/07/2005	01:20:40	41.7806	-9.1088	-3.73	0.97	165	3.9	1842	166
187	06/07/2005	02:20:40	41.7907	-9.1130	1.73	-0.27	351	1.8	1848	344
187	06/07/2005	03:20:40	41.7825	-9.1094	0.24	-0.23	316	0.3	1853	343
187	06/07/2005	04:20:40	41.7833	-9.1095	-0.16	0.56	106	0.6	1854	355
187	06/07/2005	05:20:40	41.7847	-9.1081	0.40	0.14	19	0.4	1854	350
187	06/07/2005	06:20:40	41.7844	-9.1013	-8.65	1.90	168	8.9	1865	165

DAY	DATE	TIME	LAT	LON	VN	VE	CMG	SMG	DIST	HEAD
187	06/07/2005	07:20:40	41.7825	-9.1088	-0.13	0.14	134	0.2	1868	351
187	06/07/2005	08:20:40	41.7831	-9.1075	-0.06	-0.11	240	0.1	1869	345
187	06/07/2005	09:20:40	41.7844	-9.1104	-0.03	-0.02	211	0.0	1869	353
187	06/07/2005	10:20:40	41.7842	-9.1082	-0.22	0.23	133	0.3	1870	348
187	06/07/2005	11:20:40	41.7938	-9.1136	-5.65	-0.36	184	5.7	1872	175
187	06/07/2005	12:20:40	41.7832	-9.1114	-0.10	-0.28	251	0.3	1878	353
187	06/07/2005	13:20:40	41.7824	-9.1112	-0.19	-0.46	247	0.5	1878	341
187	06/07/2005	14:20:40	41.7849	-9.1102	0.15	-0.18	310	0.2	1879	352
187	06/07/2005	15:20:40	41.7838	-9.1109	-0.08	-0.52	261	0.5	1880	340
187	06/07/2005	16:20:40	41.7819	-9.1120	-0.50	-0.27	209	0.6	1881	346
187	06/07/2005	17:20:40	41.7843	-9.1137	0.17	-0.28	302	0.3	1881	350

Appendix 3. Surface Sampler Log

Date	Time (GMT)	Stn. No.	NSSD	MLSD	Garrett Screens	Comments
22/06/05	14:00	1	YES	NO	YES	NSSD Bottles failed to fire
23/06/05	14:20	1	YES	YES	YES	NSSD 2 Bottles Leaking
24/06/05	13:15	2	YES	YES	YES	All OK
25/06/05	13:20	2	YES	YES	YES	
26/06/05	12:50	2	YES	YES	YES	Visible Surface Slick
27/06/05	06:00	3	YES	YES	YES	
28/06/05						Weather too rough for RIB deployment
29/06/05	06:00	4	YES	YES	YES	
29/06/05	13:40	4	YES	YES	YES	
30/06/05	16:15	4	NO	NO	NO	RIB Engine failure – deployment aborted
01/07/05	12:50	4	YES	NO	YES	Too rough for MLSD
02/07/05	13 :20	4	YES	NO	YES	Too rough for MLSD
03/07/05						Weather too rough for RIB deployment
04/07/05						Weather too rough for RIB deployment
05/07/05	06:20	6	YES	YES	YES	

Appendix 4. CTD Log

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
CTD #	001										1	110		Test CTD
DAY	171										2	110		
DATE	20/06/05										3	110		
STN	0										4	65		
TIME IN	09:57										5	65		
BOTTOM											6	65		
ON DECK			1L		2x1L						7	31		
LAT	40 44.17										8	31		
LON	09 51.79										9	31		
WATER D	2500		1L		1L						10	25		
MAX DEPTH	250										11	25		
											12	25		
			1L		1L						13	16.5		
											14	16.5		
											15	16.5		
			1L		2x1L						16	2		
											17	2		
											18	2		
CTD #	002										1	200		Main CTD
DAY	172			Y		X					2	200		
DATE	21/06/05		1L		1L						3	112		
STN	1		1L	Y	1L						4	76		
TIME IN	09:37										5	76		
BOTTOM	09:57										6	76		
ON DECK	10:26		1L		1L						7	69		
LAT	42 00.20		1L		1L	X	X				8	61		
LON	10 29.91		1L		1L	X					9	50		
WATER D	2843										10	50		
MAX DEPTH	250		1L		1L						11	40		Seal Fail
											12	40		
			1L		1L	X					13	18		Seal Fail
											14	18		
											15	12		
											16	12		
			1L		1L	X					17	7		
											18	7		
											19	7		
											20	7		
											21	7		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
			1L	Y		X	X				22	Surf		
											23	Surf		
											24	Surf		
CTD #	003		3x1L		3x1L						1	15		Nitrification
DAY	172										2	15		
DATE	21/06/05										3	15		
STN	1													
TIME IN	14:08													
BOTTOM	14:11													
ON DECK	14:18													
LAT	42 02.39													
LON	10 31.08													
WATER D	2819													
MAX DEPTH	25													
CTD #	004			Y							1	200		Productivity
DAY	173										2	100		
DATE	22/06/05										3	80		
STN	1		2L	Y	2L						4	66		
TIME IN	03:55										5	66	265	
BOTTOM	04:08										6	66		Seating Fail
ON DECK	04:41										7	66		
LAT	42 01.51		2L		2L						8	50		
LON	10 30.10										9	50		
WATER D	2820										10	50		
MAX DEPTH	200										11	50		
											12	50		
			2L		2L						13	30		
			2L		2L	X	X				14	18.5	266	
											15	18.5		
			2L		2L						16	12.3		
											17	12.3		
			2L		2L						18	8		
											19	8		
			2L	Y	2L						20	2		
											21	2		
CTD #	005			Y							1	200		Main CTD
DAY	173										2	100	267	
DATE	22/06/05										3	80		
STN	1		2L								4	66		
TIME IN	09:36										5	66		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
BOTTOM	09:40										6	66		
ON DECK	10:29										7	66		
LAT	41 59.80		2L		2L						8	50		
LON	10 29.50										9	50		
WATER D	2846										10	50		
MAX DEPTH	200		2L	Y	2L						11	45		
			2L		2L						12	40		
			2L		2L						13	30		
			2L		2L						14	18		
											15	18	268	
			2L		2L						16	12		
											17	12		
			2L		2L						18	8		
											19	8		
											20	8		
											21	8		
											22	8		
			2L	Y	2L						23	Surf		
											24	Surf		
CTD #	006			Y							1	200		Productivity
DAY	174										2	200	269	
DATE	23/06/05										3	80		
STN	1		2L								4	66		
TIME IN	02:19										5	66		
BOTTOM	03:02										6	66		
ON DECK											7	66		
LAT	42 00.89		2L								8	50		
LON	10 30.05										9	50		
WATER D	2839										10	50		
MAX DEPTH	200			Y							11	40		
											12	40		
											13	36		
											14	33		
											15	30		
			2L								16	18		
											17	18		
											18	18		
			2L								19	12		
											20	12	270	
			2L								21	8		
											22	8		
			2L								23	Surf		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
				Y							24	Surf		
CTD #	007			Y							1	200		Main CTD
DAY	174		2L		2L	X					2	100		
DATE	23/06/05										3	81		
STN	1		2L		2L						4	66.7		
TIME IN	09:08										5	66.7		
BOTTOM	09:19										6	66.7		
ON DECK	09:58										7	66.7		
LAT	41 59.99		2L		2L						8	50		
LON	10 29.52										9	50		
WATER D	2844		2L	Y	2L	X					10	39		
MAX DEPTH	200										11	39		
											12	39		
											13	37		Seat Fail
						X					14	34		
			2L		2L	X					15	18		
											16	18		
			2L		2L	X					17	12		
											18	12		
			2L		2L						19	8		
											20	8		
											21	8		
											22	8		
			2L	Y	2L	X					23	Surf		
											24	Surf		
CTD #	008										1	100		N cycling
DAY	174										2	40		
DATE	23/06/05										3	18		
STN	1										4	8		
TIME IN	21:40										5	8		
BOTTOM	21:53										6	8		
ON DECK	22:14										7	1		
LAT	41 59.87													
LON	10 29.75													
WATER D	2845													
MAX DEPTH	100													
CTD #	009			Y							1	200		Main CTD
DAY	175					X		X			2	101.9		
DATE	24/06/05										3	80		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
STN	2		1L		1L	X		X			4	60		
TIME IN	09:41		1L		1L						5	35		
BOTTOM	09:52		1L	Y	1L	X		X			6	29		
ON DECK	10:36										7	29		
LAT	41 43.24		1L		1L						8	25		
LON	09 19.75										9	25		
WATER D	461										10	25		
MAX DEPTH	200		1L		1L						11	22.6		
			1L		1L	X		X			12	15.5		
											13	15		Seal Fail
											14	9.5		
			1L		1L						15	9		
			1L		1L						16	6		
						X	X	X			17	6		
			1L		1L						18	3		
											19	3		
											20	3		
											21	3		
			1L	Y	1L	X		X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	010										1	10		Nitrification
DAY	175										2	10		
DATE	24/06/05										3	10		
STN	2													
TIME IN	17:34													
BOTTOM	17:35													
ON DECK	17:41													
LAT	41 43.98													
LON	09 19.56													
WATER D	364													
MAX DEPTH	10													
CTD #	011										1	3		N Cycling
DAY	175										2	3		
DATE	24/06/05										3	3		
STN	2													
TIME IN	21:24													
BOTTOM														
ON DECK	21:34													
LAT	41 43.79													
LON	09 19.93													

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
WATER D	467													
MAX DEPTH	10													
CTD #	012			Y							1	200		Productivity
DAY	176										2	101	272	
DATE	25/06/05										3	61		
STN	2										4	41		
TIME IN	02:37			Y							5	30		
BOTTOM	02:48										6	30	271	
ON DECK	03:20										7	30		
LAT	41 44.02										8	27		
LON	09 19.46		2L								9	25		
WATER D	333										10	25		
MAX DEPTH	200		2L								11	15		
											12	15		
											13	15		
			2L								14	9		
											15	9		
			2L								16	6		
											17	6		
			2L								18	3		
											19	3		Leaking
											20	3		
											21	3		
											22	3		
			2L	Y							23	Surf		
											24	Surf		
CTD #	013			Y							1	200		Main CTD
DAY	176					X		X			2	102	274	
DATE	25/06/05		2L		2L			X			3	62		
STN	2		2L		2L						4	40		
TIME IN	09:13		2L	Y	2L	X		X			5	30		
BOTTOM	09:23										6	30		
ON DECK	09:59		2L		2L						7	27		
LAT	41 43.99										8	27		
LON	09 19.66		2L		2L	X		X			9	25		
WATER D	366										10	25		
MAX DEPTH	200		2L		2L						11	15		
											12	15		
			2L		2L						13	9	273	
						X					14	9		
			2L		2L						15	6		

	DETAILS	PP	PIGS	ETC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
											16	6		
			2L		2L						17	3		
											18	3		
											19	3		
											20	3		
											21	3		
			2L	Y	2L	X		X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	014			Y							1	200		Main CTD
DAY	177					X		X			2	101	275	
DATE	26/06/05		2L		2L			X			3	60		
STN	2		1.5L		1.5L						4	50		
TIME IN	09:41		1L		1L						5	40		
BOTTOM	09:53										6	40		
ON DECK	10:31		1L		1L	X					7	35		
LAT	41 42.67										8	35		
LON	09 20.76										9	35		
WATER D	633		1L	Y	1L	X	X	X			10	30		
MAX DEPTH	200										11	30		
											12	30		
			2L		2L						13	24		
			2L		2L	X		X			14	22		
											15	22		
			2L		2L						16	18		
											17	18		
			2L		2L	X		X			18	10		
											19	10		
											20	10	276	
											21	10		
											22	10		
			2L	Y	2L	X	X	X			23	Surf		
											24	Surf		
CTD #	015										1	15		
DAY	177										2	15		
DATE	26/06/05										3	15		
STN	2													
TIME IN	18:54													
BOTTOM	18:56													
ON DECK	18:59													
LAT	41 43.37													

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
LON	09 17.80													
WATER D	181													
MAX DEPTH	15													
CTD #	016		1L	Y	1L	X		X			1	46		
DAY	178										2	46		
DATE	27/06/05		1L	Y	1L	X		X			3	41		
STN	3										4	41		
TIME IN	09:37										5	41		
BOTTOM	09:46		1L		1L						6	35		
ON DECK	10:20										7	35		
LAT	41 51.26										8	35		
LON	08 58.29		1L		1L						9	28		
WATER D	57										10	28		
MAX DEPTH	46										11	28		
			1L		1L						12	21		
											13	21		
											14	21	277	
			1L		1L						15	14		
											16	14		
			1L		1L	X		X			17	7		
											18	7		
			1L		1L						19	4		
											20	4		
											21	4		
											22	4	278	
			1L	Y	1L	X		X			23	Surf		
											24	Surf		
CTD #	017		2L	Y	2L						1	92		
DAY	179		2L		2L						2	60	279	
DATE	28/06/05		2L	Y	2L						3	50		
STN	4										4	50		
TIME IN	09:37										5	50		
BOTTOM	09:54										6	50		
ON DECK	10:30										7	50		
LAT	42 12.31		2L		2L						8	40		
LON	09 00.42										9	40		
WATER D	107		2L		2L						10	30		
MAX DEPTH	100										11	30		
											12	30		
			2L		2L						13	17		
											14	17		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover				Bottle	Depth	Salinity Bottle	Comment
			2L		2L						15	10		
											16	10		
			2L		2L						17	4		
											18	4	280	
											19	4		
											20	4		
											21	4		
			2L	Y	2L						22	Surf		
											23	Surf		
											24	Surf		
CTD #	018										1	3		N cycling
DAY	179										2	3		
DATE	28/06/05										3	3		
STN	4													
TIME IN	21:50													
BOTTOM														
ON DECK	22:05													
LAT	42 12.90													
LON	09 00.94													
WATER D	109													
MAX DEPTH	3													
CTD #	019			Y							1	89		Main CTD
DAY	180		2L		2L						2	75	287	
DATE	29/06/05										3	75		
STN	4		2L		2L	X					4	60		
TIME IN	09:45		2L		2L	X	X				5	45		
BOTTOM	09:55										6	45		
ON DECK	10:25										7	45		
LAT	42 12.86		2L	Y	2L	X	X				8	30		
LON	09 00.33										9	30		
WATER D	108										10	30		
MAX DEPTH	100										11	30		
			2L		2L	X	X				12	26		
											13	26		
											14	26		
			2L		2L						15	16		
											16	16		
			2L		2L						17	11		
											18	11		
			2L		2L	X					19	6	288	
											20	6		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
											21	6		
			2L	Y	2L	X					22	Surf		
											23	Surf		
											24	Surf		
CTD #	020			Y							1	90		Main CTD
DAY	181		2L		2L						2	75	285	
DATE	30/06/05										3	75		
STN	4		2L		2L						4	60		
TIME IN	13:45		2L	Y	2L			X			5	45		
BOTTOM	13:57										6	45		
ON DECK	14:28										7	45		
LAT	42 12.89		2L		2L						8	41		
LON	09 00.92										9	41		
WATER D	113		2L		2L						10	35		
MAX DEPTH	100										11	35		
			2L		2L			X			12	26		
											13	26		
											14	26		
			2L		2L						15	16		
											16	16	286	
			2L		2L			X			17	11		
											18	11		
			2L		2L						19	6		
											20	6		
											21	6		
			2L	Y	2L						22	Surf		
								X			23	Surf		
											24	Surf		
CTD #	021										1	4		N Cycling
DAY	181										2	4		
DATE	30/06/05										3	4		
STN	4													
TIME IN	21:30													
BOTTOM														
ON DECK	21:42													
LAT	42 12.48													
LON	09 00.72													
WATER D	114													
MAX DEPTH	4													

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
CTD #	022			Y		X		X			1	91.6		Productivity
DAY	182										2	77	283	
DATE	01/07/05										3	62		
STN	4										4	50		
TIME IN	02:18		2L			X		X			5	45		
BOTTOM	02:55										6	45		
ON DECK	02:59										7	45		
LAT	42 12.37			Y		X		X			8	36		
LON	09 00.54										9	36		
WATER D	112										10	36		
MAX DEPTH	100							X			11	30		
			2L			X					12	23		
											13	23		
											14	15		
			2L			X		X			15	10		
											16	10		
			2L								17	7		
											18	7	284	
			2L								19	3		
											20	3		
											21	3		
			2L	Y		X		X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	023			Y				X			1	89.5		
DAY	182		2L		2L						2	75	282	
DATE	01/07/05		2L		2L						3	50		
STN	4		2L		2L			X			4	45		
TIME IN	09:13										5	45		
BOTTOM	09:21										6	45		
ON DECK	09:55		2L	Y	2L			X			7	30		
LAT	42 12.76										8	30		
LON	09 00.57										9	30		
WATER D	111		2L		2L						10	27		
MAX DEPTH	100		2L		2L			X			11	23		
											12	23		
			2L		2L			X			13	10		
											14	10		
			2L		2L						15	7	281	
											16	7		
			2L		2L						17	3.3		
											18	3.3		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
											19	3.3		
											20	3.3		
											21	3.3		
			3x2L	Y	3x2L			X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	024										1	4		N Cycling
DAY	182										2	4		
DATE	01/07/05										3	4		
STN	4													
TIME IN	21:20													
BOTTOM	21:22													
ON DECK	21:30													
LAT	42 12.06													
LON	09 00.38													
WATER D	111													
MAX DEPTH	4													
CTD #	025			Y							1	92		Productivity
DAY	183										2	75	97	
DATE	02/07/05										3	50		
STN	4		2L								4	45		
TIME IN	02:40										5	45		
BOTTOM	02:47										6	45		
ON DECK	03:20										7	37		
LAT	42 12.10										8	37		
LON	09 00.54			Y							9	28		
WATER D	113										10	28		
MAX DEPTH	100										11	28		
											12	26		
			2L								13	23		
											14	23		
			2L								15	10	98	
											16	10		
			2L								17	7		
											18	7		
			2L								19	3		
											20	3		
											21	3		
			2L	Y							22	Surf		
											23	Surf		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
											24	Surf		
CTD #	026			Y		X		X			1	89.9		Main CTD
DAY	183										2	75	100	
DATE	02/07/05		2L		2L						3	55		
STN	4		2L		2L	X		X			4	40		
TIME IN	09:29		2L		2L						5	35		
BOTTOM	09:37										6	35		
ON DECK	10:12		2L	Y	2L	X		X			7	32		
LAT	42 12.57										8	32		
LON	09 00.62										9	32		
WATER D	113		2L		2L	X		X			10	25		
MAX DEPTH	100		2L		2L						11	20		
			2L		2L						12	12		
											13	12		
						X	X	X			14	10		
			3x2L		3x2L						15	8		
											16	8	99	
			2L		2L						17	5		
											18	5		
											19	5		
											20	5		
											21	5		
			2L	Y	2L	X		X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	027										1	15		Nitrification
DAY	183										2	15		
DATE	02/07/05										3	15		
STN	4													
TIME IN	18:30													
BOTTOM														
ON DECK	18:37													
LAT	42 12.28													
LON	09 01.08													
WATER D	114													
MAX DEPTH	15													
CTD #	028										1	40		Q&D Nitrate
DAY	183										2	40		
DATE	02/07/05										3	28		
STN	5										4	28		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
TIME IN	22:59										5	10		
BOTTOM	23:09										6	10		
ON DECK	23:19										7	Surf		
LAT	41 46.70										8	Surf		
LON	09 01.06													
WATER D	89													
MAX DEPTH	40													
CTD #	029		2L	Y	2L	X		X			1	75		Main CTD
DAY	184		2L		2L						2	55	101	
DATE	03/07/05					X		X			3	44		Seat Fail
STN	5		3x2L		3x2L						4	44		
TIME IN	09:30										5	44		
BOTTOM			2L		2L						6	38		
ON DECK			2L	Y	2L	X		X			7	33		
LAT	41 46.88										8	33		
LON	09 00.88										9	33		
WATER D	87		2L		2L	X		X			10	23		
MAX DEPTH	75										11	23		
											12	23		
			2L		2L						13	14		Seat Fail
											14	14		
			2L		2L	X	X	X			15	9		
											16	9		
			2L		2L						17	6		
											18	6	102	
											19	6		
											20	6		
											21	6		
			2L	Y	2L	X		X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	030		2L	Y	2L	X		X			1	90		Main CTD
DAY	185		2L		2L						2	75		
DATE	04/07/05		2L		2L						3	55	104	
STN	6		2L		2L	X		X			4	44		
TIME IN	09:14										5	44		
BOTTOM	09:21										6	44		
ON DECK	09 :58		1L	Y	1L	X		X			7	30		
LAT	41 47.00										8	30		
LON	09 06.66										9	30		
WATER D	107										10	26		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
MAX DEPTH	90		3x1L		3x1L	X		X			11	23		
											12	23		
			1L		1L						13	14	103	
											14	14		
			1L		1L	X		X			15	9.5		
											16	9.5		
			1L		1L						17	6.5		
											18	6.5		
											19	6.5		
											20	6.5		
											21	6.5		
			1L	Y	1L	X		X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	031		2L		2L			X			1	90		
DAY	185		2L		2L						2	75		
DATE	04/07/05		2L		2L						3	55		
STN	6		2L		2L	X		X			4	44		
TIME IN	13:04										5	44		
BOTTOM	13:09										6	44		
ON DECK	13 :36		1L		1L			X			7	35		
LAT	41 46.81										8	35		
LON	09 06.47		1L		1L	X		X			9	23		
WATER D	110										10	23		
MAX DEPTH	90							X			11	23		
											12	23		
											13	23		
											14	23		
			1L		1L						15	14		
											16	14		
			1L		1L	X					17	9		
											18	9		
			1L		1L						19	6		
											20	6		
											21	6		
			1L		1L	X		X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	032											90		Light Profile
DAY	185													
DATE	04/07/05													

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
STN	6													
TIME IN	15:05													
BOTTOM	15:14													
ON DECK	15 :23													
LAT	41 46.95													
LON	09 06.68													
WATER D	110													
MAX DEPTH	90													
CTD #	033										1	15		Nitrification
DAY	185										2	15		
DATE	04/07/05										3	15		
STN	6													
TIME IN	18:00													
BOTTOM	18:08													
ON DECK	18 :10													
LAT	41 46.87													
LON	09 06.79													
WATER D	108													
MAX DEPTH	15													
CTD #	034			Y				X			1	90		Productivity
DAY	186		2L								2	65		
DATE	05/07/05										3	65		
STN	6										4	65		
TIME IN	02:50										5	55	105	
BOTTOM	02:57							X			6	44		
ON DECK	03:30		2L								7	34		
LAT	41 47.02										8	34		
LON	09 06.69										9	30		
WATER D	107										10	30		
MAX DEPTH	90										11	30		
				Y				X			12	27		
											13	27		
								X			14	23		
											15	15		
			1L								16	15		
			1L					X			17	11		
											18	11		
			1L								19	6	106	
											20	6		
											21	6		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
			1L	Y				X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	035			Y		X		X			1	90		Main CTD
DAY	186		2L		2L	X		X			2	65	107	
DATE	05/07/05										3	65		
STN	6										4	65		
TIME IN	09:20		2L		2L						5	55		
BOTTOM	09:29		2L		2L						6	44		
ON DECK	09:59		1L	Y	1L	X		X			7	34		
LAT	41 46.94										8	34		
LON	09 06.72										9	34		
WATER D	107										10	34		
MAX DEPTH	90		1L		1L						11	27		
			1L		1L	X		X			12	23		
			1L		1L						13	15		
											14	15		
			1L		1L	X		X			15	11	108	
											16	11		
			1L		1L						17	6		
											18	6		
											19	6		
											20	6		
											21	6		
			1L	Y	1L	X		X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	036										1	90		Seat Fail
DAY	186							X			2	65		
DATE	05/07/05										3	65		
STN	6										4	65		
TIME IN	13:12										5	55		Seat Fail
BOTTOM	13:18										6	44		
ON DECK	13:43										7	34		
LAT	41 47.00										8	34		
LON	09 06.55										9	34		
WATER D	109							X			10	30		
MAX DEPTH	90										11	30		
											12	30		
											13	27		
								X			14	23		

	DETAILS	PP	PIGS	POC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
											15	15		
											16	15		
											17	11		Seat Fail
											18	11		
								X			19	6		
											20	6		
											21	6		
								X			22	Surf		
											23	Surf		
											24	Surf		
CTD #	037			Y							1	90		Productivity
DAY	187		2L								2	65		
DATE	06/07/05										3	65	109	
STN	6										4	65		
TIME IN	03:06										5	55		
BOTTOM	03:14										6	44		
ON DECK	03:55		2L								7	34		
LAT	41 46.97										8	34		
LON	09 06.56										9	30		
WATER D	109										10	30		
MAX DEPTH	90										11	23		
				Y							12	20		
											13	20		
											14	20		
			1L								15	15		
											16	15		
			1L								17	11		
											18	11		
			1L								19	6		
											20	6	110	
											21	6		
			1L	Y							22	Surf		
											23	Surf		
											24	Surf		
CTD #	038		2L	Y	2L	X		X			1	90		Main CTD
DAY	187		2L		2L						2	65	112	
DATE	06/07/05		2L		2L	X		X			3	44		
STN	6		2L		2L						4	34		
TIME IN	09:20		1L		1L	X		X			5	30		
BOTTOM	09:28										6	30		
ON DECK	10:05		1L		1L						7	24		

	DETAILS	PP	PIGS	ETC	MAAs	DMS(P)	DOS-turnover	Halocarbons			Bottle	Depth	Salinity Bottle	Comment
LAT	41 47.03		1L		1L	X					8	18		
LON	09 06.61		1L		1L						9	14		
WATER D	107		1L	Y	1L						10	12		
MAX DEPTH	90										11	12		
			1L		1L	X		X			12	9	111	
											13	9		
			1L		1L						14	6		
											15	6		
			1L		1L						16	3		
											17	3		
											18	3		
											19	3		
											20	3		
											21	3		
			1L	Y	1L	X		X			22	Surf		
											23	Surf		
											24	Surf		

Appendix 5. SAPS Log

CAST #	DAY	DATE	STN	LAT	LON	PUMP	TIME IN	PUMPING TIME	DEPTH (m)	START VOLUME	END VOLUME	SAMPLE VOLUME	STN CODE
1	171	20/06/05	0	40 44.29	09 52.10	03-02	11:43	00:42	100	3284.6	3347.8	63.2	
1	171	20/06/05	0	40 44.29	09 52.10	03-03	11:58	00:42	Surf	5450.5	5546.8	96.3	
2	172	21/06/05	1	42 02.03	10 30.16	03-02	04:27	00:42	Surf	3347.8	3394.3	47.3	S1D1am
2	172	21/06/05	1	42 02.03	10 30.16	03-03	04:21	00:42	30	5546.8	5589.2	42.4	
3	172	21/06/05	1	42 00.73	10 30.17	03-03	20:01	00:48	67	5589.3	5589.3	0	S1D1pm
3	172	21/06/05	1	42 00.73	10 30.17	02-04	20:09	00:48	18	7617.4	7656.7	39.3	
3	172	21/06/05	1	42 00.73	10 30.17	03-02	20:13	00:48	Surf	3394.3	3437.2	42.9	
TEST	173	22/06/05	1	41 59.00	10 30.03	03-03	18:15	00:48	-	5589.6	5597.3	7.7	
4	175	24/06/05	2	41 43.00	09 19.40	03-03	07:50	00:48	33	5597.3	5617.1	19.8	S2D1am
4	175	24/06/05	2	41 43.00	09 19.40	02-04	07:55	00:48	15	7656.9	7683.2	26.3	
4	175	24/06/05	2	41 43.00	09 19.40	03-02	08:05	00:48	Surf	3437.2	3467.8	30.6	
5	175	24/06/05	2	41 43.93	09 19.69	03-02	19:23	00:48	Surf	3467.8	3489.9	22.1	S2D1pm
5	175	24/06/05	2	41 43.93	09 19.69	02-04	19:24	00:48	15	7683.3	7708.9	25.6	
5	175	24/06/05	2	41 43.93	09 19.69	03-03	19:20	00:48	35	5617.1	5662.6	45.5	
6	178	27/06/05	3	41 51.41	08 57.92	03-03	03:58	00:48	20	5662.8	5690.0	27.2	S3D1am
6	178	27/06/05	3	41 51.41	08 57.92	02-04	04:02	00:48	10	7709.0	7743.2	34.2	
6	178	27/06/05	3	41 51.41	08 57.92	03-02	04:05	00:48	Surf	3490.1	3514.8	24.7	
7	179	28/06/05	4	42 12.26	09 00.59	03-03	03:20	00:48	30	5690.2	5724.1	33.9	S4D1am
7	179	28/06/05	4	42 12.26	09 00.59	02-04	03:24	00:48	15	7734.3	7771.6	37.3	
7	179	28/06/05	4	42 12.26	09 00.59	03-02	03:28	00:48	Surf	3514.8	3548.1	33.3	
8	179	28/06/05	4	42 12.69	09 00.78	03-03	17:37	00:48	40	5724.2	5758.6	34.4	S4D1pm
8	179	28/06/05	4	42 12.69	09 00.78	02-04	17:41	00:48	15	7771.6	7804.1	32.5	
8	179	28/06/05	4	42 12.69	09 00.78	03-02	17:43	00:48	Surf	3548.2	3581.7	33.5	
9	180	29/06/04	4	42 12.46	09 00.73	03-03	03:27	00:48	40	5758.7	5793.1	34.4	S4D2am
9	180	29/06/04	4	42 12.46	09 00.73	02-04	03:29	00:48	15	7804.1	7842.3	38.2	
9	180	29/06/04	4	42 12.46	09 00.73	03-02	03:30	00:48	Surf	3581.8	3625.8	44.0	
10	180	29/06/04	4	42 12.46	09 00.56	03-02	16:12	00:48	Surf	3625.9	3670.9	45.0	S4D2pm
10	180	29/06/04	4	42 12.46	09 00.56	02-04	16:10	00:48	15	7842.4	7888.7	46.3	
10	180	29/06/04	4	42 12.46	09 00.56	03-03	16:07	00:48	40	5793.2	5835.8	42.6	
11	181	30/06/04	4	42 12.46	09 00.56	03-02	18:09	00:48	Surf	3670.9	3703.2	32.3	S4D3pm
11	181	30/06/04	4	42 12.46	09 00.56	02-04	18:07	00:48	15	7888.7	7924.6	35.9	
11	181	30/06/04	4	42 12.46	09 00.56	03-03	18:04	00:48	45	5835.8	5869.3	33.5	
12	183	02/07/04	4	42 12.00	09 00.00	03-03	03:40	00:48	28	5869.1	5904.7	35.6	S4D5am
12	183	02/07/04	4	42 12.00	09 00.00	02-04	03:43	00:48	14	7924.6	7966.7	42.1	
12	183	02/07/04	4	42 12.00	09 00.00	03-02	03:46	00:48	Surf	3703.3	3740.7	37.4	

CAST #	DAY	DATE	STN	LAT	LON	PUMP	TIME IN	PUMPING TIME	DEPTH (m)	START VOLUME	END VOLUME	SAMPLE VOLUME	STN CODE
13	183	02/07/04	4	42 12.79	09 00.63	03-02	17:05	00:48	Surf	3740.7	3779.0	38.3	
13	183	02/07/04	4	42 12.79	09 00.63	02-04	17:07	00:48	15	7966.7	8030.9	64.2	S4D5pm
13	183	02/07/04	4	42 12.79	09 00.63	03-03	17:05	00:48	30	5904.7	5941.9	37.2	
14	184	03/07/04	5	40 46.74	09 01.03	03-03	17:37	00:48	28	5941.9	5981.7	39.8	
14	184	03/07/04	5	40 46.74	09 01.03	02-04	17:40	00:48	14	8031.0	8074.2	43.2	S5D1pm
14	184	03/07/04	5	40 46.74	09 01.03	03-02	17:42	00:48	Surf	3779.0	3821.1	42.1	
15	185	04/07/04	6	41 47.15	09 06.88	03-02	18:28	00:48	Surf	3821.1	3859.2	38.1	
15	185	04/07/04	6	41 47.15	09 06.88	02-04	18:25	00:48	12m	8074.3	8113.0	38.7	S6D1pm
15	185	04/07/04	6	41 47.15	09 06.88	03-03	18:24	00:48	24m	5981.8	6011.5	29.7	
16	186	05/07/04	6	41 47.08	09 06.72	02-04	17:51	00:48	15m	8113.1	8152.7	39.6	
16	186	05/07/04	6	41 47.08	09 06.72	03-02	17:54	00:48	Surf	3859.3	3899.5	40.2	S6D2pm
16	186	05/07/04	6	41 47.08	09 06.72	03-03	17:47	00:48	30	6011.5	6052.6	41.1	
17	187	06/07/04	6	41 46.98	09 06.79	03-02	16:19	00:48	Surf	3899.5	3932.2	32.7	
17	187	06/07/04	6	41 46.98	09 06.79	02-04	16:20	00:48	15	8152.8	8188.9	36.1	S6D3pm
17	187	06/07/04	6	41 46.98	09 06.79	03-03	16:16	00:48	30	6052.7	6098.6	35.9	

Appendix 6. Optical properties, photophysiology an photooxidation of CDOM

Station	Date	Time GMT	Lat	Long	Measurement
CTD001	20/06/200	10:00	40	9 51.77	0 , 30 mts Pabs, TSM, CDOM,
OPTICS00	20/06/200	15:48	40	9 51.77	AOP, IOP, UV, FRRF profiles
OPTICS00	21/06/200	14:01	42 02.51	10	AOP, IOP, UV, FRRF profiles
OPTICS00	21/06/200	20:24	42 00.00	10	AOP, IOP, UV, FRRF profiles
OPTICS00	22/06/200	06:14	41 59.88	10	AOP, IOP, UV, FRRF profiles
OPTICS00	22/06/200	08:38	41 59.83	10	AOP, IOP, UV, FRRF profiles
CTD005	22/06/200	11:00	41 59.68	10	0, 45, 66 mts Pabs, TSM, CDOM,
OPTICS00	22/06/200	11:41	42 00.62	10	AOP, IOP, UV, FRRF profiles
CTD007	23/06/200	09:08	42 00.05	10	0, 39, 66 mts Pabs, TSM, CDOM,
microlayer	23/06/200				Garrett.
OPTICS00	23/06/200	13:20	41 59.32	10	AOP, IOP, UV, FRRF profiles
OPTICS00	23/06/200	13:50	41 59.32	10	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS00	23/06/200	19:27	41 59.70	10	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS01	23/06/200	20:02	41 59.70	10	AOP, IOP, UV, FRRF profiles
CTD009	24/06/200	09:30	41 43.24	9 19.75	AOP, IOP (incl CDOM), UV, FRRF profiles
microlayer	24/06/200				Garrett, MLSD, NSSD 0.2 & 2.14 mts.
OPTICS01	24/06/200	17:56	41 43.51	9 19.37	AOP, IOP, UV, FRRF profiles
OPTICS01	24/06/200	18:25	41 43.51	9 19.37	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS01	25/06/200	03:38	41 44.32	9 18.96	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS01	25/06/200	04:05	41 44.32	9 18.96	AOP, IOP, UV, FRRF profiles
OPTICS01	25/06/200	07:16	41 43.24	9 19.47	AOP, IOP, UV, FRRF profiles
OPTICS01	25/06/200	07:52	41 43.24	9 19.47	AOP, IOP (incl CDOM), UV, FRRF profiles
CTD013	25/06/200	09:30	41 43.94	9 19.84	0, 30, 40 mts Pabs, TSM, CDOM,
microlayer	25/06/200				Garrett, MLSD, NSSD 0.2 & 2.14 mts.
OPTICS01	25/06/200	10:19	41 43.49	09	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS01	25/06/200	10:39	41 43.49	09	AOP, IOP, UV, FRRF profiles
OPTICS01	25/06/200	14:43	41 43.59	9 19.58	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS02	25/06/200	15:12	41 43.59	9 19.58	AOP, IOP, UV, FRRF profiles
OPTICS02	25/06/200	18:18	41 43.59	9 19.58	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS02	25/06/200	18:48	41 43.59	9 19.58	AOP, IOP, UV, FRRF profiles
OPTICS02	26/06/200	08:54	41 43.08	9 20.30	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS02	26/06/200	09:17	41 43.08	9 20.30	AOP, IOP, UV, FRRF profiles
CTD014	26/06/200	09:30	41 42.61	9 20.73	0, 30, 40 mts Pabs, TSM, CDOM,
OPTICS02	26/06/200	12:02	41 43.93	9 12.69	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS02	26/06/200	12:24	41 43.93	9 12.69	AOP, IOP, UV, FRRF profiles
OPTICS02	26/06/200	15:10	41 43.81	9 18.83	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS02	26/06/200	15:38	41 43.81	9 18.83	AOP, IOP, UV, FRRF profiles
OPTICS02	27/06/200	02:57	41 51.42	8 57.98	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS03	27/06/200	03:19	41 51.25	8 57.92	AOP, IOP, UV, FRRF profiles
OPTICS03	27/06/200	08:46	41 51.25	8 57.92	AOP, IOP (incl CDOM), UV, FRRF profiles
OPTICS03	27/06/200	09:00	41 51.25	8 57.92	AOP, IOP, UV, FRRF profiles
CTD016	27/06/200	09:30	41 51.99	8 57.78	0, 41 mts Pabs, TSM, CDOM
OPTICS03	28/06/200	04:51	42 12.54	9 00.51	AOP, IOP, UV, FRRF profiles
OPTICS03	28/06/200	07:43	42 12.37	9 00.39	AOP, IOP, UV, FRRF profiles
CTD017	28/06/200	09:30	42 12.37	9 00.39	0, 30, 50 mts Pabs, TSM, CDOM
OPTICS03	28/06/200	12:24	42 12.20	9 00.68	AOP, IOP, UV, FRRF profiles
OPTICS03	28/06/200	16:38	42 12.52	9 00.62	AOP, IOP, UV, FRRF profiles
OPTICS03	29/06/200	05:47	42 12.51	9 00.78	AOP, IOP, UV, FRRF profiles
Microlayer	29/06/200	06:10			Garrett, MLSD, NSSD 0.2 & 2.14 mts.
OPTICS03	29/06/200	10:08	42 12.83	9 00.47	AOP, IOP, UV, FRRF profiles

Station	Date	Time GMT	Lat	Long	Measurement
CTD019	29/06/200	12:30	42 12.87	9 00.12	0, 30, 45 mts Pabs, TSM, CDOM
Microlayer	29/06/200	14:00			Garrett, MLSD, NSSD 0.2 & 2.14 mts.
OPTICS03	29/06/200	16:02	42 42.52	09	AOP, IOP, UV, FRRF profiles
OPTICS04	29/06/200	19:14	42 42.57	09	AOP, IOP, UV, FRRF profiles
OPTICS04	30/06/200	13:10	42 12.42	09	AOP, IOP, UV, FRRF profiles
CTD020	30/06/200	14:00	42 12.67	9 00.57	0, 45, 60 mts Pabs, TSM, CDOM
OPTICS04	30/06/200	17:22	42 12.40	9 00.52	AOP, IOP, UV, FRRF profiles
OPTICS04	01/07/200	04:27	42 12.64	9 00.66	AOP, IOP, UV, FRRF profiles
OPTICS04	01/07/200	08:13	42 12.32	9 00.42	AOP, IOP, UV, FRRF profiles
OPTICS04	01/07/200	09:22	42 12.32	9 00.42	Freefall
CTD023	01/07/200	10:00	42 12.76	9 00.57	0, 30, 50 mts Pabs, TSM, CDOM
OPTICS04	01/07/200	11:05	42 12.86	9 00.38	AOP, IOP, UV, FRRF profiles
OPTICS04	01/07/200	11:45	42 12.86	9 00.38	Freefall
OPTICS04	01/07/200	15:15	42 12.35	9 00.69	AOP, IOP, UV, FRRF profiles
OPTICS04	01/07/200	16:12	42 12.40	9 00.54	Freefall
OPTICS05	01/07/200	18:15	42 12.36	9 00.67	AOP, IOP, UV, FRRF profiles
OPTICS05	01/07/200	18:54	42 12.31	9 00.79	Freefall
OPTICS05	02/07/200	06:02	42 12.41	9 00.88	AOP, IOP, UV, FRRF profiles
OPTICS05	02/07/200	08:30	42 12.36	9 00.74	AOP, IOP, UV, FRRF profiles
OPTICS05	02/07/200	09:21	42 12.41	9 00.85	Freefall
CTD026	02/07/200		42 12.53	9 00.46	0, 32, 55 mts Pabs, TSM, CDOM
OPTICS05	02/07/200	11:19	42 12.45	9 00.43	AOP, IOP, UV, FRRF profiles
OPTICS05	02/07/200	11:58	42 12.45	9 00.43	Freefall (lost at sea)
OPTICS05	03/07/200	08:10	41 46.77	9 00.97	AOP, IOP, UV, FRRF profiles
CTD029	03/07/200		41 46.88	9 00.88	0, 35, 44 mts Pabs, TSM, CDOM
OPTICS05	03/07/200	11:20	41 46.93	9 01.06	AOP, IOP, UV, FRRF profiles
OPTICS05	03/07/200	16:10	41 46.73	9 01.04	AOP, IOP, UV, FRRF profiles
OPTICS06	03/07/200	18:05	41 46.73	9 00.99	AOP, IOP, UV, FRRF profiles
OPTICS06	05/07/200	08:11	41 46.99	9 06.54	AOP, IOP, UV,
OPTICS06	05/07/200	11:04	41 46.94	9 06.75	AOP, IOP, UV,
OPTICS06	05/07/200	16:17	41 46.78	9 06.73	AOP, IOP, UV, FRRF profiles
OPTICS06	05/07/200	18:06	41 46.08	9 06.68	AOP, IOP, UV, FRRF profiles
OPTICS06	06/07/200	04:10	41 47.01	9 06.55	AOP, IOP, UV, FRRF profiles
OPTICS06	06/07/200	08:18	41 46.94	9 06.52	AOP, IOP, UV, FRRF profiles
OPTICS06	06/07/200	11:14	41 47.06	9 06.50	AOP, IOP, UV, FRRF profiles
OPTICS06	06/07/200	14:08	41 46.98	9 06.59	AOP, IOP, UV, FRRF profiles
OPTICS06	06/07/200	16:35	41 46.97	9 06.75	AOP, IOP, UV, FRRF profiles

Appendix 7. Primary production and heterotrophic bacterial production

Date	Time	Station	Samples collected
Sun 19 June 05 Shakedown	~10:04	CTD01	97%, 55%, 33%, 20%, 7%, 1% (Guess at depths no PAR data yet!) & V_{max} experiment (from surface 2 m) Bacterial production
Tue 21 June 05 Station 1	14:11	CTD 03	Nitirification expt#1 (15m, ~33%)
Wed 22 June 05 Station 1	04:45	CTD 04	97%, 55%, 33%, 20%, 7%, 1% **(Prod #1)** Carbon fixation (+T_0 & Carbosorb samples) Bacterial production
	09:00	CTD 05	97%, 55%, 33%, 20%, 7%, 1% Bacterial production
	14:00	RIB & NSSD	Garrat, Pipette & Bottles 1, 7 & 8[a] Bacterial production
Thur 23 June 05 Station 1	02:20	CTD 06	97%, 55%, 33%, 20%, 7%, 1% **(Prod #2)** Carbon fixation (+T_0 & Carbosorb samples) Bacterial production Trace Metal (4d) incubation #1 started
	09:05	CTD 07	97%, 55%, 33%, 20%, 7%, 1% Bacterial production
	14:20	RIB, NSSD & Cat	No NSSD bottles fired Pipette, Cat & Garrat samples only Bacterial production & AFC samples collected
Fri 24 June 05 Station 2	09:40	CTD 09	97%, 55%, 33%, 20%, 7%, 1% Bacterial production
	13:15	RIB, NSSD & Cat!	All NSSD bottles fired but Bottle 3 leaky therefore not sampled. Cat, Garrat, Pipette & Bottles 1,2, 4-8[a] Bacterial production & AFC samples collected
	17:22	CTD 10	Nitirification expt#2 (from 10m, ~33%)
Sat 25 June 05 Station 2	02:40	CTD 12	97%, 55%, 33%, 20%, 7%, 1% **(Prod #3)** Carbon fixation (+T_0 & Carbosorb samples) Bacterial production Unsure of light levels!
	09:20	CTD 13	97%, 55%, 33%, 20%, 7%, 1% Bacterial production
	13:20	RIB, NSSD & Cat!	Cat, Garrat, & Bottles 1-8[a] Bacterial production & AFC samples collected
Sun 26 June 05 Station 2	04:00		Sampling cancelled as had to urgently return to Vigo for transfer of personnel
	09:41	CTD 14	97%, 55%, 33%, 20%, 7%, 1% Bacterial production
	12:50	RIB, NSSD & Cat! Visible surface 'slick', Garrat needed +13 dips for same volume of water	Cat, Garrat, & Bottles 1-8[a] Bacterial production & AFC samples collected
Mon 27 June 05 Station 3 (v close to shore!)	06:00	RIB, NSSD & Cat! Early deployment therefore no pre-dawn CTD	Cat, Garrat, pipette & Bottles 1-8[a] Bacterial production & AFC samples collected Carbon fixation (Pipette, Bottles 1, 2 & 8 NSSD) incubated in large on deck tanks. Also compared Pc bottles with Whirlpak bags for surface and Bottle 2.
	09:40	CTD 16	97%, 55%, 33%, 20%, 7%, 1% Bacterial production (? in a rapidly decaying bloom)
Tue 28 June 05 Station 4	09:45	CTD 17	97%, 55%, 33%, 20%, 7%, 1% Bacterial production (? Light levels1)
Wed 29 June 05 Station 4	05:50	RIB, NSSD & Cat! Early deployment therefore no pre-dawn CTD	Cat, garret and bottles 1-4, 6 & 8. Bacterial production, AFC samples. Bottles 1, 2 & 8 Carbon fixation (plus comparison of incubation at surface and bottom of incubator)
	09:30	CTD 19	97%, 55%, 33%, 20%, 7%, 1% Bacterial production

Date	Time	Station	Samples collected
	13:40	RIB, NSSD & Cat	Cat, garret, pipette & NSSD Bottles 1-8 Bacterial production & AFC samples Pipette, NSSD Botles 1,2 & 8 Carbon fixation
Ship into Vigo for water & supplies			
Thur 30 June 05 Station 4	14:50	CTD 20	97%, 55%, 33%, 20%, 7%, 1% Bacterial production Nitrification expt #3 (from 11m ~33%)
Fri 1 July 05 Station 4	02:30	CTD 22	97%, 55%, 33%, 20%, 7%, 1% **(Prod #4)** Carbon fixation (+T_0 & Carbosorb samples) Bacterial production
	09:30	CTD 23	97%, 55%, 33%, 20%, 7%, 1% Bacterial production
	12:50	RIB, NSSD & Cat Too rough for cat & screens (NSSD sampler angled in water)	Pipette, NSSD Bottles 1-8 Bacterial production Bottles 1, 2 & 8 Carbon fixation
Sat 2 July 05 Station 4	03:00	CTD 25	97%, 55%, 33%, 20%, 7%, 1% **(Prod #5)** Carbon fixation Bacterial production
	09:30	CTD 26	97%, 55%, 33%, 20%, 7%, 1% Bacterial production
Sun 3 July 05 Station 5	09:45	CTD 29	97%, 55%, 33%, 20%, 7%, 1% Bacterial production
Mon 4 July 05 Station 6 (4 miles west of Stn 5)	03:00		Pre dawn CTD cancelled due to the poor weather (Force 7/8)
	09:30	CTD 30	97%, 55%, 33%, 20%, 7%, 1% Bacterial production 55%, 33% Short term carbon fixation (due to cancelled pre dawn)
	13:15	CTD 31	97%, 55%, 33%, 20%, 7%, 1% Bacterial production 55%, 33% Short term carbon fixation
Tue 5 July 05 Station 6	03:00	CTD 34	97%, 55%, 33%, 20%, 7%, 1% **(Prod #6)** Carbon fixation BUT non toxic off so samples not in tanks until 10:30 when back on! Bacterial production
	06:20	RIB, NSSD & Cat	Cat, Garrat, pipette & NSSD Bottles 1-8 Bacterial production & AFC samples
	09:10	CTD35	97, 55, 33% Only Bacterial production & carbon fixation (55 & 33%) short term
	13:20	CTD36	55 & 33% Only Carbon fixation (no bacterial production as not enough μ-tubes left)
Wed 6 July 05 Station 6	03:20	CTD 37	97%, 55%, 33%, 20% Bacterial production
	09:30	CTD 38	55 & 33% only Bacterial production

[a]Micro-layer samples were collected using both the Garrett screens and the SMS (cat). Near surface samples were collected using the NSSD from the following depths; Bottle 1: 25 cm (from surface), Bottle 2: 44.5 cm, Bottle 3: 64 cm, Bottle 4: 84 cm, Bottle 5: 104 cm, Bottle 6: 151 cm, Bottle 7: 182.5 cm, Bottle 8: 217 cm. Pipette samples (~30 mls) were collected by hand using an Eppendorf pipette from the Rib (from about 10cm from surface) – sampler always wore gloves etc.

Appendix 8. Mesozooplankton Sampling Log

Stn	Day	Date	Time	Long	Lat	Species	# per sample
1	1	21/06/2005	2:30	10 30.07	42 00.3	Centropages females	21
1	2	22/06/2005	2:35	10 30.07	41 59.94	Centropages females	22
1	2	22/06/2005	2:35	10 30.07	41 59.94	Centropages females	21
1	2	22/06/2005	2:35	10 30.07	41 59.94	Centropages females	11
1	3	23/06/2005	1:07	10 30.03	41 59.85	Centropages females	25
1	3	23/06/2005	1:07	10 30.03	41 59.85	Centropages females	31
1	2	22/06/2005	10:45	10 29.20	41 59.82	Centropages females	4
1	3	23/06/2005	10:05	10 29.50	42 00.25	Centropages females	6
1	3	23/06/2005	10:05	10 29.50	42 00.25	Centropages females	9
1	1	21/06/2005	2:30	10 30.07	42 00.3	Centropages males	10
1	2	22/06/2005	2:35	10 30.07	41 59.94	Centropages males	20
1	2	22/06/2005	2:35	10 30.07	41 59.94	Centropages males	13
1	3	23/06/2005	1:07	10 30.03	41 59.85	Centropages males	23
1	3	23/06/2005	10:05	10 29.50	42 00.25	Centropages males	8
1	1	21/06/2005	10:45	10 29.93	42 00.48	Centropages C5	15
1	1	21/06/2005	2:30	10 30.07	42 00.3	Acartia clausi females	25
1	2	22/06/2005	2:35	10 30.07	41 59.94	Acartia clausi females	19
1	2	22/06/2005	2:35	10 30.07	41 59.94	Candacia females	10
1	2	22/06/2005	2:35	10 30.07	41 59.94	Candacia females	10
1	2	22/06/2005	2:35	10 30.07	41 59.94	Candacia females	8
1	3	23/06/2005	10:05	10 29.50	42 00.25	Candacia females	3
1	2	22/06/2005	2:35	10 30.07	41 59.94	Calanus C5	22
1	2	22/06/2005	2:35	10 30.07	41 59.94	Calanoides carinatus	20
1	2	22/06/2005	2:35	10 30.07	41 59.94	Calanoides carinatus	20
1	2	22/06/2005	2:35	10 30.07	41 59.94	Calanoides carinatus	31
1	2	22/06/2005	2:35	10 30.07	41 59.94	Calanoides carinatus	20
1	3	23/06/2005	1:07	10 30.03	41 59.85	Calanoides carinatus	22
1	3	23/06/2005	1:07	10 30.03	41 59.85	Calanoides carinatus	32
1	2	22/06/2005	10:45	10 29.20	41 59.82	Calanoides carinatus	11
1	3	23/06/2005	10:05	10 29.50	42 00.25	Calanoides carinatus	20
1	3	23/06/2005	10:05	10 29.50	42 00.25	Calanoides carinatus	23
1	3	23/06/2005	10:05	10 29.50	42 00.25	Calanoides carinatus	26
1	1	21/06/2005	2:30	10 30.07	42 00.3	Euphausiids	2
1	3	23/06/2005	1:07	10 30.03	41 59.85	Euphausiids	3
1	1	21/06/2005	2:30	10 30.07	42 00.3	Decapod larvae	7
1	2	22/06/2005	2:35	10 30.07	41 59.94	Decapod larvae	16
1	2	22/06/2005	2:35	10 30.07	41 59.94	Decapod larvae	15
1	3	23/06/2005	1:07	10 30.03	41 59.85	Decapod larvae	17
1	1	21/06/2005	2:30	10 30.07	42 00.3	Podon	7
1	1	21/06/2005	2:30	10 30.07	42 00.3	Evadne	37
1	3	23/06/2005	1:07	10 30.03	41 59.85	Evadne	50
1	2	22/06/2005	10:45	10 29.20	41 59.82	Evadne	56
1	1	21/06/2005	10:45	10 29.93	42 00.48	Appendicularian	37
1	1	21/06/2005	10:45	10 29.93	42 00.48	Appendicularian	26
1	1	21/06/2005	10:45	10 29.93	42 00.48	Appendicularian	29
1	3	23/06/2005	10:05	10 29.50	42 00.25	Appendicularian	41
1	3	23/06/2005	10:05	10 29.50	42 00.25	Appendicularian	46
1	3	23/06/2005	10:05	10 29.50	42 00.25	Appendicularian	42
1	3	23/06/2005	1:07	10 30.03	41 59.85	Amphipods	20
1	3	23/06/2005	1:07	10 30.03	41 59.85	Amphipods	20
1	1	21/06/2005	2:30	10 30.07	42 00.3	Trichodesmium	1 sample
1	2	22/06/2005	2:35	10 30.07	41 59.94	Trichodesmium	1 sample
1	3	23/06/2005	10:05	10 29.50	42 00.25	Trichodesmium	1 sample
2	2	25/06/2005	1:05	9 19.62	41 44.38	Centropages females	20
2	2	25/06/2005	1:05	9 19.62	41 44.38	Centropages females	20
2	3	26/06/2005	10:40	9 20.75	41 42.50	Centropages females	19
2	2	25/06/2005	1:05	9 19.62	41 44.38	Centropages males	20
2	3	26/06/2005	10:40	9 20.75	41 42.50	Centropages males	20

Stn	Day	Date	Time	Long	Lat	Species	# per sample
2	1	24/06/2005	10:45	9 19.62	41 44.38	Centropages C5	17
2	2	25/06/2005	11:10	9 20.12	41 43.49	Centropages C5	40
2	1	24/06/2005	5:27	9 19.48	41 43.75	Acartia clausi females	16
2	2	25/06/2005	1:05	9 19.62	41 44.38	Acartia clausi females	41
2	2	25/06/2005	1:05	9 19.62	41 44.38	Acartia clausi females	36
2	2	25/06/2005	1:05	9 19.62	41 44.38	Acartia clausi females	35
2	1	24/06/2005	5:27	9 19.48	41 43.75	Clausocalanus females	20
2	1	24/06/2005	10:45	9 19.62	41 44.38	Clausocalanus females	36
2	1	24/06/2005	10:45	9 19.62	41 44.38	Clausocalanus females	35
2	1	24/06/2005	5:27	9 19.48	41 43.75	Clausocalanus females	24
2	2	25/06/2005	11:10	9 20.12	41 43.49	Clausocalanus females	18
2	3	26/06/2005	10:40	9 20.75	41 42.50	Clausocalanus females	34
2	3	26/06/2005	10:40	9 20.75	41 42.50	Clausocalanus females	34
2	3	26/06/2005	10:40	9 20.75	41 42.50	Clausocalanus females	16
2	1	24/06/2005	5:27	9 19.48	41 43.75	short antennna	57
2	2	25/06/2005	1:05	9 19.62	41 44.38	Candacia C5	20
2	1	24/06/2005	5:27	9 19.48	41 43.75	Appendicularian	46
2	3	26/06/2005	10:40	9 20.75	41 42.50	Appendicularian	66
2	2	25/06/2005	11:10	9 20.12	41 43.49	Trichodesmium	1 sample
2	3	26/06/2005	10:40	9 20.75	41 42.50	Trichodesmium	1 sample
3	1	27/06/2005	1:03	08 58.25	41 51.36	Centropages females	3
3	1	27/06/2005	10:25	08 57.82	41 51.69	Centropages females	4
3	1	27/06/2005	10:25	08 57.82	41 51.69	Centropages males	4
3	1	27/06/2005	1:03	08 58.25	41 51.36	Acartia clausi females	40
3	1	27/06/2005	1:03	08 58.25	41 51.36	Acartia clausi females	40
3	1	27/06/2005	1:03	08 58.25	41 51.36	Acartia clausi females	70
3	1	27/06/2005	10:25	08 57.82	41 51.69	Acartia clausi females	40
3	1	27/06/2005	1:03	08 58.25	41 51.36	Isias clavipes females	12
3	1	27/06/2005	1:03	08 58.25	41 51.36	Candacia armata C5	20
3	1	27/06/2005	1:03	08 58.25	41 51.36	Candacia armataC5	8
3	1	27/06/2005	1:03	08 58.25	41 51.36	Decapod larvae	4
3	1	27/06/2005	1:03	08 58.25	41 51.36	Evadne	80
3	1	27/06/2005	1:03	08 58.25	41 51.36	Evadne	80
3	1	27/06/2005	1:03	08 58.25	41 51.36	Evadne	91
3	1	27/06/2005	10:25	08 57.82	41 51.69	Appendicularian	46
4	1	28/06/2005	1:10	09 00.77	42 12.63	Centropages females	25
4	1	28/06/2005	1:10	09 00.77	42 12.63	Centropages females	25
4	2	29/06/2005	1:04	09 00.64	42 12.41	Centropages females	20
4	2	29/06/2005	1:04	09 00.64	42 12.41	Centropages females	20
4	2	29/06/2005	1:04	09 00.64	42 12.41	Centropages females	26
4	4	1/7/2005	1:05	09 00.60	42 12.49	Centropages females	21
4	5	2/7/2005	1:20	09 00.61	42 12.53	Centropages females	25
4	5	2/7/2005	1:20	09 00.61	42 12.53	Centropages females	25
4	5	2/7/2005	1:20	09 00.61	42 12.53	Centropages females	14
4	1	28/06/2005	10:40	09 00.46	42 11.98	Centropages females	20
4	1	28/06/2005	10:40	09 00.46	42 11.98	Centropages females	20
4	2	29/06/2005	10:40	09 00.12	42.12.98	Centropages females	15
4	2	29/06/2005	10:40	09 00.12	42.12.98	Centropages females	27
4	3	30/06/2005	12:40	09 00.7	42 12.6	Centropages females	20
4	3	30/06/2005	12:40	09 00.7	42 12.6	Centropages females	20
4	3	30/06/2005	12:40	09 00.7	42 12.6	Centropages females	11
4	4	1/7/2005	1:05	09 00.60	42 12.49	Centropages females	20
4	4	1/7/2005	1:05	09 00.60	42 12.49	Centropages females	20
4	4	1/7/2005	1:05	09 00.60	42 12.49	Centropages females	25
4	1	28/06/2005	1:10	09 00.77	42 12.63	Centropages males	25
4	1	28/06/2005	1:10	09 00.77	42 12.63	Centropages males	26
4	2	29/06/2005	1:04	09 00.64	42 12.41	Centropages males	25
4	2	29/06/2005	1:04	09 00.64	42 12.41	Centropages males	17
4	4	1/7/2005	1:05	09 00.60	42 12.49	Centropages males	14
4	1	28/06/2005	10:40	09 00.46	42 11.98	Centropages males	20

Stn	Day	Date	Time	Long	Lat	Species	# per sample
4	1	28/06/2005	10:40	09 00.46	42 11.98	Centropages males	25
4	1	28/06/2005	10:40	09 00.46	42 11.98	Centropages males	28
4	2	29/06/2005	10:40	09 00.12	42.12.98	Centropages males	20
4	3	30/06/2005	12:40	09 00.7	42 12.6	Centropages males	20
4	3	30/06/2005	12:40	09 00.7	42 12.6	Centropages males	18
4	4	1/7/2005	1:05	09 00.60	42 12.49	Centropages males	24
4	2	29/06/2005	1:04	09 00.64	42 12.41	Acartia clausi females	40
4	5	2/7/2005	1:20	09 00.61	42 12.53	Acartia clausi females	53
4	5	2/7/2005	1:20	09 00.61	42 12.53	Acartia clausi females	50
4	5	2/7/2005	1:20	09 00.61	42 12.53	Acartia clausi females	36
4	1	28/06/2005	10:40	09 00.46	42 11.98	Acartia clausi females	35
4	2	29/06/2005	10:40	09 00.12	42.12.98	Acartia clausi females	20
4	3	30/06/2005	12:40	09 00.7	42 12.6	Acartia clausi females	30
4	4	1/7/2005	1:05	09 00.60	42 12.49	Acartia clausi females	30
4	4	1/7/2005	1:05	09 00.60	42 12.49	Acartia clausi females	31
4	1	28/06/2005	1:10	09 00.77	42 12.63	Calanus helgolandicus fem	15
4	4	1/7/2005	1:05	09 00.60	42 12.49	Calanus helgolandicus fem	14
4	5	2/7/2005	1:20	09 00.61	42 12.53	Calanus helgolandicus fem	9
4	4	1/7/2005	1:05	09 00.60	42 12.49	Calanus helgolandicus C5	15
4	4	1/7/2005	1:05	09 00.60	42 12.49	Calanus helgolandicus C5	15
4	4	1/7/2005	1:05	09 00.60	42 12.49	Calanus helgolandicus C5	8
4	5	2/7/2005	1:20	09 00.61	42 12.53	Calanus helgolandicus C5	22
4	2	29/06/2005	1:04	09 00.64	42 12.41	Isias clavipes females	23
4	4	1/7/2005	1:05	09 00.60	42 12.49	Isias clavipes females	25
4	4	1/7/2005	1:05	09 00.60	42 12.49	Temora longicornis females	11
4	1	28/06/2005	1:10	09 00.77	42 12.63	Candancia females	7
4	2	29/06/2005	1:04	09 00.64	42 12.41	Candancia females	3
4	4	1/7/2005	1:05	09 00.60	42 12.49	Candancia females	10
4	4	1/7/2005	1:05	09 00.60	42 12.49	Candancia females	7
4	5	2/7/2005	1:20	09 00.61	42 12.53	Candancia females	5
4	4	1/7/2005	1:05	09 00.60	42 12.49	Candacia males	8
4	1	28/06/2005	1:10	09 00.77	42 12.63	Candancia C5	20
4	1	28/06/2005	1:10	09 00.77	42 12.63	Candancia C5	20
4	1	28/06/2005	1:10	09 00.77	42 12.63	Candancia C5	21
4	1	28/06/2005	1:10	09 00.77	42 12.63	Candancia C5	25
4	1	28/06/2005	1:10	09 00.77	42 12.63	Candancia C5	25
4	1	28/06/2005	1:10	09 00.77	42 12.63	Candancia C5	25
4	2	29/06/2005	1:04	09 00.64	42 12.41	Candancia C5	22
4	2	29/06/2005	1:04	09 00.64	42 12.41	Candancia C5	29
4	2	29/06/2005	1:04	09 00.64	42 12.41	Candancia C5	31
4	4	1/7/2005	1:05	09 00.60	42 12.49	Candancia C5	13
4	4	1/7/2005	1:05	09 00.60	42 12.49	Candancia C5	11
4	5	2/7/2005	1:20	09 00.61	42 12.53	Candancia C5	10
4	1	28/06/2005	1:10	09 00.77	42 12.63	Decapod larvae	10
4	1	28/06/2005	1:10	09 00.77	42 12.63	Decapod larvae	10
4	2	29/06/2005	1:04	09 00.64	42 12.41	Decapod larvae	11
4	1	28/06/2005	1:10	09 00.77	42 12.63	Sagitta	15
4	1	28/06/2005	1:10	09 00.77	42 12.63	Sagitta	18
4	2	29/06/2005	1:04	09 00.64	42 12.41	Sagitta	14
4	1	28/06/2005	1:10	09 00.77	42 12.63	Appendicularian	40
4	1	28/06/2005	1:10	09 00.77	42 12.63	Appendicularian	52
4	2	29/06/2005	1:04	09 00.64	42 12.41	Appendicularian	40
4	1	28/06/2005	10:40	09 00.46	42 11.98	Appendicularian	57
5	1	3/7/2005	1:28	09 01.18	41 48.88	Centropages females	25
5	1	3/7/2005	1:28	09 01.18	41 48.88	Centropages females	25
5	1	3/7/2005	1:28	09 01.18	41 48.88	Centropages females	10
5	1	3/7/2005	10:55	09 01.35	41 47.04	Centropages females	23
5	1	3/7/2005	1:28	09 01.18	41 48.88	Centropages males	25
5	1	3/7/2005	10:55	09 01.35	41 47.04	Centropages males	16
5	1	3/7/2005	N	09 01.18	41 48.88	Acartia clausi females	30

Stn	Day	Date	Time	Long	Lat	Species	# per sample
5	1	3/7/2005	1:28	09 01.18	41 48.88	Acartia clausi females	45
5	1	3/7/2005	10:55	09 01.35	41 47.04	Acartia clausi females	43
5	1	3/7/2005	10:55	09 01.35	41 47.04	Acartia clausi females	45
5	1	3/7/2005	10:55	09 01.35	41 47.04	Acartia clausi females	46
5	1	3/7/2005	1:28	09 01.18	41 48.88	Calanus C5	19
5	1	3/7/2005	1:28	09 01.18	41 48.88	Temora females	25
5	1	3/7/2005	1:28	09 01.18	41 48.88	Temora females	30
5	1	3/7/2005	1:28	09 01.18	41 48.88	Sagitta	6
5	1	3/7/2005	10:55	09 01.35	41 47.04	Cirriped larvae	36
5	1	3/7/2005	10:55	09 01.35	41 47.04	Cirriped larvae	26
6	1	4/7/2005	11:03	09 06.53	41 47.05	Centropages females	25
6	1	4/7/2005	11:03	09 06.53	41 47.05	Centropages females	25
6	1	4/7/2005	11:03	09 06.53	41 47.05	Centropages females	25
6	3	6/7/2005	1:20	09 06.53	41 46.84	Centropages females	21
6	3	6/7/2005	1:20	09 06.53	41 46.84	Centropages females	20
6	3	6/7/2005	1:20	09 06.53	41 46.84	Centropages females	14
6	1	4/7/2005	11:03	09 06.53	41 47.05	Centropages males	25
6	1	4/7/2005	11:03	09 06.53	41 47.05	Centropages males	25
6	3	6/7/2005	1:20	09 06.53	41 46.84	Centropages males	23
6	1	4/7/2005	11:03	09 06.53	41 47.05	Acartia clausi females	25
6	1	4/7/2005	11:03	09 06.53	41 47.05	Acartia clausi females	26
6	1	4/7/2005	11:03	09 06.53	41 47.05	Acartia clausi females	25
6	1	4/7/2005	11:03	09 06.53	41 47.05	Acartia clausi females	26
6	1	4/7/2005	11:03	09 06.53	41 47.05	Acartia clausi females	27
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus females	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus females	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus females	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus females	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus females	8
6	3	6/7/2005	1:20	09 06.53	41 46.84	Calanus females	20
6	3	6/7/2005	1:20	09 06.53	41 46.84	Calanus females	20
6	3	6/7/2005	1:20	09 06.53	41 46.84	Calanus females	20
6	3	6/7/2005	1:20	09 06.53	41 46.84	Calanus females	20
6	1	4/7/2005	11:03	09 06.53	41 47.05	Calanus C5	10
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus C5	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus C5	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus C5	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus C5	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus C5	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus C5	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus C5	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus C5	6
6	2	5/7/2005	1:18	09 06.62	41 46.99	Calanus males	7
6	3	6/7/2005	1:20	09 06.53	41 46.84	Calanus males	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Isias clavipes females	20
6	2	5/7/2005	1:18	09 06.62	41 46.99	Isias clavipes females	9
6	3	6/7/2005	1:20	09 06.53	41 46.84	Candacia females	6
6	3	6/7/2005	1:20	09 06.53	41 46.84	Candacia males	7
6	3	6/7/2005	1:20	09 06.53	41 46.84	Candancia C5	13
6	3	6/7/2005	1:20	09 06.53	41 46.84	Decapod larvae	20
6	3	6/7/2005	1:20	09 06.53	41 46.84	Decapod larvae	20
6	3	6/7/2005	1:20	09 06.53	41 46.84	Decapod larvae	21
6	2	5/7/2005	1:18	09 06.62	41 46.99	Sagitta	10
6	2	5/7/2005	1:18	09 06.62	41 46.99	Amphipods	10
6	1	4/7/2005	11:03	09 06.53	41 47.05	Trichodesmium	1 sample

Appendix 9. Microzooplankton Sampling Log

Date	Station	Sampling Device	Depth m / cms	Lugol Vol (ml)	Slide prep Volume (ml)	Volume (l)
6/21/2005	1	CTD2	0	200	100	
6/21/2005	1	CTD2	12	200	100	
6/21/2005	1	CTD2	18	200	100	
6/21/2005	1	CTD2	50	200	100	
6/21/2005	1	CTD2	61	200	100	
6/21/2005	1	CTD2	75	200	100	
6/21/2005	1	CTD2	110	200	100	
6/21/2005	1	CTD2	200	200	100	
6/22/2005	1	CTD4	0	200	100	
6/22/2005	1	CTD4	12	200	100	
6/22/2005	1	CTD4	18	200	100	
6/22/2005	1	CTD4	50	200	100	
6/22/2005	1	CTD4	100	200	100	
6/22/2005	1	CTD4	200	200	100	
6/22/2005	1	CTD5	0	200	100	
6/22/2005	1	CTD5	12	200	100	
6/22/2005	1	CTD5	18	200	100	
6/22/2005	1	CTD5	50	200	100	
6/22/2005	1	CTD5	100	200	75	
6/22/2005	1	CTD5	200	200	100	
6/23/2005	1	CTD7	0	250	100	
6/23/2005	1	CTD7	18	250	100	
6/23/2005	1	CTD7	39	250	100	
6/23/2005	1	CTD7	100	250	100	
6/23/2005	1	G. screens		250	100	
6/23/2005	1	MLSD		250	100	
6/23/2005	1	CTD8	0	250	100	
6/23/2005	1	CTD8	18	250	62	
6/23/2005	1	CTD8	40	250	100	
6/23/2005	1	CTD8	100	250	100	
6/23/2005		Zoo pump	1.2m			10L
6/24/2005	2	CTD9	surf	250ml	100	10L
6/24/2005	2	CTD9	9	250ml		10L
6/24/2005	2	CTD9	29	250ml	100	
6/24/2005	2	CTD9	60	250ml		
6/24/2005	2	CTD9	100	250ml		
6/24/2005	2	CTD9	200	250ml		
6/24/2005	2	NSSD	84	250ml	100	
6/24/2005	2	NSSD	104	250ml	100	
6/24/2005	2	NSSD	151	250ml	100	
6/24/2005	2	NSSD	182	250ml	100	
6/24/2005	2	NSSD	217	250ml	100	
6/24/2005	2	G. screens		250ml	100 x 2	
6/24/2005	2	MLSD		250ml	100 x 2	
6/25/2005	2	CTD13	surf	250ml	100	10L
6/25/2005	2	CTD13	9	250ml	100	10L
6/25/2005	2	NSSD	25	250ml	100	
6/25/2005	2	NSSD	44.5	250ml	100	
6/25/2005	2	NSSD	64		88	
6/25/2005	2	NSSD	84	250ml	100	
6/25/2005	2	NSSD	104	250ml	100	
6/25/2005	2	NSSD	151	250ml	100	
6/25/2005	2	NSSD	182	250ml	100	
6/25/2005	2	NSSD	217	250ml	100	
6/25/2005	2	G. screens		250ml	100 x 2	
6/25/2005	2	MLSD		250ml	100 x 2	
6/26/2005	2	NSSD	25	250ml	100	

Date	Station	Sampling Device	Depth m / cms	Lugol Vol (ml)	Slide prep Volume (ml)	Volume (l)
6/26/2005	2	NSSD	44.5	250ml	100	
6/26/2005	2	NSSD	64	250ml	88	
6/26/2005	2	NSSD	84	250ml	100	
6/26/2005	2	NSSD	104	250ml	100	
6/26/2005	2	NSSD	151	250ml	100	
6/26/2005	2	NSSD	182	200ml	37	
6/26/2005	2	G. screens		250ml	2 x 100	
6/26/2005	2	MLSD		250ml	2 x 100	
6/26/2005	2	CTD14	30m			10L
6/27/2005	3	NSSD	25	250ml	100	
6/27/2005	3	NSSD	44.5	250ml	100	
6/27/2005	3	NSSD	64	250ml	100	
6/27/2005	3	NSSD	84	250ml	100	
6/27/2005	3	NSSD	104	250ml	100	
6/27/2005	3	NSSD	151	250ml	100	
6/27/2005	3	NSSD	182	200ml	100	
6/27/2005	3	NSSD	217	250ml	100	
6/27/2005	3	G. screens		250ml	3 x 30	
6/27/2005	3	MLSD		250ml	3 x 30	
6/27/2005	3	zoo pump	1.2M			10L
6/27/2005	3	CTD16	40m			10L
6/28/2005	4	CTD17	0	250ml	100ml	10L
6/28/2005	4	CTD17	4	250ml	100ml	
6/28/2005	4	CTD17	10	250ml	100ml	
6/28/2005	4	CTD17	17	250ml	100ml	
6/28/2005	4	CTD17	30	250ml	100ml	
6/28/2005	4	CTD17	40	250ml	100ml	
6/28/2005	4	CTD17	50	200ml	100ml	10L
6/28/2005	4	CTD17	90	250ml	100ml	
6/29/2005	4	G. Screens		250ml	3 x 30	
6/29/2005	4	MLSD		250ml	3 x 30	
6/29/2005	4	NSSD	25cm	250ml	100ml	
6/29/2005	4	NSSD	64cm	250ml		
6/29/2005	4	NSSD	84cm	250ml	100ml	
6/29/2005	4	NSSD	104cm	250ml		
6/29/2005	4	NSSD	151cm	250ml	100ml	
6/29/2005	4	G. Screens		250ml	3 x 30	
6/29/2005	4	MLSD		250ml	3 x 30	
6/29/2005	4	NSSD	25cm	250ml	100ml	
6/29/2005	4	NSSD	44.5cm	250ml		
6/29/2005	4	NSSD	64cm	250ml	100ml	
6/29/2005	4	NSSD	84cm	250ml		
6/29/2005	4	NSSD	151cm	250ml	100ml	
6/29/2005	4	CTD19	surface			10L
6/29/2005	4	CTD19	30			10L
6/30/2005	4	CTD20	6	250	100	10L
6/30/2005	4	CTD20	11	250	100	
6/30/2005	4	CTD20	16	250	100	
6/30/2005	4	CTD20	35	250	100	
6/30/2005	4	CTD20	45	250	100	10L
6/30/2005	4	CTD20	60	250	100	
6/30/2005	4	CTD20	90	250	100	
7/1/2005	4	NSSD	25	250	100	
7/1/2005	4	NSSD	44.5	250	100	
7/1/2005	4	NSSD	64	250	100	
7/1/2005	4	NSSD	84	250	100	
7/1/2005	4	NSSD	104	250	100	
7/1/2005	4	NSSD	151	250	100	
7/1/2005	4	NSSD	182.5	250	100	

Date	Station	Sampling Device	Depth m / cms	Lugol Vol (ml)	Slide prep Volume (ml)	Volume (l)
7/1/2005	4	NSSD	217	250	100	
6/30/2005	4	CTD23	0	10L		
6/30/2005	4	CTD23	30	10L		
7/2/2005	4	NSSD	25	250	100	
7/2/2005	4	NSSD	44.5	250	100	
7/2/2005	4	NSSD	64	250	100	
7/2/2005	4	NSSD	84	250	100	
7/2/2005	4	NSSD	104	250	100	
7/2/2005	4	NSSD	151	250	100	
7/2/2005	4	NSSD	182.5	250	100	
7/2/2005	4	NSSD	217	250	100	
7/2/2005	4	G. screens		250	3 x 30	
7/2/2005	4	CTD26	0			10L
7/2/2005	4	CTD26	32			10L
7/3/2005	5	CTD29	0	250	100	10L
7/3/2005	5	CTD29	9	250	100	
7/3/2005	5	CTD29	23	250	100	
7/3/2005	5	CTD29	33	250	100	10L
7/3/2005	5	CTD29	55	250	100	
7/3/2005	5	CTD29	75	250	100	
7/4/2005	6	CTD30	0	250	100	10L
7/4/2005	6	CTD30	9	250	50	
7/4/2005	6	CTD30	23	250	50	
7/4/2005	6	CTD30	30	250	100	10L
7/4/2005	6	CTD30	44	250	50	
7/4/2005	6	CTD30	55	250	50	
7/4/2005	6	CTD30	75	250	100	
7/4/2005	6	CTD30	90	250	100	
7/4/2005	6	CTD31	0	250	100	
7/4/2005	6	CTD31	9	250	100	
7/4/2005	6	CTD31	23	250	100	
7/4/2005	6	CTD31	35	250	100	
7/4/2005	6	CTD31	75	250	50	
7/4/2005	6	CTD31	90	250	100	
7/5/2005	6	NSSD	25	250	50	
7/5/2005	6	NSSD	44.5	250	50	
7/5/2005	6	NSSD	64	250	50	
7/5/2005	6	NSSD	217	250	50	
7/5/2005	6	G. screen		250	3 x 30	
7/5/2005	6	MLSD		250	2 x 25	
7/5/2005	6	CTD36	0	250	50	
7/5/2005	6	CTD36	30	250	50	
7/5/2005	6	CTD36	90	250	50	
7/5/2005	6	CTD35	0			10L
7/5/2005	6	CTD35	35			10L
7/6/2005	6	CTD38	0	250	50	10L
7/6/2005	6	CTD38	6	250	50	
7/6/2005	6	CTD38	12	250	50	10L
7/6/2005	6	CTD38	18	250	50	
7/6/2005	6	CTD38	44	250	50	
7/6/2005	6	CTD38	65	250	50	
7/6/2005	6	CTD38	90	250	50	