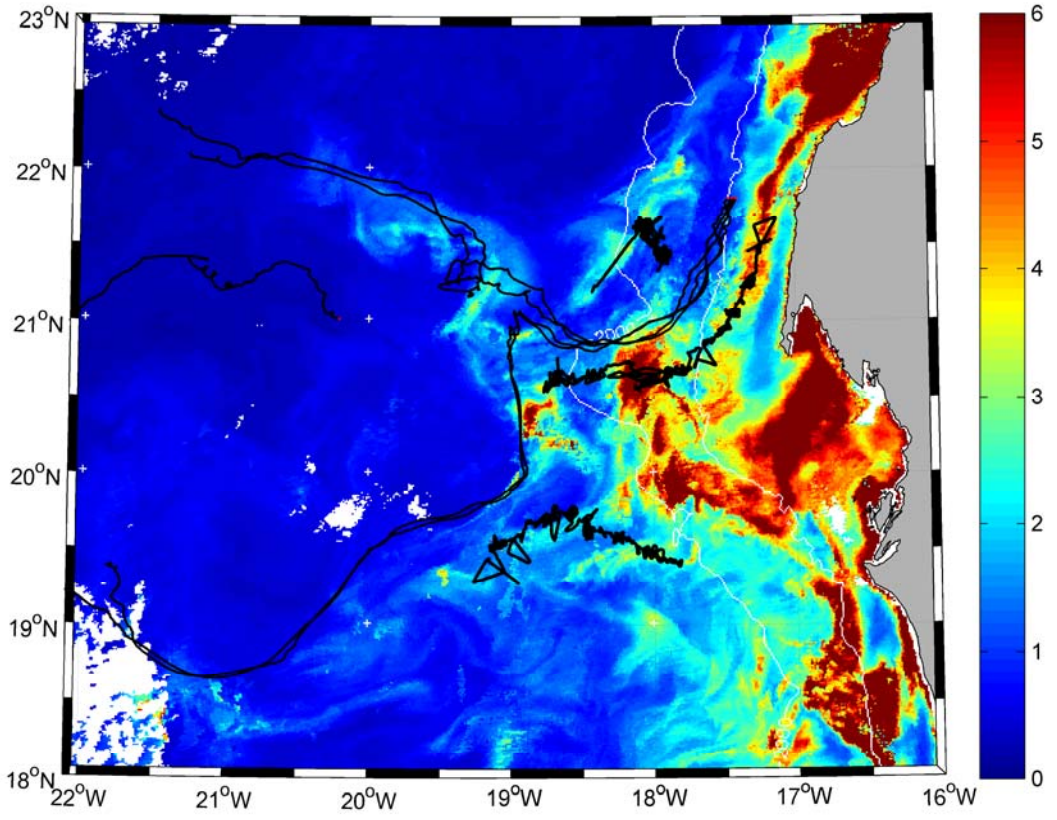
surface ocean solas lower atmosphere study

The impact of coastal upwelling on the air-sea exchange of climatically important gases (ICON)

RRS Discovery 338 Cruise Report

Principal Scientist : Carol Robinson,
University of East Anglia



PML Plymouth Marine Laboratory
UEA University of East Anglia
CSIC
IIM Instituto de Investigaciones Marinas de Vigo
NATURAL ENVIRONMENT RESEARCH COUNCIL
UNIVERSIDADE DE VIGO
National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

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Acknowledgements

Fieldwork such as this cannot take place without the contribution of a very large number of people, and we'd like to thank all those who ensured this cruise happened and made it such a memorable experience.

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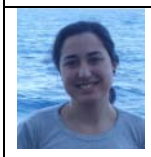
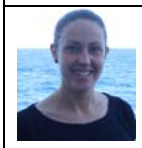
Many thanks to Phil Williamson and the UK SOLAS Scientific Steering Committee for believing in us so much that they supplemented the grant TWICE in order to bear the costs incurred when the cruise was postponed at short notice in both 2006 and 2008.

Many thanks to Ed Blockley at the UK Met Office, and Steve Groom, Peter Walker, Ben Taylor and Jane Netting at NEODAAS (NERC Earth Observation Data Acquisition and Analysis Service) who supplied us with ocean forecast temperature, salinity, mixed layer depth and ocean current data and ocean colour and sea surface temperature satellite images throughout the cruise.

We thank the officers and crew on board RRS Discovery 338 for their outstanding support in ensuring the success and safety of this cruise. Thanks to the NMF-SS team Dan Comben, Dave Teare, John Wynar, Kev Smith and Martin Bridger whose technical excellence and professionalism we rely upon. Thanks to Malcolm Woodward for cruise logistics and Dawn Ashby for maintaining the cruise diary website.

Cruise participants

	Carol Robinson	University of East Anglia	Principal Scientist O_2 & DIC cycling
	Beatriz Barreiro	Instituto Investigaciones Marinas (CSIC), Vigo, Spain	MVP, surface drifters, turbulence probe
	Rachael Beale	Plymouth Marine Laboratory	Oxygenated volatile organic compounds
	Ian Brown	Plymouth Marine Laboratory	pCO_2, DIC, N_2O, CH_4, SF_6
	Darren Clark	Plymouth Marine Laboratory	Nitrogen cycling
	Jo Dixon	Plymouth Marine Laboratory	Microbial turnover of oxygenated volatile organic compounds
	Polly Hill	National Oceanography Centre, Southampton	Microbial cycling of organic compounds
	Frances Hopkins	Plymouth Marine Laboratory	DMS dynamics

	Susan Kimmance	Plymouth Marine Laboratory	DMS dynamics
	Vassilis Kitidis	Plymouth Marine Laboratory	O_2 dynamics, CO, pH, DOC, amino acids
	Malcolm Liddicoat	Plymouth Marine Laboratory	SF_6
	Thomas Meunier	Instituto Investigaciones Marinas (CSIC), Vigo, Spain	MVP, turbulence probe
	Phil Nightingale	Plymouth Marine Laboratory	SF_6, air-sea exchange
	Andrew Rees	Plymouth Marine Laboratory	CH_4, N_2O dynamics
	Pablo Serret	University of Vigo, Spain	O_2 dynamics, plankton respiration
	Tim Smyth	Plymouth Marine Laboratory	Optics, surface drifters, Carioca buoy

	John Stephens	Plymouth Marine Laboratory	DMS dynamics, SF_6 deployment
	Glen Tarran	Plymouth Marine Laboratory	Plankton community structure, DMS dynamics
	Simon Thomas	Plymouth Marine Laboratory	Phosphate cycling
	Gavin Tilstone	Plymouth Marine Laboratory	CDOM, fDOM photochemistry
	Ricardo Torres	Plymouth Marine Laboratory	MVP, surface drifters, turbulence probe
	Claire Widdicombe	Plymouth Marine Laboratory	Primary production, chlorophyll
	Malcolm Woodward	Plymouth Marine Laboratory	Inorganic nutrients

National Marine Facilities – Sea Systems

	Dan Comben		Kevin Smith
	Dave Teare		Martin Bridger
	John Wynar		

Officers and crew

	Peter Newton Master		John Leask Chief Officer
	Mike Hood Second officer		Iain Macleod Third officer
	Ian Slater Chief Engineer		Chris Carey Second Engineer
	Gary Slater Third Engineer		Tom Levy Third Engineer

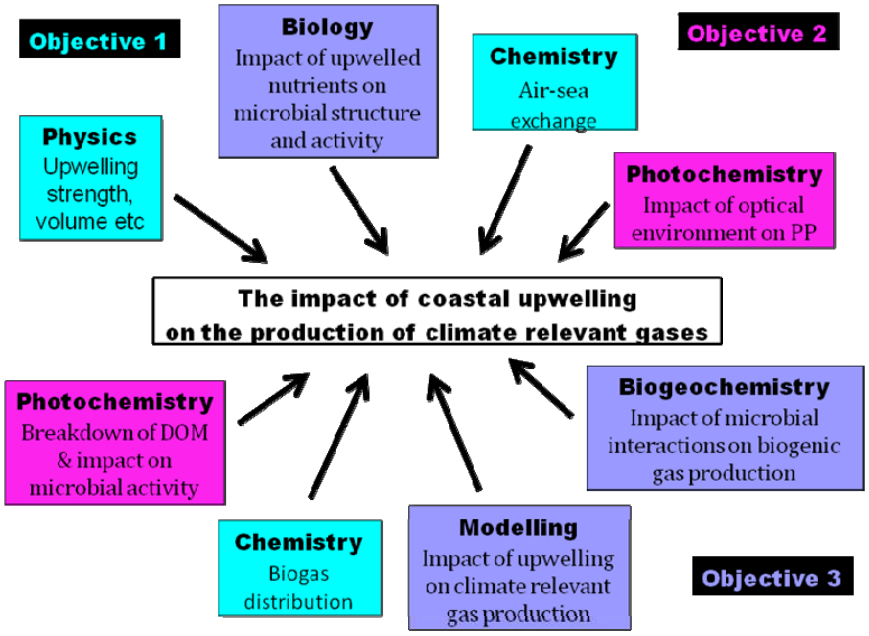
	Patrick Fieldhouse Electrician		Mike Ripper Purser
	Greg Lewis		John Smyth
	Philip Allison		Mark Squibb
	Steve Duncan		John Brodowski
	Paul Backhouse		Ian Sarginson
	Mark Preston Head Chef		Lloyd Sutton Chef
	Peter Robinson Steward		

Cruise objectives

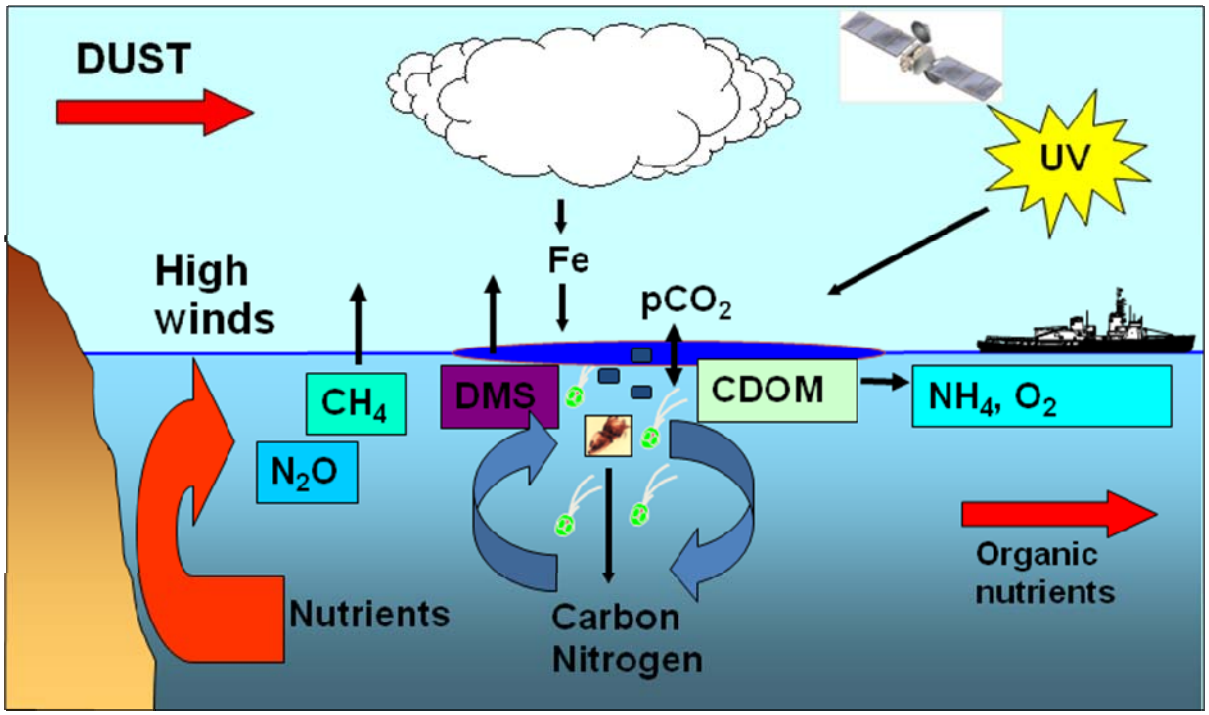
This cruise is part of the UK science contribution to the international SOLAS project (Surface Ocean Lower Atmosphere Study www.uea.ac.uk/env/solas/) which aims to advance our understanding of environmentally important interactions between the ocean and the atmosphere. Data collected during the cruise will help to determine the influence of coastal/shelf regions (20-200 km offshore) on microbiological activity in the ocean and chemical interactions between the ocean and the atmosphere. Deep water containing high concentrations of nutrients such as nitrate, and gases such as nitrous oxide and methane, rises to the surface (upwells) at the Mauritanian shelf edge and moves offshore. These nutrients can be chemically altered by sunlight and used by bacteria and microscopic plants to grow. The gases escape to the atmosphere and contribute to global warming. This cruise will sample the upwelled water as it moves offshore measuring its temperature, salinity, nutrient and gas content and the impact this water has on microbiological growth and atmospheric composition in order to improve international global climate models.

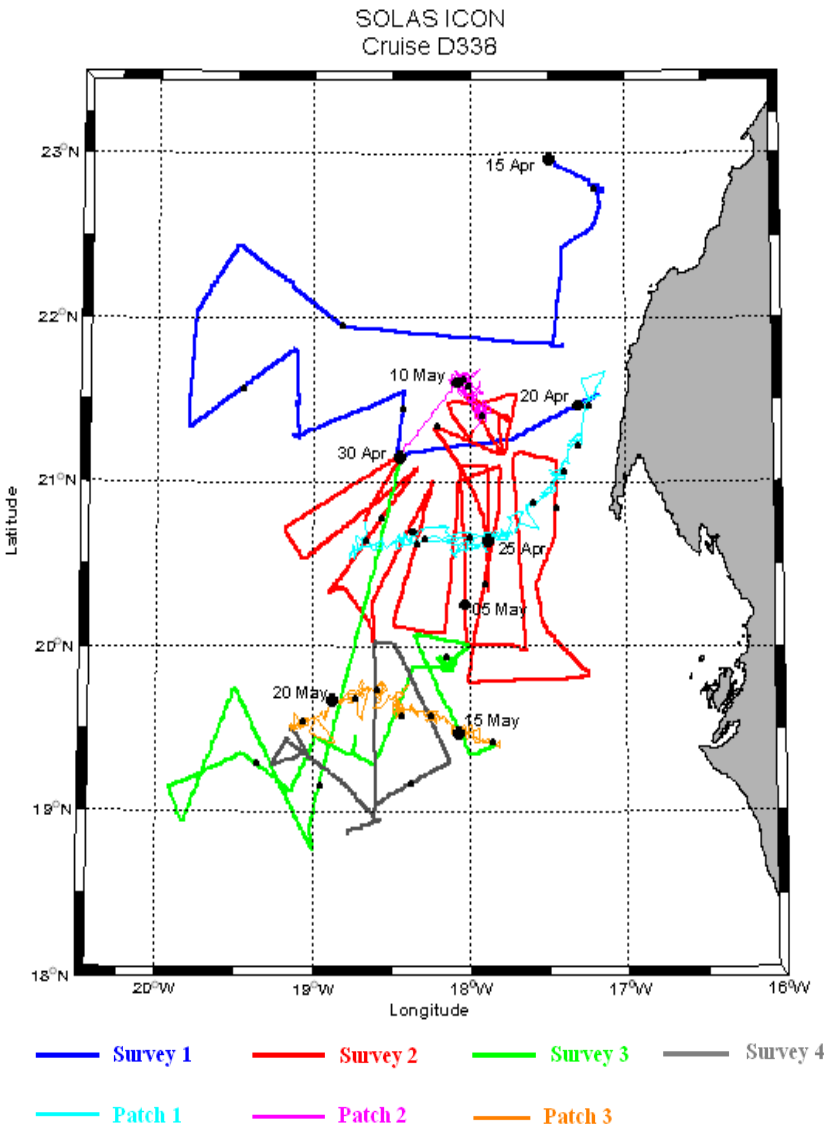
The cruise has three scientific objectives:

- To determine the role of upwelling on the supply, loss and air-sea exchange of climatically important gases produced by plankton
- To determine the role of light in breaking down upwelled and recently produced dissolved organic matter and in producing climatically important trace gases
- To determine the impact of nutrient enriched upwelled water on the spatial and temporal variability of plankton community structure and activity and resultant influence on biogenic gas flux

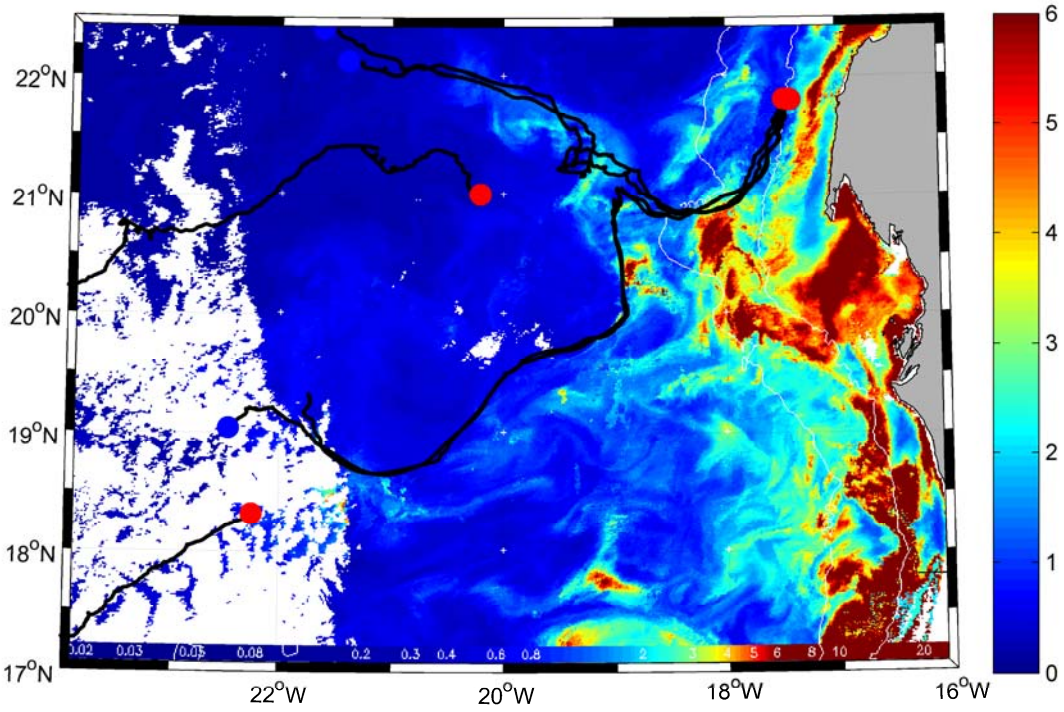


To achieve these objectives, the first part of the cruise will consist of a detailed hydrographic study of the transport of the deep cold water filaments as they reach the surface and move offshore. We will then release 5 drifting buoys within the cold water filament together with the inert tracer sulphur hexafluoride. This tracer is biologically non-toxic, not taken up by plankton or fish and is not retained in the ocean, but is released (over a period of 30 days) from the upper ocean to the atmosphere. Using the buoys and measuring the tracer, we will continually position the ship in the centre of the filament and so determine a time series of microbiological growth and decay and photochemical degradation of organic matter associated with the upwelled water.





Cruise Track during SOLAS-ICON RRS Discovery 338 cruise (15th of April to 27th May 2009)



Drifter tracks covering the period 17 April to 22 May 2009 overlaid on a Modis chlorophyll-a satellite composite covering the period 5 to 10 May 2009. Drifter starting points are indicated with a red circle. Drifter ending points are indicated with a blue circle. The drifters and daily data updates were provided by Mayra Pazos from NOAA.

CRUISE DIARY

Wednesday 15 April 2009 Julian Day 105

We departed Tenerife (28^{o} 28'12.54'' N 16^{o} 14'33.16'' W) at 09:00 BST, passing a huge luxury liner on the way out of the harbour (see photo). Problems with both of RRS Discovery's radars threatened to delay us, however these were rectified during Tuesday. We plotted a course south to Cap Corveiro, at 21^{o}N on the coast of Western Sahara. With the ship rolling gently, the scientists continued to set up and calibrate their instruments, and sort out the usual teething problems with baselines, and standardisation.

The first emergency muster station occurred at 16:15, when we practised getting into our immersion suits and the lifeboats (see photo). This was followed by the first meeting of the 'senior management committee' – consisting of myself and the objective leaders Phil, Andy, Gavin and Riqui. Andy Rees agreed to be the deputy Principal Scientist (Deputy Fahrtleiter), and we discussed co-ordination of the science. The scientists were introduced to the Master - Peter Newton and the Chief Engineer Ian Slater at the first science meeting, held at 19:00. We arranged to put together a photo board of the officers, crew and scientists to help us get to know each other. The scientific plan for the next few days includes flushing out and testing the non-toxic seawater supply, and undertaking a 'shakedown' or test deployment of all the over-side scientific equipment tomorrow afternoon. On arrival at Cap Corveiro we will deploy the Moving Vehicle Profiler (MVP) and undertake a grid survey around the area of most intense upwelling. After the 4 day grid survey we will deploy 5 drifting buoys and the tracer sulphur hexafluoride (SF_6), and begin a 10-12 day 'Lagrangian' study following the patch of upwelled water as it moves offshore. The engineers reported a problem with the CCTV in the winch room, such that the winch driver of the CTD (Conductivity, temperature and depth data collection package) would not be able to monitor the wires on the winch drum as the CTD was deployed. If the CCTV cannot be mended, then at least 2 engineers will need to be in the winch room during each CTD deployment.

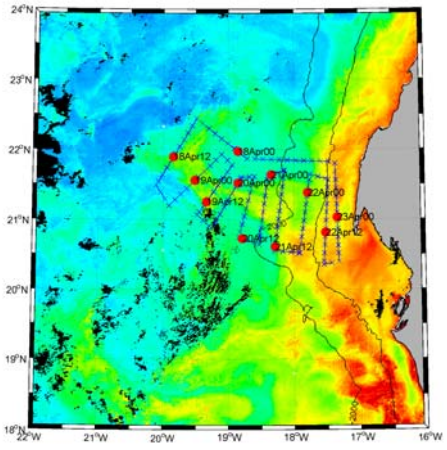
Science on a research ship is always recorded in Greenwich Mean Time (GMT), and so in order to minimise the risk of confusion between the science recorded in GMT and meals occurring at times in BST (British Summer Time), the clocks will go back one hour tonight to GMT.

Thursday 16 April Julian Day 106

Dawn occurred at approximately 06:15 (official sunrise at 06:47, sunset at 19:29 and twilight until after 20:00), wind speed 10 knots and wind direction 69^{o} True. At 07:10 GMT we were at 24^{o} 21.62^{o}N 17^{o} 01.10 ^{o}W, heading south, and keeping west of the 1000m depth contour in order to deploy the instruments in deep water. The sunny weather encouraged lots of willing pairs of hands to set up the incubators on the aft deck (see photo). After lunch we completed the 'shakedown' station, deploying a drogue drifter with an instrument package called a 'wirewalker' which mechanically 'walks' or moves up and down the vertical wire collecting data. This is a newly configured instrument/buoy/drogue package and so it took some time to achieve the correct buoyancy and design an efficient method of deployment and recovery. We will be deploying and recovering one of these buoys every few days during the 'Lagrangian' experiment and so it was important to plan and practise the deployment and recovery. Dan Comben and Mark Squibb are to be congratulated for their effective co-ordination of this operation. We then deployed the towed 'fish', which pumps 'clean' surface seawater into the deck laboratory from which we will sample for volatile organic compounds, nutrients and biogenic gases. We also deployed the CTD + water bottle rosette and the optics rig before recovering the drifter and wirewalker. The final test deployment of the day was the MVP, which was towed for 6 hours across the shelf break.

Friday 17 April 2009 JD 107

MVP operations finished at 05:00. The weather forecast for the next few days is force 6 gusting force 7. The sea surface temperature monitored continually with a flow-through thermosalinograph (TSG) is 17.8^{o}, the salinity is 36.3, and the air temperature is 17^{o}C. Most of the scientific equipment is working well, apart from the liquid nitrogen generator. This prevents us from measuring dimethylsulphide, one of the climate relevant gases this project is focussing on. At 09:00 we deployed four 'throw over' buoys which will track the water currents and transmit temperature data back to the ship. We hadn't been able to receive satellite images on the ship until this morning, when the problem with the email was solved. This meant that Riqui Torres could use the latest image of ocean colour (an indicator of the plankton production due to the high nutrient upwelled water) to design a grid survey to quantify the volume and speed of upwelled water moving offshore. Once the grid was designed, Mike Hood, the Second Officer could input the co-ordinates into the ship's navigation system to allow us to



sample the high and low productivity waters (see satellite image : red / orange is high plankton biomass and blue / green is low plankton biomass). We deployed the MVP at 13:00 in a maximum depth of 350m and followed the survey grid at a speed of 7 knots. We will continue to follow this grid over the next 4 days, collecting samples for chlorophyll to calibrate the underway fluorometer, dissolved oxygen to calibrate the underway oxygen optode, temperature, salinity and inorganic nutrients. We will stop once a day, bring the MVP inboard and carry out one CTD station to sample vertically through the water column. Unfortunately the MilliQ water system broke down this evening – this provides ultra clean water for the chemists and microbiologists to use. We have a back-up system, but this is too small to provide sufficient water for all the scientists at the speed they require it. The increased rolling of the ship during today meant that several people were feeling worse for wear, or had taken to their bunks. We turned in early, ready for the first 'pre-dawn' productivity station at 04:00, not knowing how many people would be fit enough to sample.

Saturday 18 April 2009 JD 108

After a good nights' sleep, many people gained their sea-legs and were able to sample from the 'monster' CTD cast (for scientists who require large 'monster' volumes [60-80 litres] of seawater for their experiments) at 04:15 and the 'pre-dawn' CTD cast (for scientists requiring smaller volumes of water but at several depths) at 05:50. The Engineers, including Chris Carey (Second), Gary Slater (Third) and Tom Levy (Third) (see photo) have successfully reconfigured the CCTV system to allow the CTD winch operator to monitor the winches. The sea surface temperature (SST) was 19.9^{o}C, salinity 36.7, and fluorescence (a measure of plankton biomass) very low at 0.17 fluorescence units. Martin Bridger, Kev Smith and Dan Comben worked in shifts through the night and day to try to mend the MilliQ water system. Without this system, many people had to curtail their experiments, and we began to calculate how much MilliQ water everyone really needed (rather than how much they would like) and the relative merits and disadvantages of travelling to either Tenerife or Cape Verde to pick up a new system. During the afternoon the wind speed was 4.4 ms^{-1} at 205^{o}. We continued the MVP survey throughout the day, with the MVP profiling (towed behind the ship moving up and down between the surface and 350m) every 8 minutes. In order to deploy the surface patch of SF_6 on Wednesday, Phil Nightingale, John Stephens and Malcolm Liddicoat flush a 6000 litre tank of seawater with SF_6 from a gas cylinder until the water is

saturated with the gas. They can only do this when the ship is facing into the wind so that any saturated SF_6 in the air blows away from the ship rather than into the laboratory where it can contaminate the instruments which can measure SF_6 at vanishingly small quantities (as low as one 'ato mole' or 1 part in 1000,000,000,000,000,000). They therefore needed to work in shifts to do this at the times the ship was travelling in the correct direction relative to the wind. In the early evening, Dan, Martin and Kev found and rectified the fault on the MilliQ system (see photo) – a tiny (8mm) fuse had blown on a circuit board. This was an amazing marathon of patient problem solving – well done lads – and thank you so much. Sometime during the day, we realised there was a problem with the email system at the National Oceanography Centre, Southampton which processes all the scientists' emails from the ship to the outside world. As it is a non-working day in the 'real' world, we didn't expect any contact with home until Monday morning when the Southampton staff return to work.

They say that an army marches on its' stomach, and in the daily routine of life onboard, food becomes a vital 'normaliser'. Meal times at sea are: breakfast 07:20-08:30, lunch 11:20-12:30 and evening meal 17:20-18:30. The food on this trip has been exceptional, with the catering staff including Head Chef Mark Preston and Chef Lloyd Sutton (see photo) producing an outstanding range of food three times a day for almost 50 people. The split pea and pea and ham soups are specialities, and the cheesecakes, chocolate cakes and quiches are out of this world.

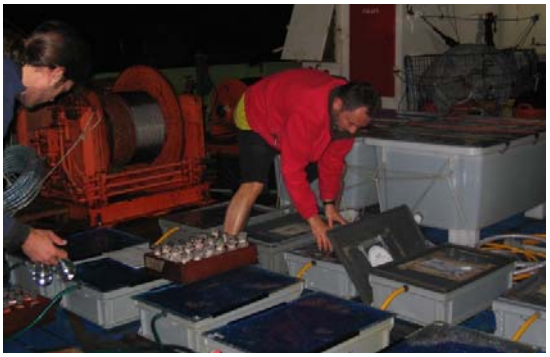
Sunday 19 April 2009 JD 109

An interesting phenomenon which happens during research cruises, is that time can simultaneously progress incredibly quickly and geologically slowly. I'm writing this narrative on Monday morning, and yet it seems that Sunday was an eon ago - so much has happened in the last 24 hours that I can hardly remember how things seemed back then. My logbook says that the 'monster' CTD cast occurred at 07:00 and the 'pre-dawn' cast just after 08:00. SST was 19.2 ^{o}C, salinity 36.6, air temperature 18.7 ^{o}C and fluorescence 0.3 fluorescence units. Although the MilliQ system was fixed last night, it cannot be used until the reservoir tank is full (estimated to occur before breakfast today). An electricity short caused some downtime of equipment and precipitated some rewiring in the port container. As the email system was still down, we arranged for any satellite images and drifter positions from NEODAAS (National Earth Observation Data Aquisition and Analysis Service, UK) and NOAA (National Oceanographic and Atmospheric Administration, USA) to go to the Captain's independent email address. We are extremely grateful for this and apologise for the extra inconvenience this caused him. We were especially pleased when we received position data from all the drifters we deployed on Friday off the coast of Morocco. In

order to try and isolate the electrical fault on the ship we systematically went through most of the laboratories switching off each power point and checking whether the electrical short reduced. Since some of the specialised instruments take several days to set up, we did not power everything down and so didn't find the problem. However, the tray containing the condensation water from the air conditioning unit above the deck laboratory flooded spectacularly through the ceiling this morning, so that is a potential culprit. Once the early morning CTDs were inboard, we deployed the MVP and continued a survey of the physical (temperature, salinity, water speed and direction) features of the upwelled filament. At 13:00, the MVP stopped working, and at 14:00 the PES fish (which accurately measures depth) stopped working. Both instruments were brought onboard, and Dan Comben, Dave Teare, John Wynar and Martin Bridger began to take them apart to find the respective faults. At 21:00 we decided to continue the survey without the MVP, recording ADCP (water current) data and stopping every 30 minutes for a CTD. This meant removing 24 x 20 litre sampling bottles from the CTD and adjusting shifts so that Dave could continue working on the MVP while Dan and John operated the CTD. Beginning to think the cruise had surely had sufficient

bad luck, we continued to monitor the 'filament' of cold upwelled water which moves south and then curls west and northwest offshore. These measurements continued overnight until the 'monster' cast at 03:00 on Monday. Meanwhile the scientists were grappling with problems associated with the breakdown of the liquid nitrogen generator (see photo), calibrating chemicals for the dissolved oxygen systems, re-plumbing solenoid valves in the nitrous oxide system, and reconfiguring the cuvette holder for the chlorophyll fluorometer. Just another boring day at the office !

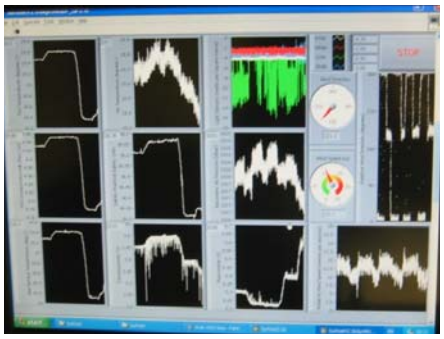
Monday 20 April 2009 JD 110



One of the most important sampling times of the day for us is the early morning CTD casts. This is the only time of the day when we can collect water, siphon it carefully into replicate bottles and 'incubate' it on the aft deck during daylight hours. The incubators are cooled to the temperature at which the sample was collected and covered in blue plastic screens which simulate the light intensity and colour spectrum of the water that was collected. The samples are incubated for 24 hours and we put the bottles in the incubators before dawn so that the plankton samples which were collected from depths where light is very low (those below about 35m here) do not get 'light shocked' (see photo). We measure the activity of the plankton by determining at the end of

the incubation, how much carbon they have taken up (Claire), how much oxygen they produce or consume (Pablo and Vas), how much amino acids they take up (Polly), how much nitrogen they consume or produce (Darren), and how much phytoplankton is eaten by zooplankton and how much is lysed by viruses (Susan). This 'pre-dawn' series of casts start at about 03:00, so you can imagine the potential chaos caused by 15 sleepy scientists wanting to collect water from various combinations of 24 depths in the dark. We also measure dissolved gases in the water – such as oxygen, nitrous oxide, methane, dimethyl sulphide and the two gases we will be deploying – helium and sulphur hexafluoride. These gases have different solubility properties in seawater and so it is important to sample the CTD bottles in a particular order so that those gases which are furthest from equilibrium in the air are sampled first. This means that the first person sampling from each CTD bottle has the pressure of knowing everyone else is waiting for them to finish. Of course, everyone would like to be first so that they can get their samples analysed quickly, so there is usually a bit of jostling and overtaking. Then just to add extra spice to the mayhem, on every cast 1 or 2 of the CTD bottles don't work and so the complex plan we had made beforehand and copied on to a white board, quickly has to be re-arranged with minimum huff taking.

This morning we aimed to sample water with a relatively high plankton concentration. Therefore



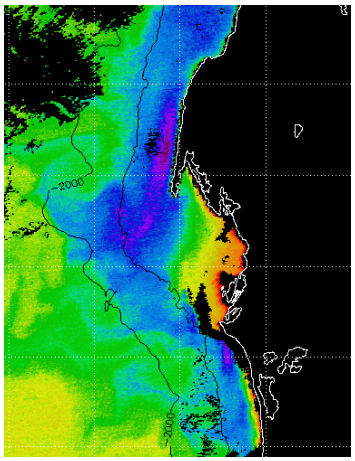
we needed to monitor the underway measurements of fluorescence (related to the amount of phytoplankton present) and stop the ship when the fluorescence reaches a maximum. This is easier said than done, as someone has to watch the data stream (see photo) and guess whether the next measurement will be higher or lower ! There is also a time lag equivalent to a few hundred metres between where the sample was taken and where the ship is by the time you see the data. We are in an area where the plankton concentration is extremely patchy and so unless you react quickly, by the time the ship has slowed down, it can travel out of the high plankton patch. This is what happened this morning, and so to try to return to an area with a high plankton concentration I asked the bridge to turn the ship around (such power I have !). 2nd Officer Mike Hood (see photo) performed a classic Williamson turn (that which is used to return to exactly the same place should someone go overboard) to get us back into a moderately high plankton region.

During the day the weather worsened from Force 7 to gusting Force 9. We tried to continue the large scale survey measuring water currents, temperature and salinity, but were restricted to one direction of travel to avoid putting the ship broadside to the weather. We headed inshore to an

area of high plankton concentration as seen in the satellite ocean colour images, and planned how to deploy the buoys and SF_6 scheduled for Wednesday. However, as the weather remained force 7-9 and the forecast predicted the same for the next 4 days, it was possible that we would soon be hove to with all over-side activities cancelled. The area in which we wanted to deploy the SF_6 and drifters was also very close to a number of pinnacles rising from the seabed at 60m or so to 11m, and marked on the chart as 'position doubtful'. This region has undergone few previous bathymetric surveys – and so understandably we were 'proceeding with caution'. The ship travelled up and down the line of least pitch and roll during the night, at one stage being close enough to land to use mobile phones.

Tuesday 21 April 2009 JD 111

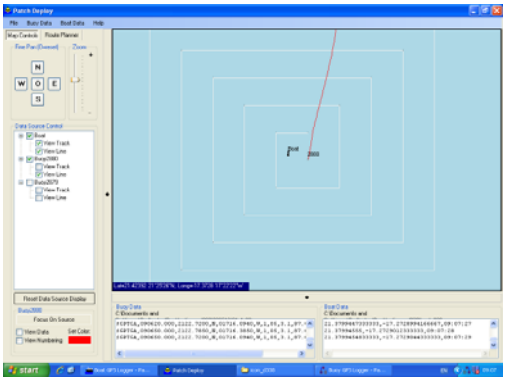
03:00 came around all too quickly, and with the wind and swell dropping overnight, we were able to deploy the two pre-dawn CTDs to collect water samples, before a short ADCP survey to the north and east of the area of high plankton concentration. The data from the ADCP survey and the tracking of the 4 'throw away' drifters we deployed on Friday suggested that this would be a good place to deploy the SF_6 with a view to following a single water mass as it moved south and west for the next 10-12 days. Riqui and Tim (see photo) spent the rest of the day deploying and recovering the drifters, adjusting the buoyancy on the 'wire walkers', and testing the deployment of the turbulence probe (which measures fine scale water movement). Around lunchtime we received a satellite image of sea surface temperature which showed that yesterday's storm had caused cold nutrient rich water to rise to the surface lowering the surface water temperature (see purple colouration on satellite image – our area of high plankton concentration is around the black splodge [cloud ?] to the west of this). This upwelling of deep water is exactly the process that we are here to study, so the timing of the storm couldn't have been better (though the people who were very ill probably don't think so) – it had produced the start of a new filament which hopefully we can measure throughout its journey from the coast to offshore. At the end of the day, we deployed the drifter plus wire walker which would become the central marker of our SF_6 Lagrangian study (=sampling the same water mass as it moves, as opposed to an Eulerian study which samples the same geographic position irrespective of the water mass flowing past). The ship kept close to this buoy overnight so that we would be ready to



sample alongside it at 03:00 on Wednesday before releasing the sulphur hexafluoride and helium gas patch.

Wednesday 22 April 2009 JD 112

The ship remained close to the wirewalker buoy throughout the night, travelling at a speed of about 1 knot. Dan Comben and the NMF-SS team have mended the liquid nitrogen generator, and so John Stephens was able to measure dimethyl sulphide (a compound produced by plankton and relevant to the atmospheric sulphur cycle) for the first time from the pre-dawn CTDs at 03:30 (see photo). After sampling the CTDs, John, Phil and Malcolm L. finished saturating the tank of seawater with sulphur hexafluoride and helium (see photo), and 3rd Officer Iain Macleod prepared to bring the ship alongside the buoy ready for the tracer release. At this point we realised that the GPS buoy had become detached from the buoyancy above the wirewalker. Since without the GPS buoy we would have no way of finding the wire walker (and so the centre of the SF_6 patch), we knew that we would have to recover both the wirewalker buoy and the GPS buoy, rejoin them and then redeploy them. Unfortunately, without the surface line of the GPS buoy, the wire walker buoy was very difficult to snag with a grapple hook. In attempting to retrieve the wire walker on board, the wire became caught under the boat on the rudder, the rope and drogue snapped and the wirewalker was lost. Ian Slater (Chief Engineer) and his team then had to undertake a series of checks to test that both the rudder and the propeller were unharmed. We waited to be told whether all was OK, or whether we would need to be towed back to Tenerife. When given the all clear to engage the propellor, we successfully retrieved the GPS buoy at around 16:08.

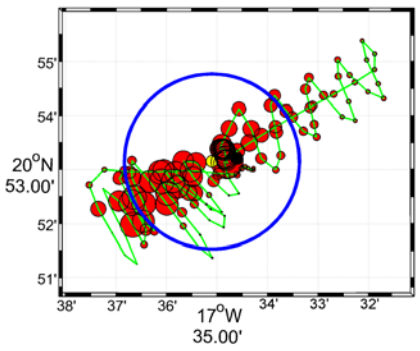


Without the wire walker, we now needed to deploy another drifter as the central marker for the release of SF_6, at the predicted latitude and longitude where the original wire walker buoy would have been had it not been lost (in order for the samples collected alongside the buoy this morning to be relevant to those collected in the future SF_6 patch). Then, using software to continually predict the position of the ship relative to the moving central buoy, we deployed the SF_6 and helium as the ship followed an expanding spiral pattern (see photo of computer screen). The deployment was completed at 23:30, seven hours later than planned, and we then deployed

drifters at the corners of the 3 x 3 km patch of SF_6, finishing at 02:00 on Thursday. These drifters are 'drogued' at a particular depth (ca. 15m), that is, there is a 6m x 2m hooped circle of tarpaulin (known as a holey sock) attached to the wire or rope which drags in the water, helping the drifter to move with the water currents rather than with the surface winds. When the final drifter was deployed, we went for a well deserved drink in the bar to commiserate the loss of the wire walker and celebrate the rest of the deployment. The time series experiment we're about to embark on, is only made possible by the hard work, commitment and professionalism of Riqui and the physics team –Tim, Bea and Thomas and Phil and the SF_6 / air-sea exchange team – Malcolm, John and Ian. After the disappointment of losing the wirewalker less than 24 hours ago, and the scare that 50m of wire had become wrapped around the ship's propeller and so we would need to be towed home, the successful completion of the deployment was a great relief.

Thursday 23 April 2009 JD 113

Only 1 hour after the SF_6 and drifter deployment, we were ready for the first pre-dawn casts within the SF_6 patch. Sea surface temperature was 17.1 ^{o}C, air temperature 16.9 ^{o}C, plankton chlorophyll fluorescence was 0.69 fluorescence units, nitrate concentrations were 7.8 µmol l^{-1} and the wind was a steady 20 knots NNE. The collection of this first data in our time series experiment is a significant milestone. We applied to do this research in 2004/5 and were originally scheduled to undertake the cruise in 2006. However, due to various problems with RRS Discovery, the cruise was postponed from 2006 to 2008 and then again from 2008 to 2009. So it has taken us almost 5 years to reach this point. To say 'well done' to Riqui, Tim, Bea, Thomas, Phil, John and Malcolm L., and 'thank you' to all the ship's officers, crew and technical staff who contributed to this achievement, we celebrated with wine at dinner. The daily timetable from now on will consist of surveying the extent and concentration of the SF_6 patch overnight, pre-dawn casts at 03:30, further CTD casts at 09:00 and 12:00, and when possible 20:00, plankton nets, atmospheric sampling, optical measurements at solar noon and 2 hourly profiles with a free-falling turbulence probe to assess the physical structure of the water column. All overside activities went well today, the net samples revealed an incredibly diverse community of diatoms in the phytoplankton, and the optical cast showed that the depth at which light reduced to 1% of surface irradiance was 35m. At the midday cast SST was 16.8 ^{o}C, salinity 36.18 and chlorophyll fluorescence 0.87. In order to map the SF_6 patch, Phil, Malcolm, John, Frankie and Ian work a shift each to monitor the SF_6 analytical system overnight (see photo – Malcolm Liddicoat monitoring the SF_6 system). The concentrations of SF_6



are plotted on a 'bubble' plot, with the diameter of the bubble indicating the concentration of SF_6 (see figure). Combining information from the ship's track, the track of the 5 buoys we deployed yesterday and the concentration of the SF_6, we can guide the ship to an area with high concentrations of SF_6 and give the navigator an estimate of the distance and direction he should stay from the nearest buoy in order to remain in the SF_6 patch during the day when we have no surface SF_6 measurements (blue circle is 3 km diameter centred on the 'best estimate' of the patch centre at the yellow circle).

Friday 24 April 2009 JD 114

We're beginning to adapt (as much as one ever does) to the routine of working very 'unsociable' hours. Arriving in the laboratory at 02:30, I prepare for the two CTD casts, checking that the weather isn't too rough to deploy anything over the side, that the ship is in an area of high SF_6 concentration, that we are less than 3km from the nearest drifter buoy which is sending its GPS position to the ship, and that the scientists who have requested it, have an early morning wake up call. John Wynar and the CTD team prepare the sensors and water bottles on the CTD, check with the bridge that it is safe to deploy, and monitor the computer display of the measurements made by the CTD sensors – temperature, salinity, dissolved oxygen, light transmission (an indication of the amount of particles in the water) and fluorescence (an indicator of plankton biomass), which are plotted in real time as the CTD package descends in the water (see photo – John Wynar monitoring the CTD). The scientists arrive in the laboratory in time to prepare for sampling or to calibrate their instruments prior to sampling. Some arrive in a fanfare of hyperactive excitement, while others quietly prepare themselves for the melee that will occur once the CTD is on board. Our position is 21^o 00.59 N 17^o 27.91 W. The water depth is 88m, sea surface temperature is 16.8^{o}C, air temperature is 17^{o}C, salinity is 36.17, and the chlorophyll fluorescence is 0.83 fluorescence units. The 1% light depth is approximately 40m and winds are light (15 knots) and from the north. We're following the buoys and SF_6 patch as they move in a south westerly direction, at a speed of approximately 0.5 knots. Today we successfully completed 2 CTDs before 04:00, one at 09:00, one at 12:55, and one at 19:16 as well as deployments of the optics rig, turbulence probe and plankton nets. Together, we are addressing three major scientific objectives, and each of these requires sampling at a particular time of the

day, or with a particular type of instrumentation. The mid day CTD will be the time when we collect the deepest water, that with the highest concentrations of the climate relevant gases produced by micro-organisms (bacteria and archaea) such as nitrous oxide and methane. These microbes thrive in low oxygen conditions, and so we monitor the oxygen concentration measured by the sensor on the CTD as it is lowered through the water column and choose the depths to sample with the water bottles where oxygen is low. Once back on board, Andy Rees and Ian Brown carefully siphon the water into sample bottles and analyse it using a gas chromatograph with flame ionisation and electron capture detectors (see photos – Andy Rees measuring CH_4 and N_2O).

Saturday 25 April 2009 JD 115

Today is day 3 of Lagrangian sampling in the SF_6 patch. Our position is 20^o 52.08 N 017^o 37.06 W, sea surface temperature is 17.2 ^oC, air temperature is 18 ^oC, chlorophyll fluorescence is 0.63 fluorescence units and winds are light (15 knots) and from the north. There was a slight delay to the start of the CTDs this morning, as despite surveying the SF_6 concentrations overnight, and monitoring the drift of the buoy in relation to the drift of the SF_6 patch, we found that the drift of the buoy and the patch had diverged. When we returned to the buoy for the start of the CTDs at 03:00 we found there was no measureable SF_6. We began a circular search for SF_6 around the buoy and found some to the north of the buoy where we deployed the pre-dawn CTDs. 'Finding the patch' has become my daily nightmare, as the pressure to interpret the movement of the boat in relation to the buoy in relation to the SF_6 patch over the previous 8 hours quickly enough to predict where the ship should be at 03:30 and have it there by 03:30 is quite intense and involves a substantial dose of luck and magical power.

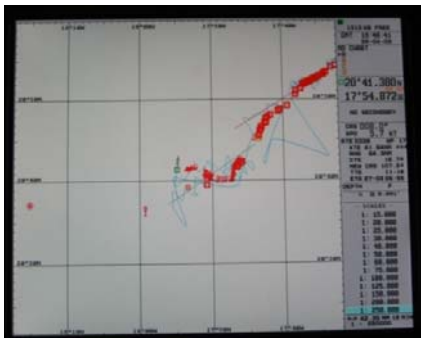
On completion of the early CTDs (ca. 05:30), we realised that the buoy that supports the wire walker was diverging in its path from the other buoys and the patch. We predicted that if we didn't recover this buoy during the daylight hours of today, we may not have sufficient time to diverge from the experimental path long enough to recover it at all. So, we planned to search for the wirewalker buoy, recover it at first light, and return to the SF_6 patch in time for the 09:00 CTD. Easier said than done ! First we had to predict where it might have travelled since the last time it communicated its position to us – and since it had diverged from the path of the other buoys, we couldn't use these as indicators of the speed and direction of its travel. Of course, these things always happen at unsociable hours ! To get the latest Argo position of the buoy, we had to wake Dan Comben for access to a satellite phone card, and Des Barton in Vigo

to access the Argo website (apologies to the Barton family for our very early Saturday morning wake up call), and to plan and prepare for the recovery of the wirewalker buoy we had to wake the deck and NMF-SS teams. With a great deal of help, especially from John Leask (Chief Officer), we found and recovered the buoy and wirewalker (see photo) and dashed back to the SF_6 patch. However, inevitably, we were later than planned and we delayed the 09:00 CTD by 2 hours. This was unfortunate as it disrupted people's shift length and sleep patterns, and in the time between the early morning CTD and this one, we had crossed the 100m contour and were now in 380m water. In addition, the buoy and SF_6 patch were still disconnected and so searching for high enough SF_6 concentrations close enough to the buoy for the bridge to stay a specific distance and direction off it for the rest of the day with the increased pressure of being late was problematic.

We caught up some time by cancelling a turbulence probe deployment and the nets, but still completed four turbulence probe deployments (see photo), and an optics rig deployment before redeploying the wirewalker and commencing the overnight SF_6 survey at 19:48.

Sunday 26 April 2009 JD 116

This morning's position is 20^{o} 41.85 N 17^{o} 47.00 W, chlorophyll fluorescence is 0.79 fluorescence units, the water depth is 506m, sea surface temperature is 17.1^{o}C, and salinity is 36.21. Claire Widdicombe (see photo) and the underway chlorophyll team have provided a preliminary calibration of the fluorometer connected to the surface seawater supply. Plankton chlorophyll = (fluorescence – 0.1561) / 0.122, which suggests that the chlorophyll concentrations we measured at the first few stations on the shelf and near the source of the upwelled water were as high as 5-9 $\mu g l^{-1}$ – about an order of magnitude higher than is usual for temperate North Atlantic waters. The winds are northerly and have increased to 25 knots, with a force 7 predicted for later today. The drifter buoy turned south during the pre-dawn CTD deployments, seeming to follow the 500m depth contour. The maximum depth at which chlorophyll occurred deepened from 60m during the 03:30 CTD to 100m during the 04:45 CTD suggesting we were drifting across a frontal feature, despite both casts being within the



SF_6 patch. By 10:20, the buoy was moving westwards again (see photo of the navigation display on the bridge – the red markers are the drift of the central buoy, and the blue lines are the track of the ship as we survey around the buoy at night and follow closely alongside it during the day). The SF_6 patch is downstream (southwest) of the buoy and is easily detectable at 154,000 'magical SF_6 units' against a background of about 6,000 magical SF_6 units. During the day, our deployments of CTD, nets and turbulence probes mean that we are 'on station' or drifting with the current for 3 hours or more without real time SF_6 measurements to allow us to reposition in the patch between deployments. We therefore positioned the ship downstream of the patch and allowed it to drift towards us, rather than chasing it all day. The prediction of the movement of the patch has been sufficiently accurate today to allow this strategy to work very well, but the oscillating changes in course of the buoy from west to south (and even north on occasion) will mean this will not work every day.

Unfortunately during the night, a power failure led to problems with a number of instruments. The -80^{o}C freezer warmed up by at least 15^{o}C, with the possible loss of all the samples stored so far – including samples for viral abundance and plankton community structure.

An amazing display around the ship by a pod of pilot whales kept everyone entranced this afternoon (see photos courtesy of Mike Hood). Unfortunately this was followed by the realisation that we had lost contact with the wirewalker buoy again, and so we cancelled the sunset CTD and went looking for it. Despite several helpers scouring the horizon for the lost buoy, we didn't find it and had to make the difficult decision to stop searching at 21:00 and resume the overnight SF_6 mapping to enable the experiment to continue tomorrow. We held a wake for the wire walker, remembering the excellent data it had provided for us and the old adage that 'if you deploy anything over the side you shouldn't expect to get it back'.

Monday 27 April 2009 JD 117

Today is Rachaels 30th birthday, and the lab was suitably decked out with confetti, balloons, cards, pressies and poster sized birthday greetings for the occasion (see photo). Our position is 20^{o} 40.36N 17^{o} 54.21 W, water depth is 677m, surface temperature is 17.2 ^{o}C, salinity is 36.23 and surface fluorescence has decreased to around 0.4 fluorescence units (or ~2 $\mu g l^{-1}$ using the preliminary calibration). Without the wire walker buoy (#7547) as a central marker, we are now following buoy # 2881 which was previously a few km north of buoy #7547, but conveniently crossed the predicted path of #7547 yesterday and so is now our best marker of the SF_6 patch. Buoy #5988 decided yesterday to emulate the London marathon and travelled 40k (about 26.2 miles) due west, and a fourth buoy #2879 is to the south of us. We surveyed as far

west as buoy #5988 last night which meant having to travel over 50km each way and reduced the number of north/south transects we could make across the patch, which we believe to be only 3km wide. SF_6 concentrations around the buoy for the first CTDs of the day are around 15,000 magical SF_6 units, still sufficiently above background, though the thin 'streaky' nature of the patch means that the SF_6 varies at least 10 fold in the vicinity of the buoy.

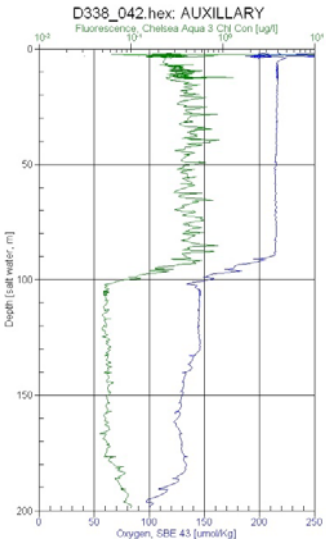
We completed CTDs at 03:30, 04:36, 09:01 and 12:34, an optics rig deployment at 12:30 from which the 1% light depth was calculated to be 43m, and deployments of nets and the turbulence probe. Andy, Phil, Tim Riqui and I met to assess progress and propose any changes to the sampling strategy, including predicting how long the SF_6 patch would last and what we would do when we could no longer measure it. Possible changes included picking up and redeploying a buoy in the centre of the patch every morning instead of following the same one, reducing 'on station' activities to give more time for mapping e.g. moving the head to wind atmospheric sampling to earlier in the day, and increasing the temporal coverage of SF_6 mapping.

We decided to continue to follow the same buoy to provide the physical context to the experiment, and to investigate ways of reducing 'on station' time and increasing SF_6 mapping time. We also discussed the most appropriate ship movement during turbulence probe deployment. Since the deployment is best achieved moving ahead at 0.5 knots, yet we want to stay within the 3km wide SF_6 patch, we had asked the ship to travel in a circle during the 1 hour deployment. However, this means that when the ship has the wind on the stern it loses steerage. We therefore proposed to either reposition so that a 1 hr steam would still be within the patch, or to steam in one direction for 30 minutes and steam back for the next 30 minutes.

During the meeting we were told that Mike Hood on the bridge had found a buoy and thought that it was the lost wire walker. Not believing that our luck could have turned for the better, and thinking that actually this was buoy # 2881 rather than # 7547, we asked that the ship stay close to the buoy and continued the meeting. Back on deck, after the meeting, we were very pleased (and suitably embarrassed at being so cynical) to see that the wire walker buoy # 7547 had been found and was successfully recovered (see photo – Riqui and his retrieved wire walker). We started SF_6 mapping at 17:30 in order to assess the size and shape of the SF_6 patch. Rachael's birthday celebrations continued with wine at dinner and a 'glamour' themed party in the bar afterwards.

Tuesday 28 April 2009 JD 118

Arghh ! the nightmare returns. I arrived in the lab at 02:30 to find that the SF_6 and physics teams were having problems predicting where the centre of the patch should be. There was no SF_6 in the immediate vicinity of the central buoy, and the patch was now so long (~ 50 km) and thin (~ 3 km) that the software used to predict the centre of the patch had insufficient data to provide a reasonable prediction. We started a search around the buoy, knowing that the scientists would be tumbling out of bed in a few minutes time expecting us to be on station and ready to deploy the CTD. We found SF_6 north to northwest of the buoy and hove to. The winds were NNE to NE 35 knots gusting 40, and after monitoring the swell and the ability to keep the ship on station, the decision was taken to cancel the CTD deployments and heave to until the winds died down. At 05:37 we were at 20° 43.90 N 018° 09.15 W, the sea surface temperature was 16.9 °C, fluorescence was 0.44 fluorescence units, and the surface SF_6 concentration was approximately 40,000 magical SF_6 units. By 08:00, the winds were dropping and we expected to be able to deploy the CTD for the 09:00 station. However, the surface SF_6 concentration decreased again, as if we were moving across the edge of the patch – either the front edge (i.e. the ship was drifting faster than the patch), or the back edge (i.e. the patch was drifting faster than the ship). We chose the former and moved east in search of higher SF_6 concentrations, only to realise we had made the wrong prediction, so we moved west and were relieved to measure increasing SF_6 concentrations. We deployed a drifter in this SF_6 patch and then a CTD at 09:43. The CTD (#42) at 12:30 was deployed in a water depth of 1566m with sea surface temperature of 17.5 °C, salinity 36.27 and fluorescence of 0.25 fluorescence units. Chlorophyll and oxygen (green and blue lines respectively on figure) were constant down to almost 100m. SF_6 concentrations in the surface waters at the 12:30 CTD station were 18,000 to 19,000 magical SF_6 units, and the data derived from the optics rig deployed at the same time, gave an estimated 1% light depth of 39 to 41m. Atmospheric sampling occurred as usual between 17:00 and 19:00, after which we resumed the SF_6 mapping. There was an emergency muster station at 16:15.



The catering staff (Mark, Lloyd and Peter) continue to provide us with outstanding meals three times a day. One dessert which truly lives up to the description 'to die for' was the crème brulée we had last weekend. This was so good, it would be a travesty not to share the recipe with everyone, so here it is : to make 5 portions, you will need 250g of mascarpone cheese, ½ cup of castor sugar, 1 whole egg, 1 egg white, 1 vanilla pod and the pièce de resistance – tart summer fruit compote. First place the compote in the base of five moulds. Whisk all the other ingredients together and place in the moulds. Cook in bain marie at 150°C for 20 minutes, and when cooled

sprinkle with castor sugar and place under the grill until golden. Serve with a little icing sugar and watch the ecstasy on the faces of those who eat it.

Wednesday 29 April 2009 JD 119

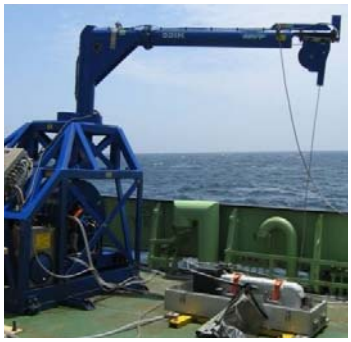
We spent an hour before the pre-dawn CTDs mapping around the buoy and assessing the direction of drift of the ship. We decided to position the ship about 0.9 nautical miles from the buoy on a bearing of 258 ^{o}T in water with an SF_6 concentration of 18,000 units. The first CTD was at 03:31 at 20^{o} 39.10N 018^{o} 27.3 W in a water depth of 1530m. The sea surface temperature was 17.5 ^{o}C, salinity was 36.27, and the chlorophyll fluorescence was 0.25 fluorescence units. The second CTD of the morning (#44) was overboard at 04:25. We also completed deployments of a CTD at 08:58, a turbulence probe at 10:40, a CTD at 12:25, an optics rig (#009) at 12:38, a turbulence probe at 14:35, Apstein, Bongo and 700 µm nets at 15:48, and a turbulence probe at 16:57. The surface layer was mixed to a depth of 60m, and the oxygen minimum occurred between a depth of 300 and 500m.

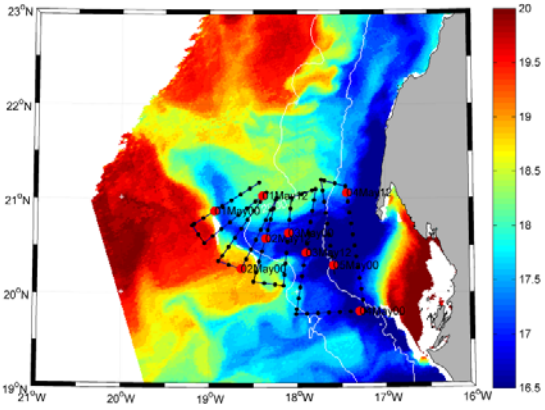
With the cancellation of the pre-dawn productivity casts yesterday, Vas and Pablo had 100 fewer oxygen titrations to do today and so were able to put their feet up and catch up with bottle washing (photos). The 09:00 CTD is when we focus on collecting samples to measure how gases produced by plankton efflux from the seawater into the atmosphere (and therefore affect climate). By measuring the ratio of the concentrations of helium and sulphur hexafluoride (the two gases we added to the seawater) Phil Nightingale, John Stephens and Ian Brown can determine the rate of loss of the gases into the air. The helium samples are collected in copper tubes which have to be tapped with a rubber hammer to remove any air bubbles before the tubes are crimped closed at each end. Helium samples are collected from the CTD bottles first and the sample collection and bubble removal process has to be done slowly and carefully, as demonstrated by John and Ian in the photo above. While everyone else waited patiently to siphon water after the helium samples had been collected, we were amused to see that one female scientist (who shall remain nameless) was wearing very appropriate underwear (see photo).

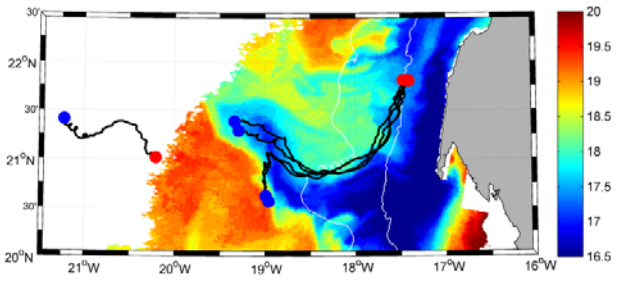
At 16:30, Phil, Andy, Gavin, Riqui and I met to discuss the implications of the spreading of the patch and what to do next. The options are 1) to try to stay with the patch despite it becoming increasingly difficult to find and to continue following only the buoys if necessary, 2) to 're-seed' the patch with the remaining SF_6 left in the tank or 3) to end this experiment, review what we've learnt and plan the next one. From the underway measurements collected during the SF_6 deployment, we know that the 3 km x 3 km area to which we initially added the SF_6 included waters with a temperature range from 16.65 to 16.95 ^{o}C and a range in chlorophyll from 0.7 to 1.1 fluorescence units (4 to 8 µg chlorophyll l^{-1} using the preliminary calibration). We also know that the buoys and the SF_6 had become aligned with a frontal feature along the northern edge of the major filament. The spatial variability in all of the chemical and biological parameters caused by these frontal features, mean that it is becoming increasingly difficult to interpret the data in a Lagrangian (i.e. temporal) way, and so it would be better to stop now and utilise the remaining time to undertake a longer Lagrangian study starting in an area away from the frontal region (if such an area exists). If we re-seed with the remaining SF_6, the likelihood is that we would add SF_6 to water that had not previously been seeded with SF_6 and so in effect begin a new experiment – there is little reason to do this for just 1 or 2 days (the length of time the SF_6 is likely to remain detectable). So we decided to stop sampling, recover the buoys and undertake a large scale MVP survey back to the shelf. However, since it is preferable to recover the buoys during daylight, we agreed to remain mapping the area overnight, complete the pre-dawn casts in the morning and begin to recover the buoys during tomorrow. In terms of the next experiment, one suggestion would be to not repeat exactly what we had just accomplished, but if sufficient data has already been collected in the highest productivity water, to start the SF_6 deployment further offshore than last time (e.g. at the 200 m depth contour) and aim to travel with it for 10-12 days ending up further offshore than we have finished this time. After the meeting and dinner, we completed 2 hours of atmospheric sampling at 19:00, the final CTD of the day at 19:06, and resumed the SF_6 mapping at 19:43. Later, in discussions with the other scientists, we realised that there would be some benefit to delaying the recovery of the buoys until we had completed a CTD tomorrow morning at 09:00. We therefore decided to risk the possibility of not finding the patch at 09:00, and not finding all the buoys in daylight hours, and try to stay in Lagrangian mode until 10:00 tomorrow.

Thursday 30 April 2009 JD120

Today is the eighth day of sampling in Lagrangian mode in the SF_6 patch. SF_6 concentrations overnight were quite low at 5,000 to 10,000 units (background levels are around 6,000 units). Using his 'patch centre' software, Riqui estimated the patch centre to be 0.5 nm N and W of the buoy. We measured SF_6 concentrations of 11,000 units and deployed CTDs at 03:34 and 04:34. The 1% light depth was at approximately 60m and most scientists sampled from this cast as it was to be the penultimate one of this Lagrangian experiment. Winds were light at NNE 20 knots, and we tracked 1 nm NW of the buoy until CTD #50 at 08:55. Water depth was 2583m, sea surface temperature was 17.6 ^{o}C, salinity was 36.26, fluorescence was 0.24 fluorescence units, and surface SF_6 concentrations were 12,000 units. On completion of the CTD we began to recover the buoys – it was strangely sad to leave the SF_6 patch, I had perhaps become addicted to the 'predator / prey' hunt for it every morning. On the other hand it was a relief to know I wouldn't have to wake up with the terror of not finding it for almost a week. We retrieved the first buoy (# 2880) at 10:14 and went hunting for the second. Despite receiving Argo positions for the buoys, it took until 17:30 to locate the second buoy (# 2881) and until 18:40 to retrieve the third (# 2879). We had then planned to do a CTD transect across the filament, to quantify the volume and speed of the water in the filament. However, after several days of working on the MVP, Dave Teare and the NMF-SS team have found the problem with the MVP (a loose connection) and repaired it, so rather than a series of CTD transects, Riqui devised a 5 day large scale MVP survey across the full length and width of the filament (see figure). Dave, John, Kev and Dan have adjusted their shifts to allow 24 hour MVP-ing (see photos). So, as the scientists enjoyed a well earned break from the slog of the Lagrangian sampling, we guiltily watched on as the NMF-SS team began their MVP shifts. We tried to assuage our guilt and express our gratitude with newspapers, and tea or coffee. The MVP survey continued throughout the night and into Friday, and on the northbound (i.e. head to wind) transects, Phil, John and Malcolm L. began to saturate the tank with SF_6, ready for the next release, which is expected to be next Wednesday or Thursday.



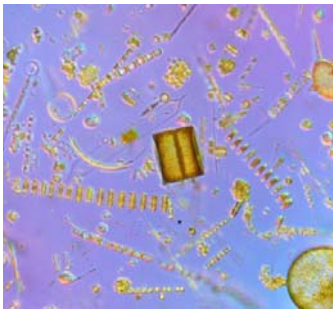




A first suggestion for the area of deployment of the second patch is in the vicinity of 20° 30 N 17° 30 W, the idea being that we would follow the centre of the filament and not get caught in the frontal feature to the northern edge of the filament, as we did this time. However, this is risky, as can be seen from the track of the four drifters we deployed on 17 April 2009 – two of the buoys have followed the filament, and two have swept south out of the filament.

Friday 1 May 2009 JD121

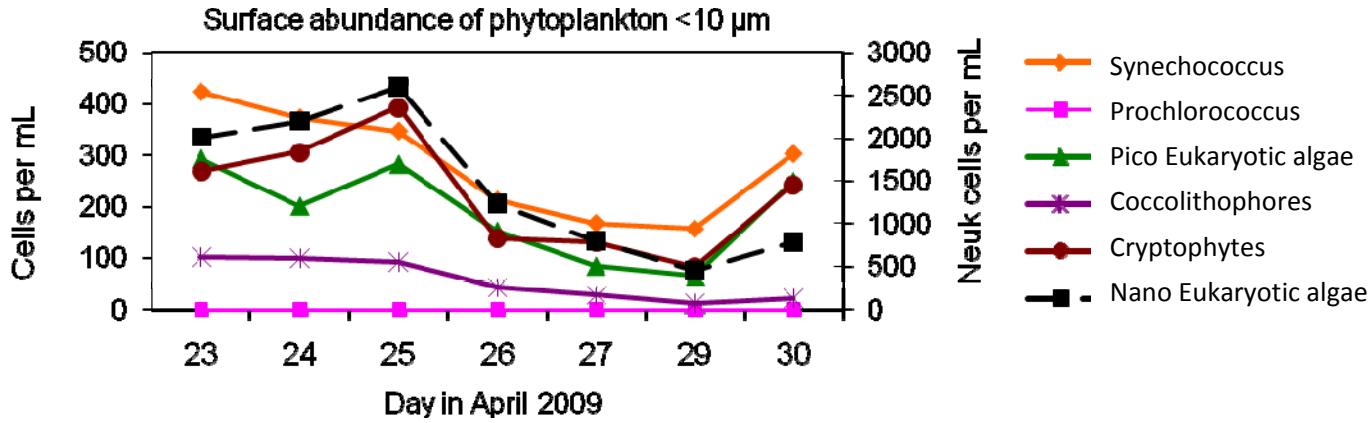
The first day I didn't have to get up at 02:00 since what seems like a few lifetimes ago, but is probably only about 12 days, and of course I forgot to switch off my alarm clock ! The MVP survey continued throughout last night and on into today, measuring temperature, salinity and fluorescence down to 350m at a rate of one vertical profile every 8 minutes. The winds were light at NNE 20 knots, and conveniently reduced to 15 knots at 16:30 when we hove to and set up a barbecue on the aft deck. During the day, the scientists caught up with their data analysis and interpretation, and we scheduled a scientific data workshop for 15:00 on Sunday 3 May 2009, when we would all present highlights of the data we have collected so far and discuss the strategy for the next experiment.



Ian Slater (Chief Engineer) spent some time rewiring Gavin's photo-oxidation incubators with 250 °C rated cable to reduce the possibility of the wiring continuing to melt in the intense heat of the light source (Many thanks Ian – see photo). Claire took some photographs of the diversity of diatoms she found in her Apstein net samples at the beginning of the Lagrangian sampling (see photos). Glen plotted the abundance of surface phytoplankton during the first seven days of the Lagrangian experiment as identified with the flow cytometer (photo and graph – to show the shift from the larger nano-eukaryotic algae to the smaller Synechococcus cyanobacteria on the 27 April 2009), and I tried to catch up with typing up the various sampling

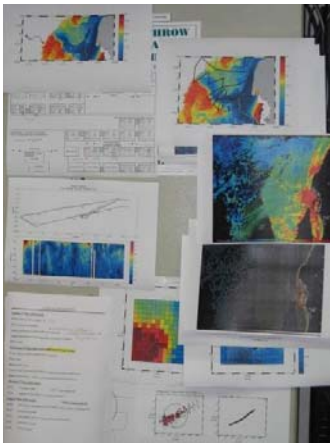
logsheets that we need to compile in order to adequately archive all of our data at the British Oceanographic Data Centre.

After a fantastic barbecue, several scientists went to the local cinema, where they were showing the latest James Bond movie 'Quantum of Solace'. The MVP was redeployed at 20:30 and we continued along the survey track, planning to stop at first light tomorrow to retrieve the final two drifters #5990 and #5988.



Saturday 2 May 2009 JD 122

Buoy #5990 was safely retrieved at 06:38. The MVP was then redeployed and we headed towards the last known position of buoy #5988. This was sighted at 10:14 bobbing merrily on the surface rather than dunking beneath the waves as the others had done, and so was obviously no longer attached to the drogue and thermistor chain it had been deployed with. Thanks to John Stephen's 'patent pending' buoy scooper, it was safely on board by 10:54. With all seven buoys now safely on board (photo), we continued on the large scale MVP survey. Our position is 20° 02.01 N 018° 37.14 W, sea surface temperature is 19.8 °C, fluorescence is 0.4 fluorescence units, salinity is 36.52, air temperature is 19.1 °C and the water depth is 2697m. Winds are light at NNE 15-20 knots. Today was a designated 'mid cruise break' or day off (!?!) for most people – a time for me to catch up with writing the cruise diary and the logsheets identifying all underway sampling and over-the-side deployments, and for others to analyse their frozen samples to reduce the backlog of sample analysis once we reach shore. We planned to collect surface water samples across the filament tomorrow morning for the determination of plankton community



structure, dimethyl sulphide and inorganic nutrient concentrations to assess the spatial variability in these parameters. Some people found the gym and cycled 10 km to work and back, and others relaxed at the local cinema where a selection of scary Sci Fi movies was being shown.

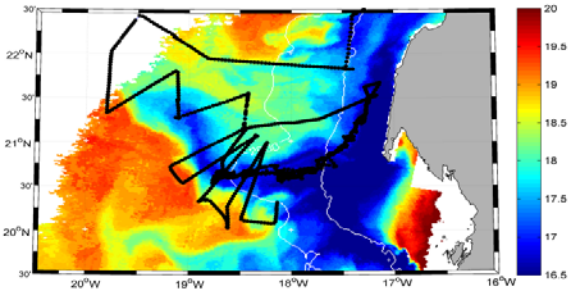
One thing which is very important during a research cruise is keeping everyone up to date with what's planned for the day, and then informing them of any changes to this plan. For example, a delay in one sampling deployment will have a knock-on delay to another, and if timing is critical, it may require cancelling an activity or prioritising one thing over another. Some analyses or activities can only be made whilst the ship is 'head to wind', so that if for any reason the ship needs to move, then the people expecting to sample head to wind have to be informed in time to switch off their instruments. Real time communication on a research ship can be difficult, as the scientists work in 6 different laboratories within the ship and 3 container laboratories on two deck levels. To help communication, we have 2 notice boards, one in the deck laboratory and one in the main laboratory where we post a daily timetable (with all too frequent updates) and any satellite images or data of interest (see photo).

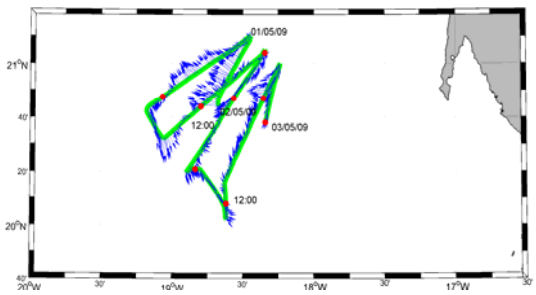
Sunday 3 May 2009 JD 123

The MVP survey continued overnight and is due to continue until Tuesday. Our position is 20^{o} 10.25 N 018^{o} 09.04 W in 3823m of water travelling at 6 knots with steady 28 knot NNE winds. The surface water chemistry sampling began at 06:00 and samples were taken at 30-60 minute intervals. Most people spent the day plotting and interpreting their data ready for the data workshop scheduled for 15:00 in the bar, where we've set up a screen and projector. Everyone gave short presentations of their results so far and gave some indication of where they would like the second Lagrangian experiment to take place. Concentrations of chlorophyll (~8 $\mu g l^{-1}$) and rates of total primary production (10 gC m^{-2} d^{-1}) were, as expected, highest at the upwelling source stations, and decreased as we moved offshore. Gross production and community respiration in surface waters decreased from 40 to 8 mmol O_2 m^{-3} d^{-1} and from 5 to 2 mmol O_2 m^{-3} d^{-1} respectively, bacterial production derived from ^{3}H-leucine incorporation decreased from 30 to 5 nM d^{-1}. The partial pressure of carbon dioxide in the upwelled surface waters reached values of 500 µatm – around 120 µatm higher than atmospheric concentrations, decreasing to 400 µatm offshore. Surface water dimethyl sulphide concentrations ranged from 2 to 9 nM, and towards the end of the Lagrangian experiment, nitrite concentrations were reaching a mid water maximum (at ~ 100m) of 0.8 µM. Gavin and Vas set up a 6 and 24 hour photo-oxidation experiment each day, measuring the impact of UV+visible light, visible light and darkness on concentrations of O_2, carbon monoxide,

pH, ammonium, dissolved organic carbon, amino acids and coloured dissolved organic matter (see photo of photo-oxidation incubators). The rate of photo-production of ammonium ranged from 1.5 to 4.5 nM hr^{-1} and the rate of photo-consumption of oxygen reached a maximum of 0.1 mmol m^{-3} hr^{-1} (or about 50% of the rate of biological consumption of oxygen). Rachael has made some of the first measurements of methanol, propanol and acetone in seawater and found concentrations ranging from 50-200 nM, 200-1100 nM and 6-12 nM respectively.

After dinner, the meeting continued until 20:30, as we discussed the possible strategy for the next experiment, including where to deploy the SF_6 along the continuum of coastal newly upwelled water to offshore waters (see cruise track so far) and which scientific objectives to prioritise on each CTD cast. It is clear that there isn't enough time in the day to complete all the CTD and turbulence probe deployments requested and still leave sufficient time to adequately map the SF_6 patch overnight – bearing in mind that it increases in surface area each day. Nor is there sufficient time to cover the full range of high to low productivity waters whilst still unequivocally in Lagrangian mode (i.e. within the SF_6 patch). The provisional plan is to continue the large scale ADCP/MVP survey of the filament through Monday and Tuesday, stopping for a CTD and net deployment at Monday lunchtime. The data from this filament survey will be used to decide where the second SF_6 deployment should be (the direction of the major currents determined by the ADCP are shown overlain on the track of the first few transects of the large scale survey – the length of the arrows is relative to the speed of the water movement). On Wednesday we will complete a smaller scale survey to choose the site for SF_6 deployment, and deploy the buoy attached to an ADCP which will become the central buoy of the next SF_6 patch. On Thursday morning we will collect water at 04:00 before deploying the SF_6 and five drifters including the Carioca buoy (which includes instrumentation capable of measuring surface water carbon dioxide concentrations). Friday will be our first Lagrangian sampling day, and we estimate that we have time for 12 Lagrangian days (providing we can continue to track the SF_6) before 5 final days surveying the large scale variability of the filament with the MVP and ADCP, and two days to pack everything and transit home.



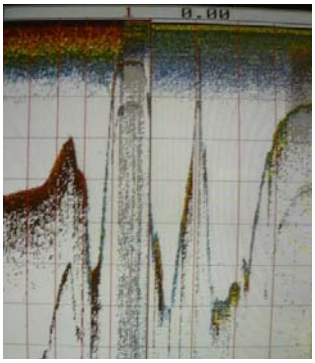


Monday 4 May 2009 JD 124

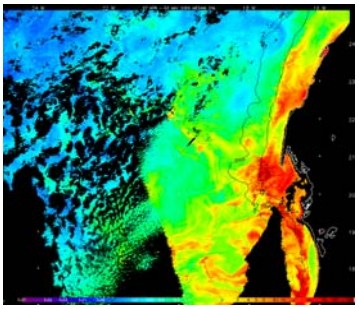
We are continuing the large scale filament survey, at position 19^{o} 47.69 N 017^{o} 38.40 W, travelling

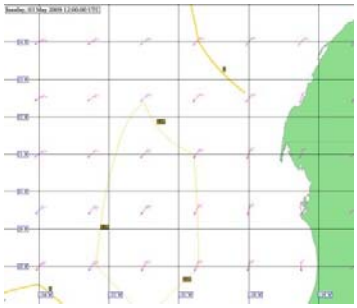
at 6.5 knots with 18 knot NNE winds. The water is very green suggesting high chlorophyll concentrations, sea surface temperature is 17.0 ^{o}C, salinity is 35.73, air temperature is 16.8 ^{o}C, barometric pressure is 1012 and underway fluorescence is 1.0 fluorescence units. At 11:00

we recovered the MVP and deployed CTD #51 to 350m to collect salinity samples to check the MVP salinity sensor which appears not to be working very well. We also collected water for measurement of background helium concentrations and some extra experiments to test the linearity of plankton growth during 24 hour incubations. We then deployed the three nets (Apstein, Bongo and 700 µm) and at 13:26 resumed the MVP survey. The 700 µm net sample is collected for Claudia Castellani at the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) in Plymouth, and contained a rich soup of large zooplankton (see photos of a Hyperiid and a Chaetognath possibly *Sagitta enflata* and a Eucalanus copepod – photos courtesy of Vas Kitidis and preliminary identification from Claudia). The



scientists continue to catch up with instrument calibrations, sample analysis, and report writing. Unfortunately the underway oxygen optode has developed a fault and so Ian spent some time today repairing that. During the net and CTD deployments we were 'buzzed' by a fishing vessel which came over to check what sort of 'fish' we were collecting in the plankton nets (see photo). The large scale filament survey continued inshore along the 100m depth contour, and the mountainous seabed topography prevented the safe deployment of the MVP (photo of echo sounder trace giving a maximum depth of a worrying 0m). Eventually as the depth became more constant (around 50m), the MVP was able to dive again to a maximum of 20m.





During this May Bank Holiday weekend, as on every other day, the staff at NEODAAS (National Earth Observation Data Acquisition and Analysis Service) at Plymouth Marine Laboratory have processed and sent

images of satellite derived sea surface temperature and chlorophyll to the ship, along with model output of predicted wind speed and direction and wave height, and Ed Blockley at the Meteorological Office in Exeter has sent daily ocean forecasts of temperature, salinity, mixed layer depth and ocean currents. These images and forecasts have been invaluable in visualizing the size, shape and variability in position of the filament we are here to study. We are very grateful to Peter Walker, Ben Taylor and Jane Netting at NEODAAS and Ed Blockley at the Met Office.

Tuesday 5 May 2009 JD 125

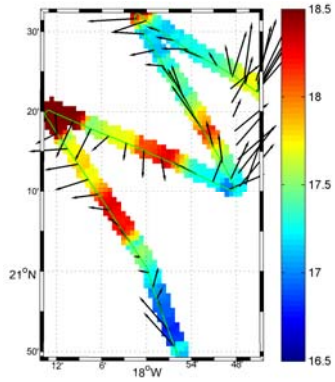
The large scale filament survey is due to continue until mid day today. At 08:18 we are at 20^{o} 43.93 N 017^{o} 41.78 W, with light (15 knot) northerly winds. The sea surface temperature is 16.3 ^{o}C, salinity is 35.88, air temperature is 16.8 ^{o}C, fluorescence is 0.49 fluorescence units, the barometric pressure is 1014 and we're in a water depth of 426m. At 14:36 the MVP was brought inboard for a well earned service (photo of Dave Teare and John Wynar servicing the MVP), and Riqui, Tim, Dan, Mark, Greg and the crew spent some time deploying and recovering the ADCP buoy (photo of yellow torpedo looking instrument) and the wire walker + turbulence probe. The local terns have decided that the aft gantry is a great place to roost and so the aft deck has become peppered with guano – another good reason to wear a protective hard hat on the aft deck !

Whilst 'head to wind' Phil and Malcolm Liddicoat took the opportunity to complete the saturation of the SF_6 tank (photo of the headspace on the top of SF_6 tank), and the rest of the scientists continued with sample analysis, instrument calibration and report writing. The buoys were all recovered by 19:20 when we resumed a north-south ADCP survey. This will continue until tomorrow lunchtime when we will decide where to lay the next SF_6 patch.

Wednesday 6 May 2009 JD 126

At 08:00 our position was 21° 06.06 N 017° 58.74 W, sea surface temperature was 17.5 °C, air temperature was 17.6 °C, salinity was 36.09, barometric pressure was 1014, water depth was 1654 m and the winds were light and northerly (20 knots).

The underway fluorescence was 0.44 fluorescence units (or with the latest calibration [chlorophyll = (fluorescence – 0.1873)/0.1192], 2.1 µg chlorophyll l^{-1}). The ADCP large scale survey continues, and the MVP is being serviced. The measurements of sea surface temperature and water movement calculated from the ADCP during the large scale survey (see figure) reveal the complexity of the water masses around us. Riqui, Andy, Phil, Tim, Gavin and myself met to discuss the ADCP results at 16:30. The conclusion was that we should survey further north (around 21° 30.0 N 18° 00.00 W) and delay the SF_6 release until we have more information to guide us in deciding the best



place to start the second experiment. We met with everyone after dinner to propose this course of action and it was agreed. During the day the scientists continued to analyse samples collected during the first Lagrangian experiment (see photos of : 1) Susan Kimmance - flow cytometric analysis of plankton community structure and Vas Kitidis – photo-chemical consumption of dissolved oxygen and 2) Ian Brown - nitrous oxide and methane concentrations in seawater). In order to aid the search for the SF_6 patch each morning, Phil Nightingale modified the software for the SF_6 gas chromatograph so that it calculates the concentration of SF_6 (in femta moles per litre – no longer SF_6 magical units !) in excess of the background concentration.

Thursday 7 May 2009 JD 127

At 08:35 our position was 21^{o} 23.20 N 017^{o} 45.07 W, sea surface temperature was 17.5 ^{o}C, air

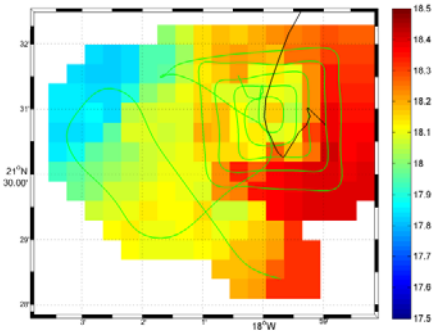
temperature was 17.5 ^{o}C, salinity was 36.02, air pressure was 1012, water depth was 680m, fluorescence was 0.3 fluorescence units and the winds were NNE 18 knots. The smaller scale ADCP survey continues to reveal the high variability in sea surface temperature around us – including a 'front' or area where two types of water structure meet, creating a 'line in the sea' where as we cross it, the temperature drops by 1.5 ^{o}C. We deployed the MVP at 08:36 with new salinity and oxygen sensors to enable us to determine the variability in physical and chemical parameters with depth. Martin Bridger (see photo) set up a system whereby we can monitor the measurements of temperature, salinity, fluorescence and oxygen made by 'in-line' sensors in a surface seawater supply that is continually pumped into the laboratory, alongside the measurements made by the sensors in the MVP and the sensors in the vertical CTD system. This means we can cross calibrate all the sensors against one another and against chemical measurements of the water collected by the CTD + bottle rosette. Ian Sarginson and Steve Duncan (see photo) continued to clean and brighten the ship up with a new lick of paint. At 15:00 Andy, Phil, Riqui, Tim and I met to assess the latest satellite images of sea surface temperature and ocean colour (an indicator of the amount of phytoplankton present) in order to select an area of relatively low chlorophyll, and low spatial variability in temperature where we could deploy the next patch of SF_6. The physics team (Bea Barreiro and Thomas Meunier, see photo) continue to process the ADCP and MVP data to help us choose a site with relatively consistent water flow. We wanted to make measurements in a region which was in the path of the major offshore filament, away from the abrupt changes in temperature which caused problems for the first patch (water masses with different temperatures

tend to move at different rates, and so when we inadvertently deployed the first patch of SF_6 across a 3 km x 3 km area which included water at two distinct temperatures, these two water masses moved at different speeds, producing 'streaks' of filament and so SF_6). Using the satellite images to guide us, we were aiming to place the ship in waters with chlorophyll concentrations similar to those measured at the end of the first patch experiment. Since the satellite images were taken two days ago, the chlorophyll features shown in them will not be in exactly the same geographic position now, so we cannot simply move the ship to a specific latitude and longitude. However, we assumed that the area of water we were aiming for would be in the same position relative to other chlorophyll and

temperature features seen in the images. So we headed west until we measured the abrupt change in temperature and chlorophyll which in the satellite image was north of the area we wished to sample, and then turned perpendicular to the angle of the front and aimed to stop after travelling about 7 miles. The MVP was recovered at 19:16. Recording the temperature, salinity and fluorescence from the underway sensors every 10 minutes, we chose an area that seemed far enough away from the front and in stable temperature and chlorophyll conditions. Tim Smyth delayed his birthday celebrations to deploy the ADCP + GPS buoy #2881 at 21:00 at 21^{o} 25.2 N 017^{o} 54.7 W. The MVP was re-deployed at 21:34 to undertake a 4 km x 4 km survey around the proposed patch area prior to the pre-dawn CTDs at 04:00 tomorrow.

Friday 8 May 2009 JD 128

We recovered the MVP at 03:35 and deployed CTDs #52 and 53 at 04:04 and 05:02 respectively. At 06:39 our position was 21^{o} 26.21 N 017^{o} 57.07 W, sea surface temperature was 17.7 ^{o}C, air temperature was 18.1 ^{o}C, salinity was 36.02, barometric pressure was 1011, water depth was 1159m and the winds were from the north (NNE 15 knots). The underway fluorescence was 0.26 fluorescence units (or 0.6 µg chlorophyll l^{-1}). We repeated the 4 km x 4 km MVP / ADCP survey until 11:00, when the ADCP data from the previous survey was collated to help choose the position of the next SF_6 patch. Using the underway temperature and fluorescence data we chose a relatively stable region in the northwest of the survey box to deploy the wire walker buoy #2879 and begin the SF_6 deployment at 14:00. Conscious that we are in a period of relatively low winds, and that



higher winds should cause the offshore filaments to be more pronounced and easier to track with SF_6, we decided to only deploy 25% of the SF_6 tank. This should be enough for a 4 day Lagrangian study (i.e. long enough to see some biological temporal change) so that if/when the wind and upwelling strength increases we have sufficient time (and SF_6) left to survey, deploy and undertake another 8 day Lagrangian study at a location that may be more suitable to track than where we are now. This was fortuitous, as when we analysed the underway temperature data collected during the SF_6 deployment (see 'expanding spiral' ship track in the figure) we found that the area that 3 hours previously had had a uniform temperature of 17.5 ^{o}C now included a front between waters with a surface temperature of 18.5^{o}C and waters with a surface temperature of 18.1 ^{o}C. On completion of the SF_6 release, we deployed the Carioca buoy #5990 (20:34) which contains instrumentation to measure carbon dioxide in seawater and then the MVP at 21:00. We continued mapping with the MVP overnight until the 04:00 CTDs. In between oxygen titrations and buoy deployments, Vas and Tim

found time to play a few competitive games of chess (see photo – the score is currently two games all).

Saturday 9 May 2009 JD 129

We completed the overnight SF_6 and MVP box survey at 03:10 this morning. CTDs #54 and #55 were deployed at 04:00 and 05:00 respectively in waters with surface concentrations of SF_6 of around 1200 fmol l^{-1}. Surface nitrate concentrations were 7.75 µmol l^{-1} and the 1% light depth was 50m. These CTDs were followed by vertical casts of the turbulence probe from 06:24 until 08:33, a CTD (#56) at 09:04, and an Apstein net (#17) at 10:11. At 08:00 our position was 21° 30.70 N 017° 59.50 W, sea surface temperature was 17.9 °C, air temperature was 18.5 °C, salinity was 36.02, barometric pressure was 1014, water depth was 1329 m and the winds were northerly 10 knots. The underway fluorescence was 0.34 fluorescence units (or 1.28 µg chlorophyll l^{-1}). The day continued with vertical casts of the turbulence probe from 10:27 until 11:30, a CTD (#57) at 12:07, two optics rig deployments (#010 and 011) at 12:35 and 13:21 respectively, and further vertical casts of the turbulence probe from 14:12 until 17:30. We monitored the surface SF_6 concentrations throughout the day and repositioned the ship into waters with SF_6 concentrations higher than background levels before each CTD deployment. The buoy and highest SF_6 concentrations were often not in the same place. The edge of the SF_6 patch was quite distinct, and even when in the SF_6 patch, it was easy to drift out of it – for example, simply by turning the ship into the wind to heave to. The surface waters contained the dinoflagellate *Noctoluca*, a type of phytoplankton which has the ability to phosphoresce (produce flashes of light when stressed). We filter seawater through filter paper with a pore size (e.g. 1 µm) designed to capture phytoplankton – this filtration process causes *Noctoluca* to 'light up' the filter paper with tiny green flashes of light.

The MVP was deployed at 17:45, to start the overnight SF_6 and MVP 6 km x 6 km box survey. However, at 18:25, as the ship turned to starboard to begin the first line of the survey, the MVP line over the port quarter tangled with the turbulence probe winch and the MVP launched itself on to the ship causing damage to its CTD and fins. The mapping survey continued, collecting only ADCP data. During the day, the aerosol collector pump stopped working (photo of metal 'beehive' shaped box with pump and filters inside). The large filters through which the air is pumped will be analysed by Alex Baker (University of East Anglia) to determine the concentrations of nutrients and metals which the phytoplankton receive from the air (possible dust input from the Sahara Desert). Ian Slater (Chief Engineer) repaired the broken motor using spare parts from a washing machine ! Meanwhile, to reduce the possibility of the detachment of the GPS drifters from the equipment and drogues again, Dan

Comben has substantially strengthened the attachment points of the drifters (see photo). Many thanks to Ian and Dan.

Sunday 10 May 2009 JD 130

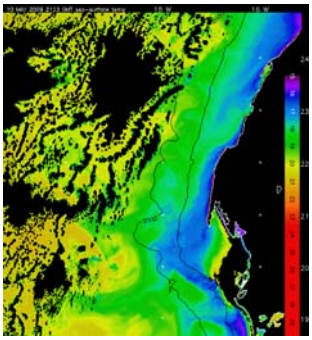
The ADCP survey continued until 04:00 when we deployed CTDs #58 and #59. SF_6 concentrations had reduced ten-fold, the patch was very streaky and not very close to the buoy, and so we had to reposition the ship between the two CTDs in order to stay within the patch. At 06:00 we surveyed the region and deployed drifter #5988 in what appeared to be a distinct patch of SF_6 at a concentration of 40 fmol l^{-1}. We then went in search of the ADCP buoy which was not moving with the patch. We retrieved this at 07:56 before returning to drifter #5988 for the 09:00 CTD. At 08:13 we were at position 21^o 39.30 N 017^o 58.43 W, the sea surface temperature was 18.1 ^{o}C, fluorescence was 0.86 fluorescence units, salinity was 36.03, air temperature was 18.3 ^{o}C, air pressure was 1014, and we were in a depth of 1250m of water. The data from the 05:00 CTD showed that the water around us was forming horizontal layers, so that in some places the SF_6 was only in a 7m layer at the surface. After the 09:00 CTD, we deployed an Apstein net and then a CTD at 11:50 at the same time as an optics rig deployment. Dan, Kev, Dave and John mended the turbulence probe winch (very many thanks) after its fight with the MVP yesterday, and Riqui, Bea and Thomas took advantage of this and made several successful vertical casts of the turbulence probe. The data from these and the CTDs suggest that the SF_6 is subducting (or moving below another layer of water), so that we are unable to map its distribution based only on our surface measurements.

During the afternoon, Phil, Andy, Riqui, Tim, Gavin and I met to discuss how to proceed. With continued light winds, high spatial heterogeneity on space scales of a few hundred metres, subduction and surface layering of the SF_6, it is highly unlikely that we will be able to measure any SF_6 concentrations above background levels (6 fmol l^{-1}) tomorrow. Reminding ourselves of our scientific priorities i.e. being able to physically describe the volume and movement of upwelled water in order to quantify its impact on the photochemical and biological production and consumption, and air sea exchange of climate relevant gases, we felt we had three options open to us: 1) continue to follow the buoys, despite no longer being able to measure SF_6, 2) carry out a transect study, moving offshore from high to low productivity waters, choosing sampling sites along a gradient of some indicator of upwelled water e.g. nutrient or dissolved gas concentrations or 3) move to another site and try again to release and follow the SF_6. Option 1 had the advantage that the study sites along the track of the buoys could be linked, however buoys and SF_6 patches rarely follow the same path, and so this would not be an unequivocally Lagrangian experiment, thereby reducing the possibility of budgeting gases or following a biological succession in plankton species. Option 2 had the advantage of minimum risk, assuming the impact of upwelling decreases with increasing distance offshore. However the disadvantage would be that each sampling station

would represent a 'snapshot' of that particular place and time, with little relationship to each other in terms of plankton succession or temporal trend. Option 3 had greatest risk (bearing in mind the difficulty of tracking the SF_6), but would best achieve the scientific challenge we had set ourselves – to follow a temporal trend in upwelled water. This temporal trend could perhaps be extended if we did several short term Lagrangian studies each starting at a different place along a filament continuum.

Writing down these options now (a few days later), belies the complexity (and length of time) of our discussion. We decided that we would prefer to follow option 3, and re-assess options 1 and 2 if option 3 fails. After dinner, we held a full science meeting to discuss the options and propose we follow option 3. This was agreed, and so the task now was to find the best place to undertake our third SF_6 deployment.

Monday 11 May 2009 JD 131



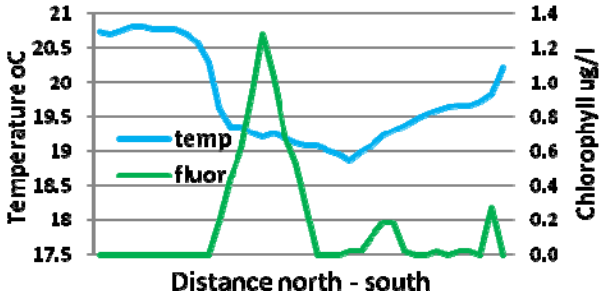
With the decision to move site, we would spend today retrieving the four drifters and surveying possible deployment sites. We picked up the ADCP buoy at 07:20, the wire walker buoy at 08:07, a drifter buoy at 09:23 and the Carioca buoy at 12:38. At 08:58 we were at position 21° 33.01N 018° 07.65 W, the sea surface temperature was 18.4 °C, the fluorescence was 0.3 fluorescence units, salinity was 36.15, air temperature was 18.2 °C, air pressure was 1014 mbar, water depth was 1851m, and the winds were NE 20 knots. As the MVP is not operational, we planned an ADCP survey to search for an area with lower chlorophyll, but still some westward flow of water. We have a forecast (from Des Barton in Vigo) for strengthening winds on Wednesday, so the hope is that we can position ourselves to take advantage of newly upwelled water moving offshore. The latest satellite image of sea surface temperature (see figure) suggests that offshore movement of upwelled water is greatest at around 20°N rather than the 21°N filament where we are now. We therefore headed south and prepared for an ADCP survey (the MVP still being out of action) and a transect across the filament collecting surface water samples for the measurement of inorganic nutrients, plankton community structure (photo Glen Tarran), DMS (photo Frances Hopkins), oVOCs (oxidized volatile organic

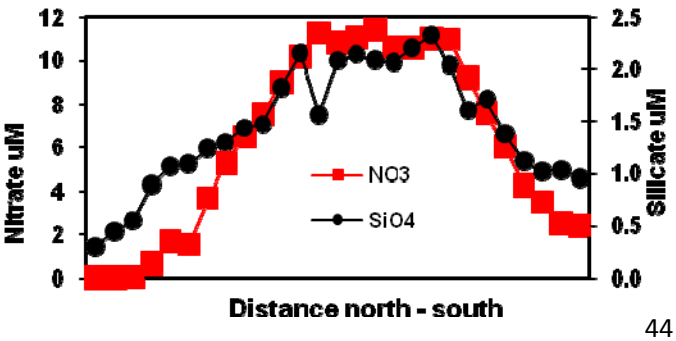
compounds), pCO_2, O_2, and the genetic (DNA/RNA) diversity of the plankton (photo Simon Thomas).

We had an emergency muster station at 16:15, with a simulated fire in the engine room and the scientists practised using the fire hoses over the side. Dave, Kev, John and Dan continued to do miracles with the mangled turbulence probe winch and the MVP. The transect across the filament started at 20:00. Glen and Simon collected water samples at 10 minute intervals for plankton community structure and nutrient analysis respectively. I monitored the temperature, salinity, fluorescence, pCO_2 and O_2 sensors, Simon collected samples for DNA/RNA diversity and Frankie collected samples for DMS analysis. The last sample was collected at 02:00, and all the data should be available tomorrow morning.

Tuesday 12 May JD 132

We continued the zigzag ADCP transects northeast/southeast along the filament throughout the day, with an estimated time to finish of 20:00. At 08:22 our position was 19° 35.55 N 019° 25.19 W, sea surface temperature was 20.7 °C, air temperature was 19.3 °C, salinity was 36.64, barometric pressure was 1014, water depth was 3231 m and the winds were northeasterly 20 knots. The weather forecast predicts a Force 7 with rough to very rough seas – just the sort of weather to create upwelling filaments ! The upwelled water we are looking for has a high nutrient content, and so Malcolm Woodward determined the nutrient concentrations in the water samples that Simon had collected during the ADCP transect yesterday, and ran the nutrient autoanalyser in continuous mode to monitor the nutrient concentrations during a further northeastwards transect of the filament. We finished this transect at 14:08 and began to collate and discuss the data collected. The ADCP data showed a good westwards flow of water that would be suitable for a Lagrangian study, so we just needed to determine where the filament was least heterogeneous and decide which type of biological community we wanted to study. While Dan, Dave, Kev and John tested the MVP, we posted all the data onto the notice board and gathered around to discuss it. Both transects

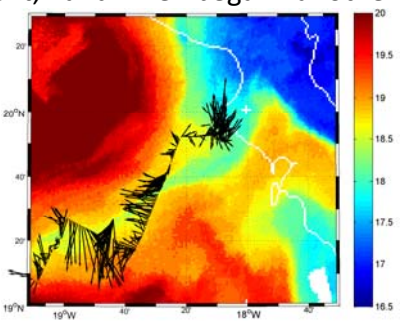




showed temperature to be lowest in the centre of the filament (upwelled water is colder than surface water) and chlorophyll reached maximum levels along the northern edge of the filament (see figure). The greatest puzzle was the nutrient data – we were very surprised to measure such high nitrate concentrations (12 µmol l^{-1} in the centre of the filament) (see figure) despite there being relatively low chlorophyll concentrations (between 1 and 3 µg l^{-1}). We expected the upwelled water to have been in the sunlit surface layer for at least 8 days (enough time for the phytoplankton to have taken up more of the nitrate as they grew). We spent some time checking the calibrations of the nutrient and chlorophyll measurements, but found no problem with either of them. Without the MVP, we still had no information on the vertical structure of the filament, and wanted to know which phytoplankton population dominated the community here. Using the latest satellite image of sea surface temperature, we plotted another transect across the filament and aimed to deploy a CTD and Apstein net in the centre of the filament. The net (#18) sample was dominated by dinoflagellates. The water samples collected from the CTD (#62) showed that nitrate concentrations were approximately 9 µmol l^{-1} and that there were large numbers of the picoautotroph *Synechococcus* sp. present. Still puzzled, we decided to transect further east - if the high nutrient concentrations were related to the upwelled water, then the concentrations should increase further east towards the source of the upwelled water.

Wednesday 13 May 2009 JD 133

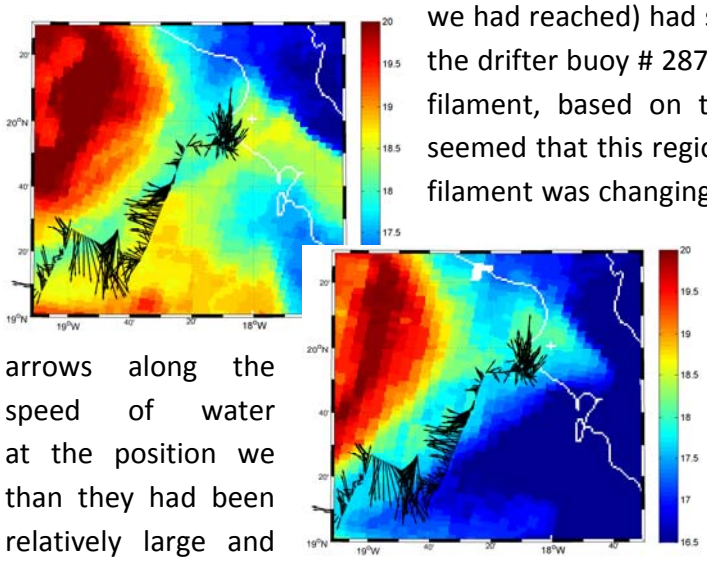
We celebrated Malcolm's birthday with a glass of Buck's Fizz (champagne and orange juice) mid-morning, and a number of the scientists grew and shaved their beards in the style Malcolm has his. The direction of travel of the ship in relation to the worsening weather caused the galley scuppers to flood, and so we hove to at 06:30 for 2 hours while this was cleaned up. The officers, crew and technical staff worked to repair problems with the CTD winch and with the MVP. At 09:41 our position was 19° 19.64 N 018° 42.22 W, sea surface temperature was 18.8 °C, air temperature was 18.5 °C, salinity was 35.77, barometric pressure was 1014, water depth was 2852 m and the winds were northeasterly 25 knots. At 11:00, the MVP was ready for a test deployment, and we began another northeast/southeast zigzag transect along the east/west axis of the filament. We aimed to deploy a CTD and Apstein net in the centre of the filament to determine the vertical distribution of nutrient concentrations and plankton community structure. We used the latest satellite image of sea surface temperature and underway measurements of temperature, salinity, chlorophyll and pCO_2 to 'guess-estimate' the position of the centre of the filament (SST satellite image 1 – 21:01 11 May 2009 with black arrows along the transect indicating



the direction and speed of water movement). We recovered the MVP at 14:34, deployed CTD # 63 at 15:18, net #20 at 16:00, and redeployed the MVP at 17:03. The data from the ADCP and MVP transect, plus the satellite image, should help us to find an area in the middle of the filament in which to deploy the pre-dawn CTDs, before releasing the SF_6 tracer tomorrow. The survey and data analysis continued until 21:20, when we thought we had found an appropriate place to release the SF_6. We deployed a drifter buoy #2879 with the wire walker at 21:37 and began a small scale box survey with the MVP and ADCP around the drifter to assess the vertical structure of the water and confirm whether this would be an appropriate place to deploy the third patch of SF_6.

Thursday 14 May 2009 JD 134

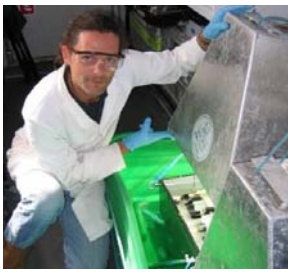
Towing the MVP was problematic last night due to the weather – especially travelling east, when the risk was that strong winds and swell could push the MVP tow line across the aft port superstructure of the ship again. To avoid this, Riqui designed a box survey grid without any west to east lines. The weather was still 'marginal' (a term heaped with innuendo and used by the officers, crew and scientists to mean that deployment of scientific equipment over the side was not certain to go ahead – usually due to adverse weather conditions) at 04:00, but had calmed down sufficiently by 04:47 to deploy CTD # 64, and then CTD # 65 at 05:36 alongside the drifter buoy #2879. The nitrate concentration in the surface water was 8 µmol l^{-1} and the silicate concentration was 1 µmol l^{-1}. At 06:34 our position was 19° 52.20 N 018° 10.75 W, sea surface temperature was 18.4 °C, air temperature was 18.2 °C, salinity was 35.81, barometric pressure was 1012, water depth was 2110 m and the winds were NNE 25 knots. The overnight MVP/ADCP survey and an updated satellite image of the sea surface temperature of the region (SST satellite image 2 – 02:58 13 May 2009 with black arrows along the transect indicating the direction and speed of water movement) suggested that the region where we had deployed the CTDs was not as homogeneous as we had wished. The area we had been aiming for on the previous image (and had thought that we had reached) had shifted westwards. We therefore recovered the drifter buoy # 2879 and started a new MVP survey across the filament, based on the position seen in satellite image 2. It seemed that this region was so dynamic, that the position of the filament was changing as quickly as we could survey it. In fact, by lunchtime, when we received the next sea surface temperature image (SST satellite image 3 – 02:47 14 May 2009 with black arrows along the transect indicating the direction and speed of water movement), it appeared that the waters at the position we had deployed the CTDs were 2 °C cooler than they had been 24 hours before. This image also showed a relatively large and homogeneous region at 19° 20'N 18°W



(image 3) where a cold finger or filament appeared to be developing – the ideal position for the next Lagrangian study ?! We headed south, with an estimated time of arrival of 20:00. Towing of the MVP became unsafe due to the weather, and so it was recovered at 13:46. On arrival at 19^{o} 20'N 18^{o}W, we deployed the wire walker buoy # 2879 again and undertook a 2 hour MVP/ADCP 'figure of 8' survey of the proposed SF_6 deployment region. On analysis of the MVP/ADCP data, we chose the most homogeneous 2 km^2 area, and at 23:30 began to deploy the SF_6.

Throughout the day, we continued to process samples and data collected from CTD deployments over the past few days. Jo Dixon is determining the impact of plankton community structure on the

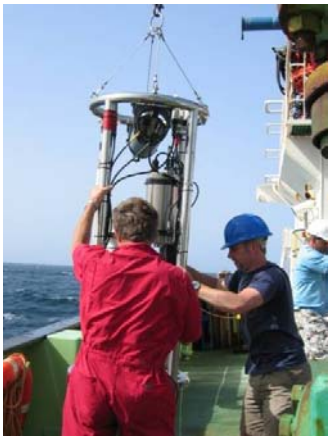


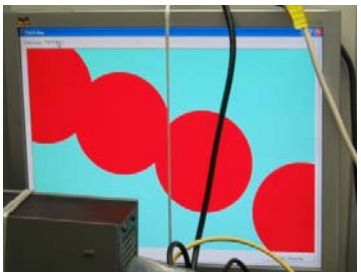



uptake of methanol and the production of methanol from the breakdown of coloured dissolved organic material in the light (photochemistry), Polly Hill is measuring the uptake of amino acids such as leucine and methionine by bacteria, Darren Clark is investigating the rate of production of nitrite and nitrate from ammonia by the plankton community, and Gavin Tilstone (together with Vas and Malcolm W.) is undertaking daily photochemical incubations to assess the impact of the photobleaching of coloured dissolved organic material on the production and consumption of climate relevant gases such as carbon monoxide, oxygen and ammonia.

Friday 15 May 2009 JD 135

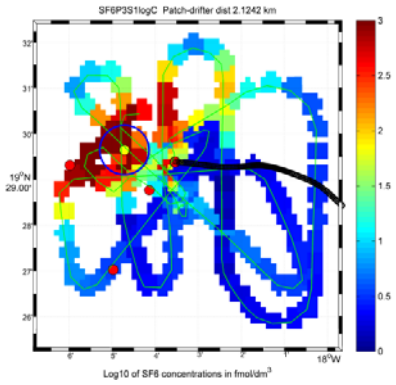
The SF_6 deployment continued until 05:30, and we deployed the Carioca buoy # 5990 at 05:42, the ADCP buoy # 2881 at 06:52, the drifter buoy # 2880 at 07:19 and the drifter buoy # 2988 at 07:56 at the four corners of the 2 km^2 SF_6 patch. At 05:23 our position was 19° 25.78 N 017° 52.91 W, sea surface temperature was 18.1 °C, air temperature was 17.7 °C, salinity was 35.62, barometric pressure was 1011, water depth was 2198 m and the winds were northeasterly 20 knots. The morning began hazily (see photo) with the sun still blanketed with an orange dust haze at 07:00 as we watched Fin whales glide past on the port side (photo courtesy of Malcolm Woodward). We moved back to the patch centre (buoy # 2879) for CTD # 66 at 09:05 in waters with an SF_6 concentration of 2753 fmol l^{-1} (a concentration too high for one of the analysers to measure !). The optics rig was deployed (OPT 013) at 09:08 (see photo) and an Apstein net (NET 21) at 10:23. CTD # 67 was deployed at 11:54, and the ship drifted out of the SF_6 patch during the 2.5 hours it took to sample to 2240m (surface SF_6 concentrations at the end of the cast were 6 fmol l^{-1}). The 1% light level calculated from data collected during the optics rig deployment (OPT 014) was 31m. We carried out turbulence probe deployments between 14:22 and 15:43 when the optics rig (OPT 015) was deployed again. The overnight MVP and SF_6 mapping survey began at 17:06. The SF_6 data is presented in near real time as red circles along the ship's track. The size of the circles on this so-called 'bubble' plot is representative of the concentration of SF_6 measured, and the software automatically scales the size of each 'bubble' relative to the previous SF_6 data collected. So, in the search for the highest SF_6 concentration before each CTD, we hope for large red SF_6 data points, surrounded by smaller SF_6 data points, which indicate where the edges of the patch are. Since this was the first mapping exercise since the SF_6 deployment this morning, the data points are huge, and worth recording here (see photo of computer screen) as, as the SF_6 mixes and dilutes, we won't see such comfortingly large data points again. During the evening, Riqui found a flying fish flapping around on deck. We photographed it for posterity (photo of flying fish alongside an A4 sheet of paper for





scale) before returning it to the sea. At midnight, the MVP developed a fault and was recovered for repair.

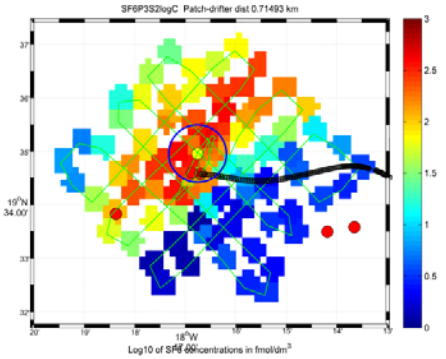
Saturday 16 May 2009 JD 136



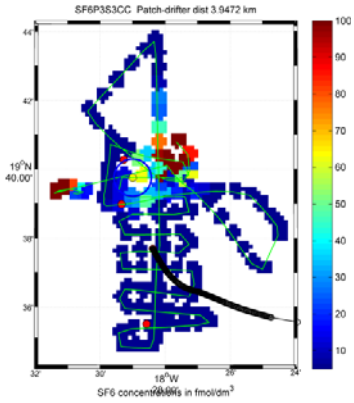
The SF_6 mapping survey continued until 03:30, when Riqui analysed the data to predict where the highest concentrations of SF_6 were, and directed the ship to the patch centre in preparation for the pre-dawn CTD casts. The figure shows the concentration of SF_6 mapped along the ship's track (highest concentrations are in red, lowest in blue, on a logarithmic scale), the trajectory of the central buoy in black, the position of all the buoys as red circles, and the predicted patch centre as a yellow circle surrounded by a 2km area blue circle. CTD #68 was deployed at 04:00, and CTD #69 at 04:54 in waters with surface concentrations of SF_6 of about 1200 fmol l^{-1}. The ships' lights directed at the CTD in the water attracted several large squid to the surface, and Riqui set about catching some for lunch (see photo [Riqui's sideburns and moustache courtesy of the ongoing facial hair competition]). At 06:52 we recovered drifter buoy # 2880 which was heading south away from the patch, and between 07:30 and 08:30 we deployed the turbulence probe. At 07:32 our position was 19° 30.62 N 018° 7.29 W, sea surface temperature was 18.0 °C, salinity was 35.64, barometric pressure was 1011, fluorescence was 0.35 fluorescence units, water depth was 2403 m and the winds were NNE 21 knots. We deployed CTD #70 at 09:03, optics rig OPT 016 at 09:10, Apstein net #22 at 10:11 and the turbulence probe between 10:35 and 11:25. The mid-day CTD #71 was deployed to 500m alongside the optics rig (OPT 017), and was followed by turbulence probe deployments between13:30 and 19:00. We deployed drifter #2880 in the SF_6 patch at 19:37 and CTD #72 at 20:07. One aim of these sunset CTDs is to measure the decrease in seawater oxygen concentration overnight due to plankton respiration. This depends on the sunset CTD and following pre-dawn CTD being unequivocally in the same water mass (difficult to do unless SF_6 is used), and the rate of plankton respiration being high enough to measure over a 7 hour night period. We're hoping to be the first scientists to make these measurements of in water respiration. Mapping of the SF_6 patch (without the MVP which is under repair) began at 21:40 and will continue until 02:00. We haven't had an Argo fix on the Carioca buoy for several days, and so sent out the following Met Warning / Safety Call to all ships : 125/09 CAP BLANC. CARIOCA BUOY ADRIFT VICINITY 19 34N 018 14W AT 16/1800. SHIPS IN AREA THAT SPOT IT SHOULD REPORT TO DISCOVERY FOR THE ATTENTION OF RICKI OR RETURN TO SENDER.

Sunday 17 May 2009 JD 137

The SF_6 mapping survey continued until 03:30, when Riqui analysed the data to predict the position of the highest SF_6 concentration (see figure), where we could re-locate to deploy the pre-dawn casts. CTD #73 was deployed at 04:03, CTD #74 at 05:31 and the turbulence probe was deployed between 06:44 and 08:25. Atmospheric sampling of oxidized volatile organic compounds took place between 04:00 and 06:00. At 07:47 our position was 19° 35.92 N 018° 17.97 W, sea surface temperature was 18.1 °C, salinity was 35.65, fluorescence was 0.49 fluorescence units (2.5 μgl^{-1} Chl), barometric pressure was 1013, water depth was 2450 m and the winds were NNE 23 knots. The optics rig (OPT 018) was deployed at 09:08, CTD #75 at 09:10 and nets 23, 24 and 25 (Apstein, Bongo and 700µm) between 10:24 and 11:25. CTD #76 was deployed at 12:05 in waters with an SF_6 concentration of between 117 and 125 fmol l^{-1} alongside the optics rig (OPT 019). We deployed a drifter in the SF_6 patch at 13:03 and deployed the turbulence probe between 13:14 and 16:15. We recovered and redeployed the ADCP buoy # 2881 and the wire walker buoy # 2879. The Carioca buoy has re-started transmitting via Argo and we started the overnight SF_6 mapping (without the MVP as it is being repaired) at 20:50.



Monday 18 May 2009 JD 138



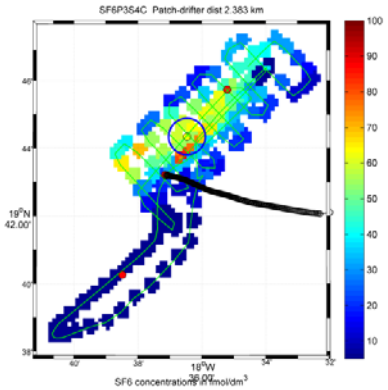
The ADCP survey finished at 03:45 and analysis of the surface SF_6 data gave the predicted position of the patch centre (see figure). We deployed CTD #77 at 04:00 to 120m, and began atmospheric sampling for volatile organic compounds. CTD # 78 was deployed to 120m at 04:58 in waters with an SF_6 concentration of 60 fmol l^{-1}, and was back on the deck at 05:25 when the frenzy of sampling began. Ten scientists take water samples from up to 12 depths for analysis of more than 24 parameters. At 04:56 our position was 19° 40.52 N 018° 27.86 W, sea surface temperature was 18.2 °C, salinity was 35.66, fluorescence was 0.57 fluorescence units (3.2 μgl^{-1} Chl), barometric pressure was 1013, water depth was 2565 m and the winds were NNE 25 knots. Once the atmospheric sampling was completed, we travelled south to pick up one of the drifters (#5988) at 07:00. The small size of the SF_6 patch, the relatively low concentrations we were measuring, and the ADCP data suggested that the patch may be subducting again. We therefore stopped on the way back to the patch to deploy a CTD (#79) to check for evidence of subduction. We collected samples for SF_6 analysis at 5m intervals down to 70m. Returning to the vicinity of the patch for the 09:00 CTD, we found that the SF_6 was no longer in the same position relative to the buoy, and we had to spend an hour

searching for it. CTD #80 was deployed to 120m at 10:06, and immediately this was inboard, we deployed a drifter (#5988) at this new 'patch centre'. Since we were only able to map a small portion of the SF_6 patch last night, we took the opportunity before the mid-day cast to assess the length of the SF_6 patch, and found that the SF_6 extended about 3.5 miles NE of the buoy. CTD #81 was deployed near the buoy # 5988, alongside optics rig OPT 020, and followed by Apstein net #26. We deployed the turbulence probe between 16:31 and 18:52, and then we went in search of the wire walker buoy, which we recovered at 20:20. Analysis of water samples collected from CTD #79 showed no evidence of subduction i.e. SF_6 concentrations were not greater at depth than at the surface. Reassured that we would be able to stay in the SF_6 patch a few more days, the overnight ADCP and SF_6 survey began at 21:15 and was due to end at 04:00 tomorrow.

Monday is 'linen change' day, and so we had the luxury of clean sheets to fall asleep between tonight. The routine of scientific work needs to be offset with some quality 'me' time each day. There are a number of places to try to relax around the ship – the gym, where Ian and Tim have an ongoing 'fastest 1km rowing' competition, the video room with a selection of books, videos and DVDs, and the TV room (or cinema).

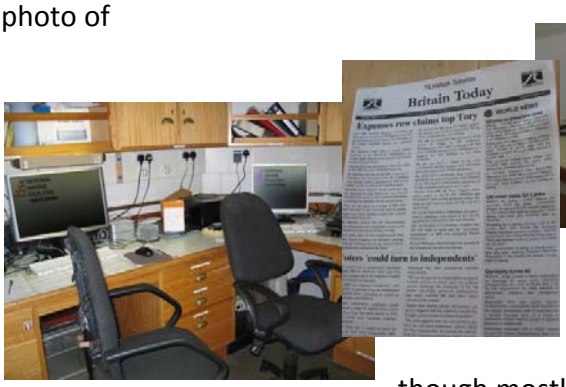
Tuesday 19 May 2009 JD 139

The SF_6 mapping we were able to undertake yesterday before the mid-day CTD, showed the SF_6 patch to be lying along a NE/SW axis, and mapping in this direction overnight provided an excellent description of the area of the patch and the predicted patch centre (see figure). We deployed CTD #82 to 120m at 03:58, CTD #83 to 120m at 04:56, and sampling for atmospheric volatile organic compounds took place between 04:00 and 06:00. We then deployed the wire walker buoy #2879 in the new patch centre. At 08:36 our position was 19° 44.65 N 018° 38.76 W, sea surface temperature was 18.3 °C, salinity was 35.66, fluorescence was 0.41 fluorescence units (1.9 μgl^{-1} Chl), barometric pressure was 1014, water depth was 2747 m and the winds were NNE 22 knots. The surface SF_6 concentrations in the patch were 60-80 fmol l^{-1}. CTD #84 was deployed at 08:55, followed by Apstein net #27 at 10:00, CTD #85 at 12:05, and optics rig OPT 021 at 12:30. The 1% light depth was 31m. We recovered the ADCP buoy at 15:07 and a drifter buoy at 16:21, and redeployed the ADCP buoy in the patch at 19:26. The MVP was then deployed at 19:32 for the overnight SF_6 mapping survey until 03:00. Taking advantage of being in an SF_6 patch and therefore



unequivocally in the same water mass, we began to plan a diel experiment for tomorrow. This would mean collecting surface water samples at hourly intervals throughout the day for analysis of SF_6, DMS/P, OVOCs, CH_4, Fire (an indicator of plankton activity), and plankton community structure, and deploying shallow CTDs for collection of samples for dissolved oxygen, dissolved inorganic carbon, alkalinity, nutrients, carbon monoxide, pH and bacterial activity. In between the CTDs, we planned to deploy the turbulence probe for up to an hour at a time. A very busy day ahead !

We keep in touch with the 'outside world' via emails (transfers twice a day at 10:00 and 20:00) (see photo of



computer room), a daily newspaper (see photo – though mostly full of football scores !), telephone (see photo of the communications room), and occasionally the world service or live coverage of a football match (see photo of relevant radio on the bridge).

Wednesday 20 May 2009 JD 140

The usual pre-dawn CTDs were deployed at 04:00 (CTD # 86 to 120m) and 05:00 (CTD #87 to 120m) at the SF_6 patch centre, and then we deployed the buoy #2880 at 05:40 to mark the patch centre for the rest of the day. A test turbulence probe deployment (originally designed to test the ability to undertake turbulence probe deployments in the dark) took place at 06:36 and this confirmed that our tight time schedule of hourly sampling in the patch centre interspersed with turbulence probe deployments which move away from the patch centre, was too difficult to achieve with so many buoys in the water at once. At 06:40 our position was 19^{o} 41.31 N 018^{o} 47.74 W, sea surface temperature was 18.4 ^{o}C, fluorescence was 0.54 fluorescence units (2.9 $\mu g l^{-1}$ Chl), barometric pressure was 1012, water depth was 2825 m and the winds were NE 20 knots. Surface SF_6 concentrations were in the region of 40 fmol l^{-1}. We retrieved drifter #2880 at 08:12 to ease navigation and moved the diel experiment ca. 500m to be centred on the ADCP buoy #2881. Even moving this short distance showed a marked difference in the depth profiles of inorganic nutrients and dissolved oxygen. CTD #88 was deployed at 08:30 to 110m, alongside optics rig OPT 022, followed by a turbulence probe deployment between 09:30 and 09:58. An Apstein net deployment (NET 28) at 10:14 was followed by a turbulence probe deployment between 10:42 and 12:28. CTD #89 was deployed alongside optics rig OPT 023 at 13:07, followed by a turbulence probe

deployment between 13:26 and 16:16. CTD #90 and optics rig OPT 024 were deployed at about 16:36 and CTD #91 and optics rig OPT 025 were deployed at about 20:30. Hourly surface water sampling continued throughout the night, and the last turbulence probe deployment was completed at 00:20.

Thursday 21 May 2009 JD 141

The pre-dawn CTDs (#92 and #93) were deployed at 03:58 and 04:59 respectively, on completion of which we went in search of the wire walker buoy (#2879) which we knew was running out of battery power. At 06:06 our position was 19^{o} 37.38 N 018^{o} 54.87 W, sea surface temperature was 18.6 ^{o}C, fluorescence was 0.58 fluorescence units (3.3 $\mu g l^{-1}$ Chl), barometric pressure was 1011, salinity was 35.66, water depth was 2904 m and the winds were NNE 20 knots. The surface SF_6 concentration reached a maxima of 26 fmol l^{-1}. The buoy was recovered at 07:16 and we returned to the SF_6 patch for CTD #94 at 09:25, followed by Apstein net #29 at 10:30. For the first time in the cruise, there was actually a hint of rain and we joked about sampling with umbrellas to prevent contamination of the samples with freshwater. As was becoming usual, the buoy marking the centre of the patch and the actual SF_6 patch became increasingly separated, and we therefore spent some time searching for the highest SF_6 concentrations in which to deploy CTD #95 at 12:03 and optics rig OPT 026 at 12:36. These short intensive searches are only achievable through the experience and expertise of the Officers on the bridge. At 15:14 we re-deployed the wire walker buoy (#2879) and undertook turbulence probe deployments between 15:23 and 16:24, before deploying the MVP at 16:51 until 22:03. We completed a high resolution SF_6 mapping exercise between 22:41 and 02:00. As tomorrow may be our last day sampling the SF_6 patch, it was important to have as much data as possible to guide us to the patch centre for the day's sampling activities. Once Riqui received the positions of all the buoys via Argo he was able to determine the length of time required to retrieve them all before undertaking the final large scale MVP survey of the cruise.

Friday 22 May 2009 JD 142

To maximize the time available to recover the 4 buoys and undertake the MVP survey, we decided

to deploy 4 CTDs immediately after each other this morning for 1) large volume experimentation, 2) pre-dawn incubation experiments, 3) SF_6/He transfer between the sea surface and the atmosphere and 4) measurements of N_2O and CH_4 in the oxygen minimum zone. We deployed CTD #96 at 04:09, CTD #97 at 05:09, CTD #98 at 06:17 and CTD #99 at 07:35. Thinking that this would be the last CTD of the cruise, we taped a few cans of lager to the CTD frame (see photo) to celebrate and thank the crew (Greg, Mark, Phil, Paul, John, Ian and Steve)

for their invaluable help. Simon wrote **RRS Discovery** on several polystyrene cups and tied them up in stockings (kindly donated by ????) to the CTD frame. The pressure of the water at 500m would reduce the cups to a third of their size and provide an unusual souvenir for his niece. At 07:31 our position was 19° 29.70 N 019° 08.34 W, sea surface temperature was 18.8 °C, fluorescence was 0.62 fluorescence units (3.6 μgl^{-1} Chl), barometric pressure was 1014, salinity was 35.69, water depth was 3068 m and the winds were NNE 18 knots. Surface SF_6 concentrations were in the range 10-12 fmol l^{-1}. We recovered the ADCP buoy at 09:45, the drifter buoy #5988 at 12:31, returned to the SF_6 patch for an optics cast (OPT 027) at 14:03, and recovered the wire walker buoy #2879 at 15:06. We deployed the MVP at 15:28 and headed for the last known position of the Carioca buoy – almost 4 hours away. The Carioca buoy (worth ca. £45k) had become detached from its GPS buoy and had no light attached. We therefore needed to find it before it got dark at 20:00. Despite several willing volunteers searching with binoculars from the bridge, we were unable to recover the buoy, and very disappointed, continued the hexagonal MVP survey of the filament at 20:00 (due to finish at almost this position at 00:00 Saturday).

Saturday 23 May 2009 JD 143

The MVP survey continues, with Dave, John and Kev working shifts to monitor its safe deployment.

Without any pre-dawn CTDs to get me out of bed, I had a very welcome lie-in this morning, and a luxurious breakfast of home-made croissants – thanks to Mark and Lloyd. At 08:23 our position was 19° 57.62 N 018° 27.17 W, the sea surface temperature was 18.4 °C, fluorescence was 0.35 fluorescence units (1.4 μgl^{-1} Chl), salinity was 35.66, barometric pressure was 1015, water depth was 3012 m and the winds were NNE 23 knots. At 09:48 the conducting cable of the MVP broke, and so the MVP was recovered inboard. The problem was expected to take at least a day to repair, and so the decision was made to return south to search again for the Carioca buoy, and prepare the CTD for repeated deployments in lieu of the broken MVP. The final number of MVP vertical profiles made during the cruise is 1797 – almost three times as many profiles as the MVP has made in its previous 7 years of use. At 10:30, the Master carried out his weekly inspection (photo from left to right – John Leask, First Officer; Peter Newton, Master; Mike Ripper, Purser) of the laboratories and cabins to ensure they are maintained in a clean, tidy and safe condition. I carried out the final oxygen titration of the cruise and the oxygen 'A' team celebrated the end of titrations on the aft deck. The incubators were switched off and cleaned during the afternoon and the Carioca buoy was successfully retrieved at 18:29. We then started CTD deployments to 500m every 3 hours. CTD

#100 was deployed at 19:16 and CTD #101 was deployed at 22:48. Very many thanks to John, Dave and Kev who stayed on shifts to complete these important CTDs.

Sunday 24 May 2009 JD 144

CTD #102 was deployed at 02:32 to 500m, and then we continued to steam north. At 06:00, due to

the slow progress of the ship against the weather, the final CTD (anticipated to be at around 06:15) was cancelled. At our current average speed of 6 knots, our estimated time of arrival in Tenerife is midnight Wednesday (i.e. 24 hours too late). However, we expect the winds to drop as we travel the 500+ miles north so that we can reach an average speed of 7.3 knots and pick up the pilot outside Santa Cruz harbor at 07:00 on Wednesday. At 09:01 our position was 20^{o} 19.59 N 018^{o} 21.60 W, the sea surface temperature was 18.3 ^{o}C, salinity was 35.71, barometric pressure was 1015, water depth was 2158 m and the winds were NNE 23 knots. We spent the day catching up with instrument calibrations, washing glassware, packing and report writing. The clocks were brought forward one hour to BST (GMT+1) at midnight.

Monday 25 May 2009 JD 145

At 07:00 BST our position was 23^{o} 10.51 N 017^{o} 39.29 W, the sea surface temperature was 19.3 ^{o}C, salinity was 36.41, barometric pressure was 1015, water depth was 2976 m and the winds were NE 24 knots. Most of the scientific instrumentation was packed into boxes and into the aft container today. All data is being backed up, and logsheets photocopied. The last 'burn' of paper and cardboard took place at 10:30, so all remaining rubbish has to be stored in the skips. The labs look empty – it's hard to remember how cramped they were only a day or two ago. The traditional Principal Scientist's 'Request the Pleasure of your Company' (RPC) is planned for this evening after dinner.

Tuesday 26 May 2009 JD 146

At 07:36 GMT our position was 26^{o} 40.30 N 016^{o} 45.39 W, the sea surface temperature was 20.2 ^{o}C, salinity was 36.62, barometric pressure was 1018, water depth was 2158 m and the winds were light at 11 knots. The final packing and report writing will be completed today. We are due to be in phone range at 20:00 BST tonight, and to dock early tomorrow morning. The scientists fly home tomorrow afternoon or Thursday morning. Then the data analysis and manuscript writing begins …….

MVP Surveys

Thomas Meunier, Beatriz Barreiro, Ricardo Torres

Instituto Investigaciones Marinas (CSIC), Vigo, Spain and Plymouth Marine Laboratory, West Hoe, Plymouth, UK

Introduction

Upwelling filaments have been recognized as dynamically rich mesoscale features for a long time, associated with a strong hydrographic signal. The relation between the density structure of filaments with their velocity field has been shown to be nearly geostrophic [Dewey et al., 199], so that a detailed monitoring of the hydrography of the upwelling filaments chosen for the ICON Lagrangian experiment appears to be of the greatest importance for a rationalized choice of the Lagrangian experiment starting point.

A Moving Vessel Profiler (MVP) has been used to determine the hydrography of the surveyed upwelling filament. The MVP is composed of a CTD-equipped fish, which is able to dive almost vertically to 350m, as the ship moves at a speed of 7 knots, thanks to a powerful electronically controlled winch. The MVP presents the great advantage of avoiding long CTD stations, and thus allows a better synopticity of the 3 dimensional mapping.

A description of the MVP surveys for each leg of the ICON experiment can be found in section 1.

A collection of preliminary plots and maps of the pre-processed data can be found in section 2, and a brief discussion about the results in section 3.

1. **The surveys**

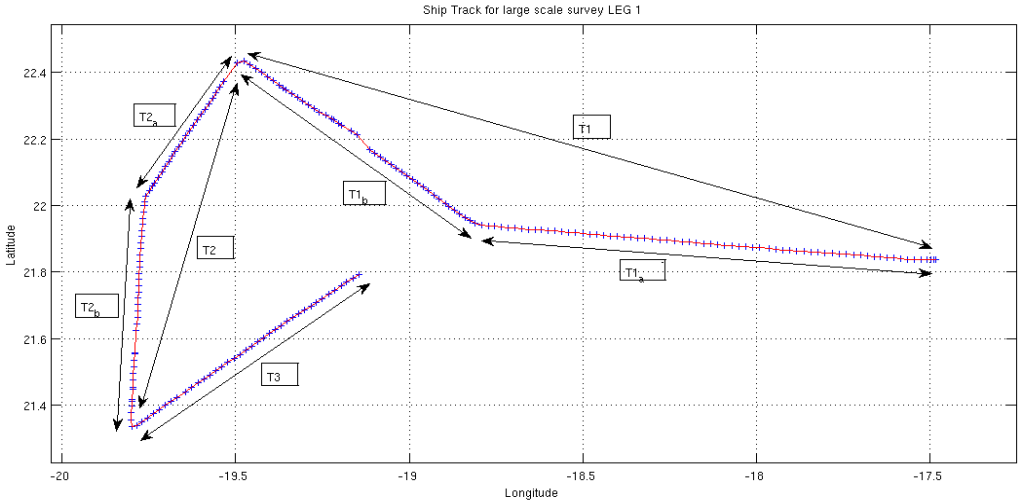
    1. **Leg 0**

        Initial testing of the MVP was carried out on a preliminary transect across the continental shelf and slope on 04/17/2009 between 01:22 and 04:40, from 22°44.94' N 17°10.18' W to 22°26.68' N 17°22.77 W. More than a simple material test, this transect is of particular interest, because it reveals the hydrographical structure of the upwelling jet and front, which might play a great role both for physics, as the filament structure forms along this front, and for biogeochemistry, because the water parcels followed during the Lagrangian experiment are assumed to be originated on the shelf. The cross sections maps can be found in figure 3 in section 2.

    2. **Leg 1**

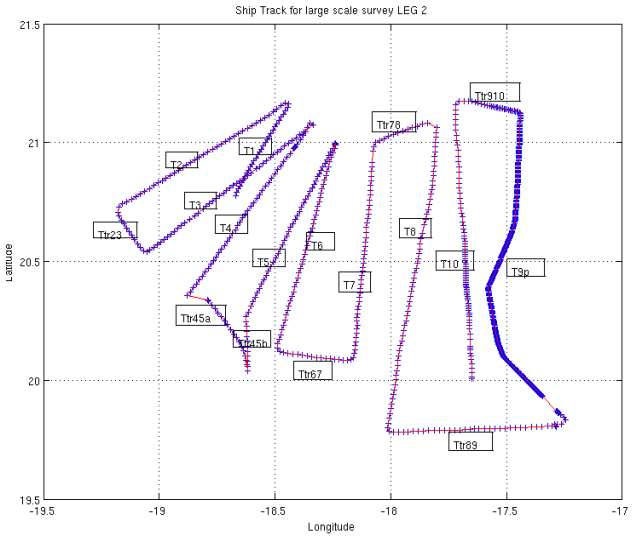
        The leg 1 MVP survey was designed to map the filament 3 dimensional structure, to help choose the most appropriate location to release the drifters and SF_6 for the Lagrangian experiment, i.e. a zone of offshore flow, but as far away as possible from the strong density fronts at the edges

of the filament, to avoid eventual subduction. The survey began on the 17/04/2009 at 13:34 and unfortunately ended prematurely on the 19/04/2009 at 03:08 because of a technical problem of the MVP. However, one large cross section of the deep eddy localized North of the filament, and 2 full transects across the filament could be done, and revealed partially the hydrographical structure of the filament. As the MVP was not repaired until the beginning of leg 2, no small scale Lagrangian survey has been carried out during leg 1.



3. Leg 2

1. Large scale

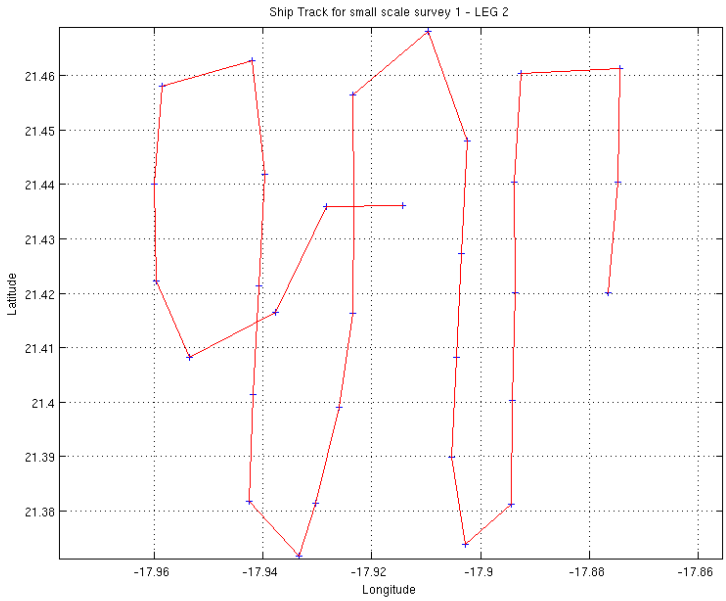


The large scale MVP survey of leg 2 was designed with the same purpose as leg 1.

Luckily, no important material failure occurred during the survey, so that an extended mapping of the filament could be done, revealing the 3 dimensional structure of the filament from sub surface down to 350 m. The horizontal and vertical sections maps can be found in section 2. A 1.1 psu shift in the salinity data occurred at Julian day time 122.308, and was

fixed on Julian day time 125.56. A comparison with underway data, along with a CTD calibration allowed us to characterize the salinity error and correct it.

2. **Small scale**
   The MVP was deployed during the overnight SF_6 mapping. This small scale survey offers a good three dimensional hydrographical mapping of the marked water mass. As the SF_6 was rapidly lost, eventually because of subduction at the filament's northern edge front, only two small scale surveys where made during leg 2. The horizontal sections can be found in section 2.



4. **Leg 3**

1. **Large scale**
   Because of a lack of time for both surveying and Lagrangian experiment, the large scale survey for leg 3 consisted only of one single cross-filament section.

2. **Small scale**
   Unfortunately, the MVP was broken again after 2 days of the Lagrangian experiment so that only two small scale surveys were done.

2. Results

The data has been preprocessed for preview plotting. The methods applied consist of a simple bin averaging in the vertical direction (over 5m deep bins), and two dimensional interpolation in the

horizontal directions. The interpolation and griding have been done using the Matlab function 'griddata', which interpolates the data over a regular grid, using the two-dimensional Delaunay method.

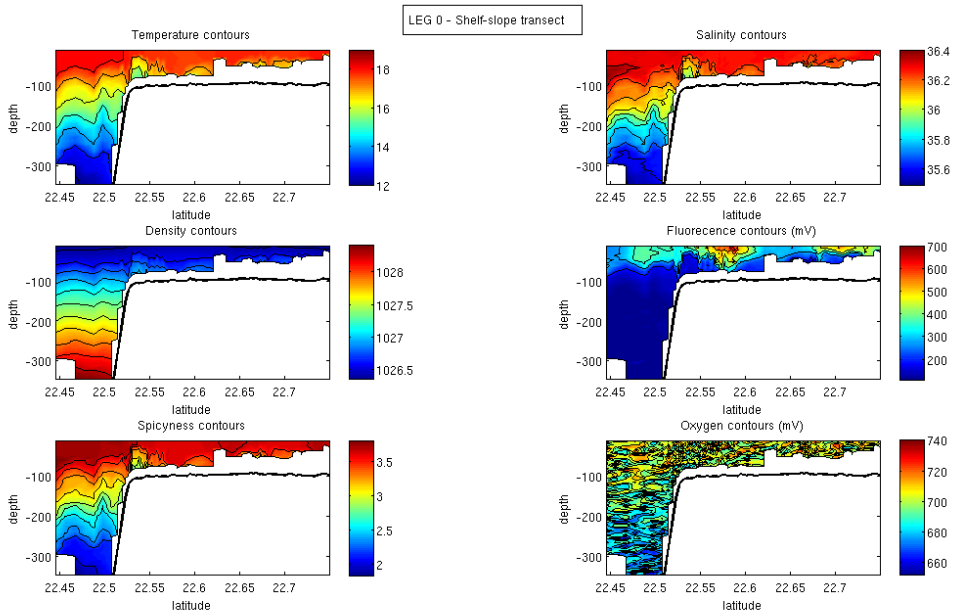


Figure 3 : Shelf and Slope transect

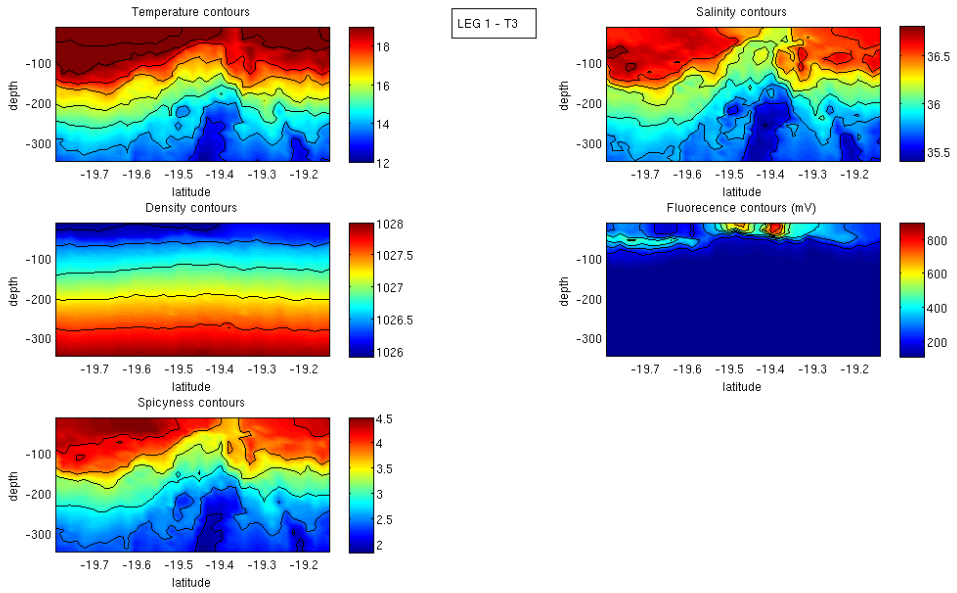


Figure 4 : Leg 1, section T3

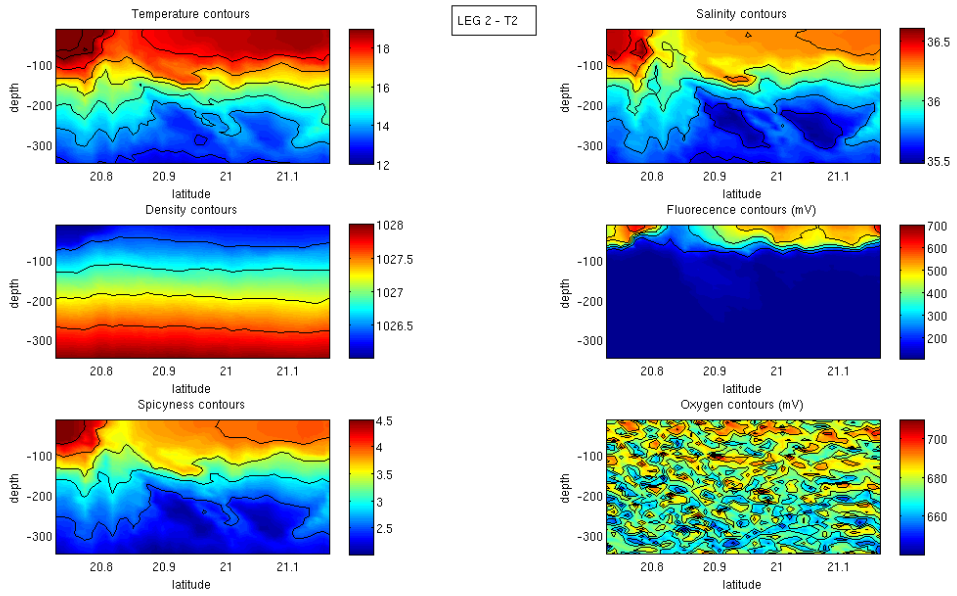


Figure 5 : Leg 2, section T2

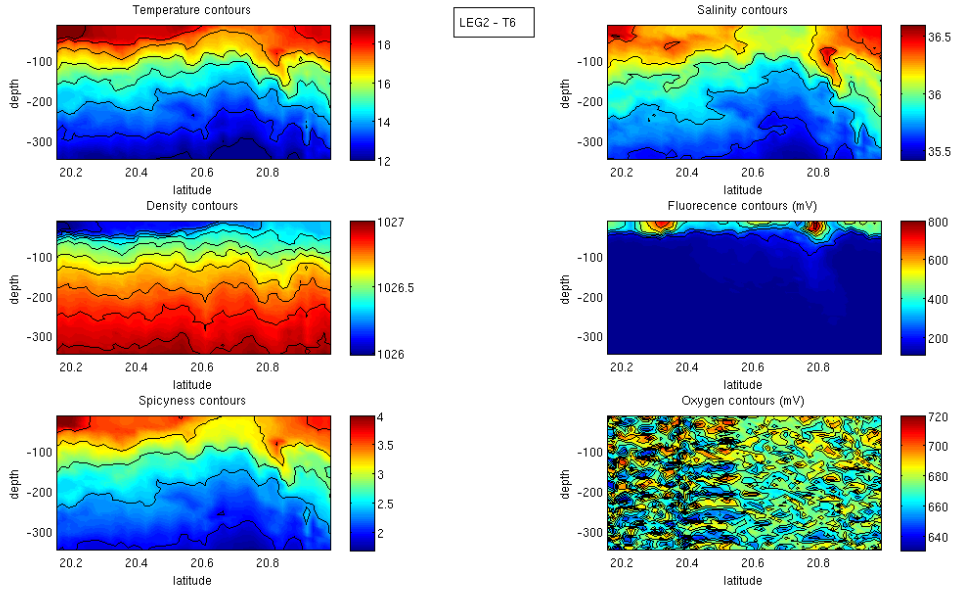


Figure 6 : Leg 2, section T6

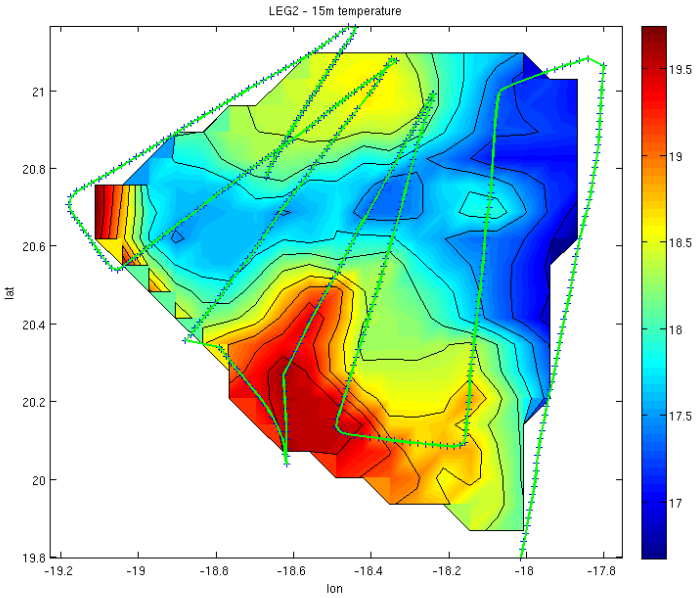


Figure 7 : Leg 2, horizontal section of temperature at depth -15m.

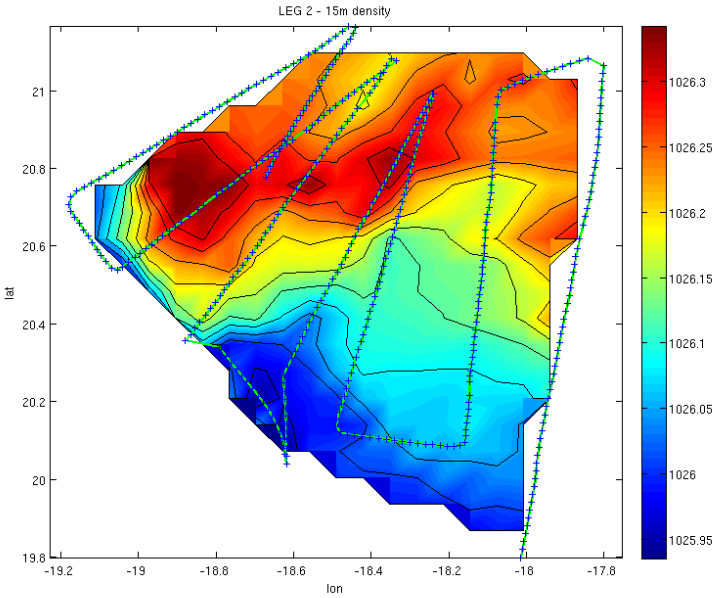


Figure 8 : Leg 2, horizontal section of density at depth -15m.

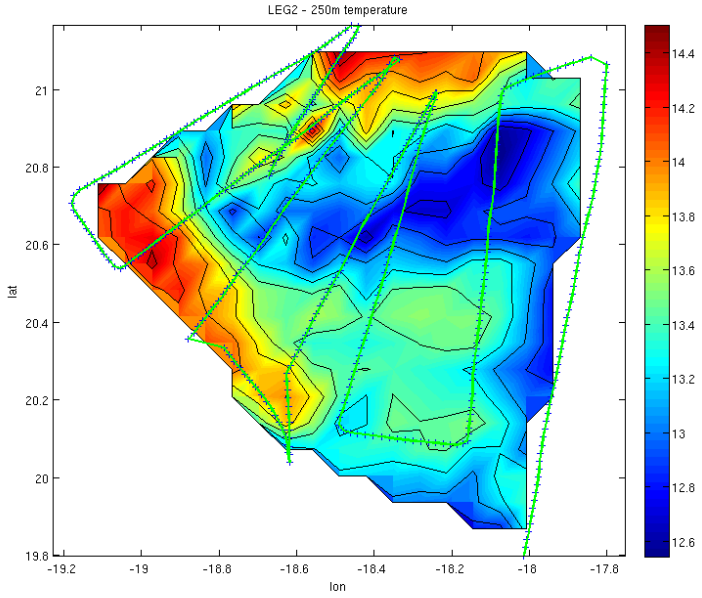


Figure 9 : horizontal section of temperature at depth -250 m.

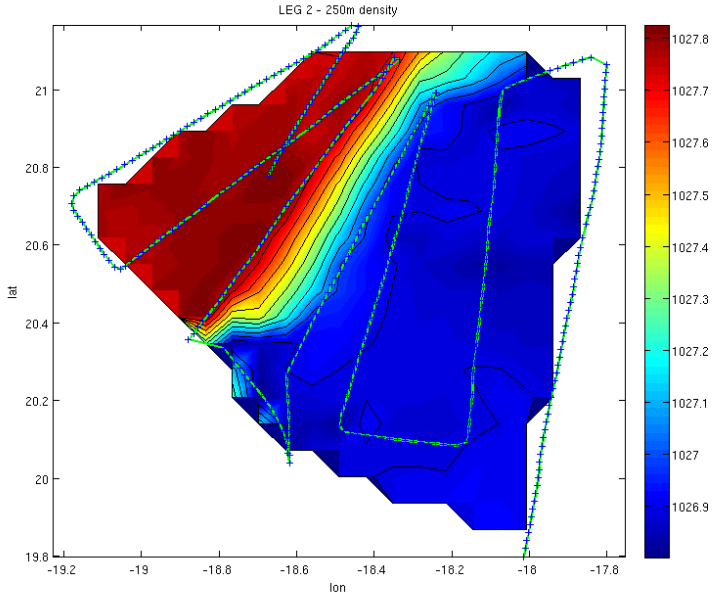


Figure 10 : Horizontal section of density at depth -250 m.

3. Discussion

The vertical sections both from leg 1 and 2 show a typical filament-like structure in terms of temperature, salinity, spiciness and density, with a great rising of the isotherms and isohalines on both sides of the filaments, resulting in sharp temperature and salinity fronts in the upper 100m. Because of the density compensating contributions of temperature and salinity of the upwelled water, the density signature of the upwelled water is weak, compared to some other upwelling fronts and filaments (Northern Morocco, Western Iberia, Benguela). The spiciness then appears to be a better tracer of the upwelled water than density in this particular case.

The horizontal sections of the second upwelling filament surveyed during leg 2 can be compared with the satellite images available for the 3 days of the experiment. A great similarity in the near-surface temperature patterns suggests that the sampled structure evolved slowly enough for the large scale survey to be nearly synoptic.

Deep horizontal section show a strong density front from 100 m to 300 m depth, with a gradient increasing with depth, perpendicular to the filament. More processing will be necessary to confirm the physical reality of this astonishing deep front.

Moving Vessel Profiler (MVP)

Dave Teare

National Marine Facilities-Sea Systems, National Oceanography Centre, Southampton, UK

The MVP had the following instruments fitted. AML micro CTD, AML micro dissolved oxygen, Chelsea instruments Mini-Tracka fluorometer, Satlantic irradiance sensors and a tilt and roll unit. Approximately 1800 undulations were completed, with undulation depths varying between 40 metres on the shelf to 350 metres in deeper water.

System performance

Although a record 1800 undulations were performed, over 4 times as many as any previous cruise, the system still suffers from serviceability problems. Some 17 workable days were lost, mainly due to lack of spares and having to perform fault diagnosis via email with the manufacturers.

A table of MVP deployments has been sent to BODC.

Surface drifters

Ricardo Torres, Tim Smyth, Beatriz Barreiro and Thomas Meunier
Plymouth Marine Laboratory, West Hoe, Plymouth, UK and Instituto Investigaciones Marinas (CSIC), Vigo, Spain

With the aim of marking and following, to a first approximation, the evolution of the SF_6 surface patches during the lagrangian experiments, five surface drifters were deployed on each experiment unless stated differently in the text below. All of the details from each deployment and recovery throughout the cruise are summarised in the tables below (

Table 2,

Table 4 and

Table 6). The tracks have been plotted for each lagrangian experiment in Figure 2-4. Details of any instrumentation attached to the surface drifters are shown in Table 1, Table 3 and Table 5.

The surface drifters were purchased from Pacific Gyre and comply to the standard WOCE configuration of a cylindrical surface buoy equipped with ARGOS and GPS radio transmission and drogued with a standard Holey Sock of 6m length and 1.5m diameter. The drogues were nominally centred at 12m from the surface.

The drifter's positions can be followed either from the GPS radio signal or from the ARGOS positioning system. The drifters are able to communicate their GPS positions when the ship is at a distance less than 5km. The GPS signal was received on board via a FREEWAVE radio receiver which feeds GPS data (along with GPS from the ship at every second) every 5 minutes into our PatchDeploy software. The object of this software is to identify the ships position relative to the buoys at any given point. This facilitates both the laying and tracking of the SF_6 patch with respect to the water movement rather than relative to the ground. Waypoints in our deployment pattern are updated relative to the movement of the buoy as the ship moves through the deployment grid. A similar methodology was used for each overnight mapping of the SF_6 patches. The drifters would send the GPS signal when interrogated by the PatchDeploy software but would only update their GPS positions every 5 minutes.

The drifters all stored the GPS positions internally and the data used in the graphs of this report have all been extracted from the complete internal dataset of each buoy rather than the intermittent GPS signal received by the ship's unit. No quality control has been applied to the data. The data can be made available to BODC immediately.

Instrumentation on surface drifters

It was originally intended that all 5 drifters would be equipped with instrumentation to provide information on the continuous evolution of the upper water column throughout the lagrangian experiments. These were either 100m long thermistor chains consisting of temperature and depth sensors from Star Oddie, a vertical

profiling platform (Wirewalker, covering 18m to 76m) equipped with a RBR CTD 740, a CARIOCA buoy (MARTEC ®) with surface met and surface CTD package as well as a pCO_2 system or a 600KHz RDI sentinel ADCP on a SUB-2 subsurface buoy fixed at 18m with a 40m range at 1m resolution.

All of the thermistor chains have either been lost or the data have been lost due to instrument malfunction. The CARIOCA buoy (Figure 1) was deployed twice as indicated in Table 5. CARIOCA buoy performs hourly measurements of several parameters: Concentration of seawater dissolved pCO_2, surface temperature, salinity and fluorescence; wind speed at 2m above sea level, air temperature and atmospheric pressure.

One wirewalker was lost early in the cruise after only several hours in the water. A second wirewalker was deployed successfully in the three patches and the ADCP SUBS-2 configuration was deployed in patches 2 and 3. For details of each deployment see the tables below. An example of one wirewalker record of 2 day duration during patch 3 can be seen in Figure 5.

The data from the instruments deployed along with the drifters have only been checked and there will be 6 months before that data can be made available to BODC.

Figure 1 Picture of the CARIOCA buoy.

DRIFTER BUOYS PATCH 1

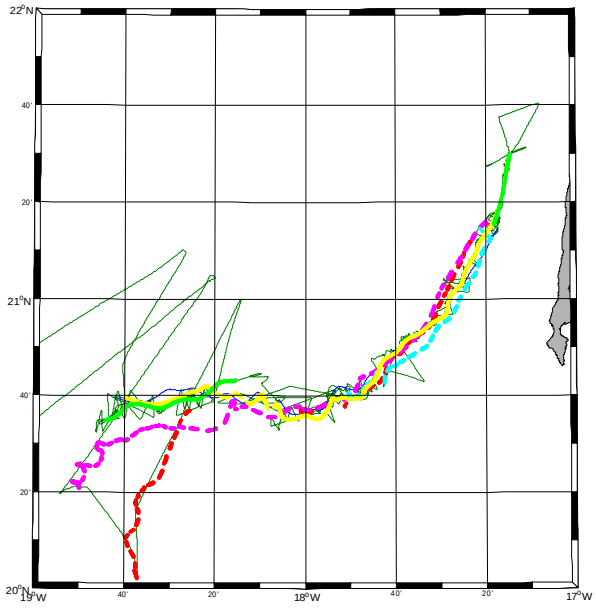


Figure 2 Drifter tracks overlaid on the cruise track during patch 1.

Table 1 Surface Drifter ID, colour style in plot and instrument configuration for all 3 patches. Shaded is the column corresponding to patch 1.

Num_buoy	Colour plot	P1	P2	P3
65988	Red	Thermistor	No Instrument	No Instrument
65990	Magenta	No Instrument	Carioca	Carioca
67546	--------	No Instrument (LOST)	-------	----
67547	Cyan	Wire Walker		
82879	Yellow	No Instrument	Wire Walker	Wire Walker
82880	Green	No Instrument	----------	No Instrument
82881	Blue	Thermistor	ADCP	ADCP

Table 2 Details of each drifter's deployment and recovery during patch 1.

DRIFTERS - 1st experiment						
Drift ID	Deployment			Recovered		
	Time	Latitude	Longitude	Time	Latitude	Longitude
82880	21/04/2009 15:55	21º 28.7400 N	17º 15.0467 W	21/04/2009 19:10	21º 26.4667 N	17º 15.5517 W
82879	21/04/2009 16:20	21º 28.5333 N	17º 15.1833 W	21/04/2009 18:35	21º 26.9750 N	17º 15.4983 W
82880	21/04/2009 21:20	21º 30.0117 N	17º 14.6567 W	22/04/2009 14:25	21º 15.6150 N	18º 15.3633 W
82879 no intrum.	22/04/2009 16:25	21º 18.5983	18º 39.9250 W	30/04/2009 18:35	20º 39.5783 N	18º 39.9250 W
82881	23/04/2009 00:30	21º 14.5567 N	17º 17.3933 W	30/04/2009 18:17	20º 39.4367 N	18º 42.0517 W
65990 no inst	23/04/2009 01:10	21º 16.0500 N	17º 20.1840 W	02/05/2009 06:45	20º 20.8867 N	18º 49.9083 W
65988	23/04/2009 01:55	21º 13.2667 N	17º 22.8717 W	26/04/2009 21:31	20º 37.0933 N	18º 25.6667 W
82880 no intrum.	28/04/2009 10:00	20º 43.1883 N	18º 15.3633 W	30/04/2009 12:12	20º 35.0517 N	18º 43.2800 W
65988	29/04/2009 13:55	20º 26.9550 N	18º 25.6667 W	02/05/2009 10:50	20º 2.1183 N	18º 37.2200 W

DRIFTER BUOYS PATCH 2

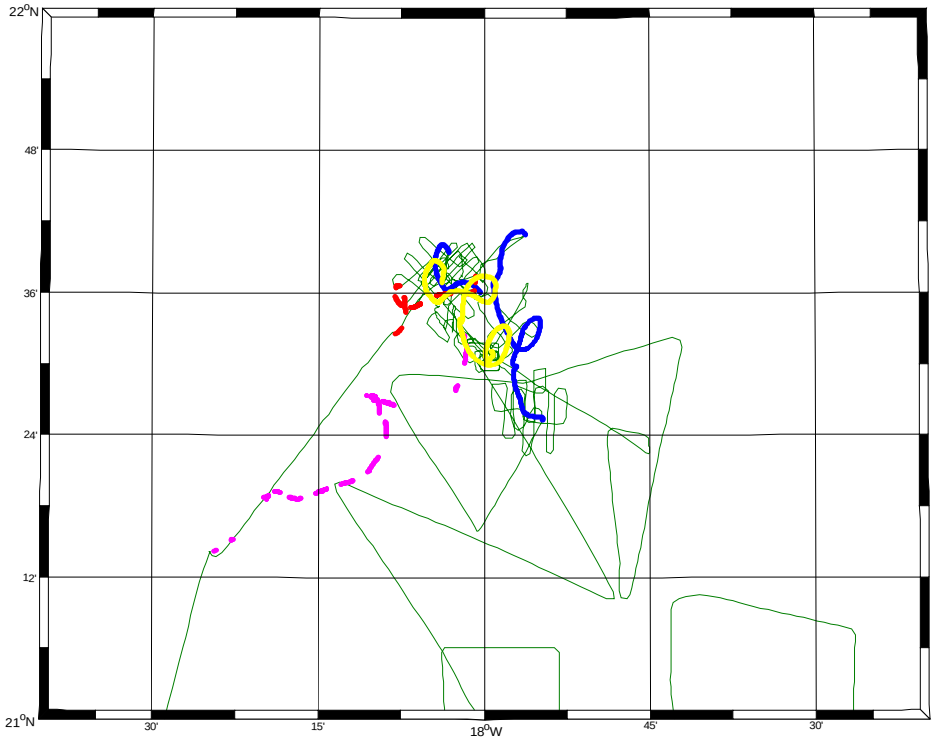


Figure 3 Drifter tracks overlaid on the cruise track during patch 2.

Table 3 Surface Drifter ID, colour style in plot and instrument configuration for all 3 patches. Shaded is the column corresponding to patch 2.

Num_buoy	Colour plot	P1	P2	P3
65988	Red	Thermistor	No Instrument	No Instrument
65990	magenta	No Instrument	No Instrument	Carioca
67546	--------	No Instrument (LOST)	-------	----
67547	Cyan	Wire Walker		
82879	Yellow	No Instrument	Wire Walker	Wire Walker
82880	Green	No Instrument	----------	No Instrument
82881	Blue	Thermistor	ADCP	ADCP

Table 4 Details of each drifter's deployment and recovery during patch 2.

DRIFTERS - 2nd experiment						
Drift ID	Deployment			Recovered		
	Time	Latitude	Longitude	Time	Latitude	Longitude
82881	07/05/2009 21:10	21° 25.2667 N	17° 54.7200 W	10/05/2009 07:40	21° 40.9233 N	17° 56.3400 W
82879	08/05/2009 13:10	21° 31.1633 N	17° 59.3633 W	11/05/2009 18:00	21° 36.9133 N	18° 3.8617 W
65990	08/05/2009 22:00	21° 32.1383 N	18° 1.8883 W	11/05/2009 12:40	21° 14.2283 N	18° 24.5233 W
65988	10/05/2009 06:50	21° 37.4767 N	18° 0.8117 W	11/05/2009 09:20	21° 32.6083 N	18° 8.0867 W
82881	10/05/2009 11:15	21° 36.0633 N	18° 0.3567 W	11/05/2009 06:40	21° 39.4950 N	18° 39.4950 W

DRIFTER BUOYS PATCH 3

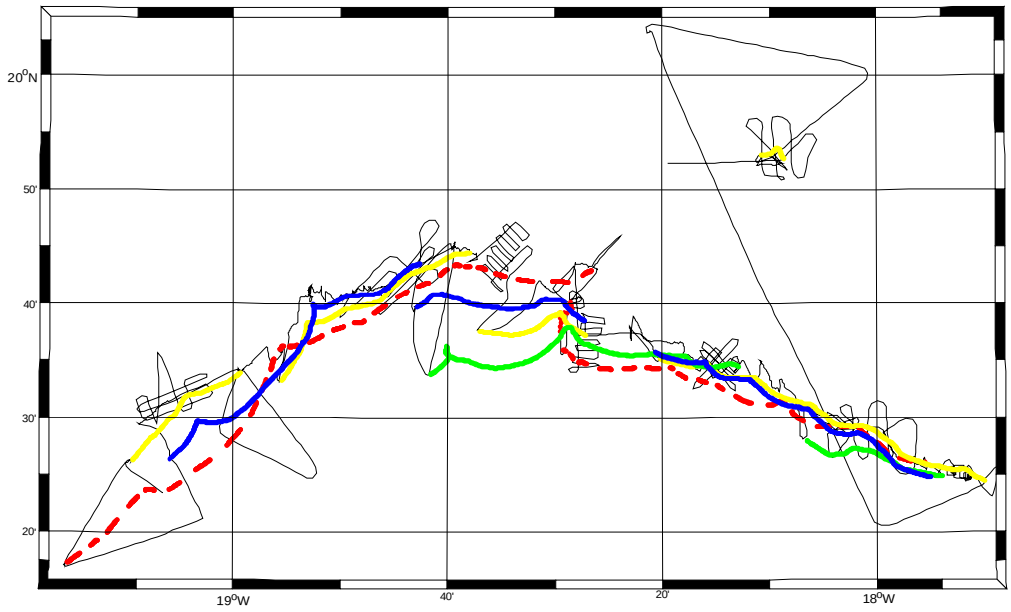


Figure 4 Drifter tracks overlaid on the cruise track during patch 3.

Table 5 Surface Drifter ID, colour style in plot and instrument configuration for all 3 patches. Shaded is the column corresponding to patch 3.

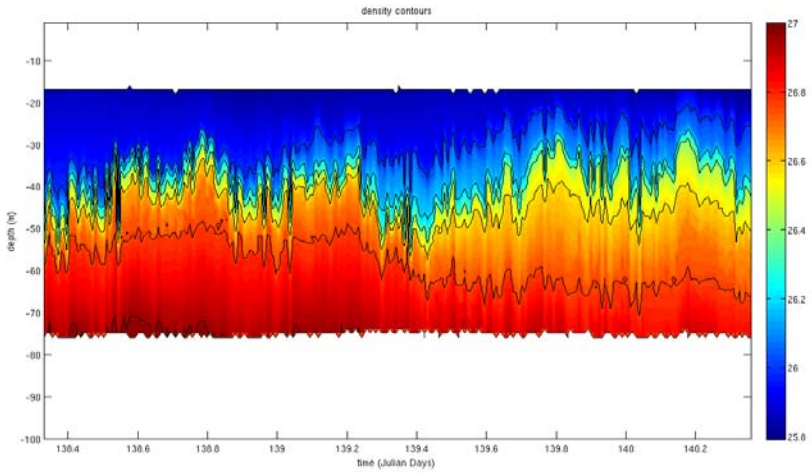
Num_buoy	Colour plot	P1	P2	P3
65988	red	Thermistor	No Instrument	No Instrument
65990	magenta	No Instrument	No Instrument	Carioca
67546	--------	No Instrument (LOST)	-------	----
67547	cyan	Wire Walker		
82879	yellow	No Instrument	Wire Walker	Wire Walker
82880	green	No Instrument	----------	No Instrument
82881	blue	Thermistor	ADCP	ADCP

Table 6 Details of each drifter's deployment and recovery during patch 3.

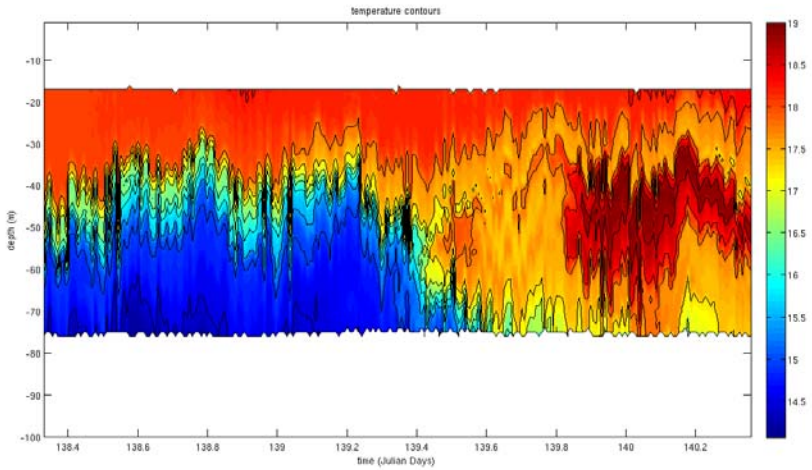
DRIFTERS – 3rd experiment						
Drift ID	**Deployment**			**Recovered**		
	Time	**Latitude**	**Longitude**	**Time**	**Latitude**	**Longitude**
82879	13/05/2009 21:40	19º 52.6833 N	18º 8.6183 W	14/05/2009 07:30	19º 53.0583 N	18º 10.8000 W
82879	14/05/2009 20:20	19º 24.4700 N	17º 49.9767 W	17/05/2009 17:10	19º 35.1950 N	18º 20.2517 W
82881	15/05/2009 01:02	19º 24.8217 N	17º 55.0550 W	17/05/2009 18:05	19º 35.7800 N	19º 20.7217 W
82880	15/05/2009 07:20	19º 24.9533 N	17º 54.0150 W	16/05/2009 05:15	19º 28.0350 N	18º 6.5300 W
65988	15/05/2009 07:50	19º 26.0967 N	17º 55.5933 W	18/05/2009 05:30	19º 35.9317 N	18º 29.2817 W
82880	16/05/2009 19:40	19º 34.5017 N	18º 12.9550 W	20/05/2009 05:02	19º 33.8217 N	18º 41.6317 W
82879	17/05/2009 19:55	19º 37.2450 N	18º 27.1183 W	18/05/2009 20:00	19º 37.6317 N	18º 37.0250 W
82881	17/05/2009 20:20	19º 38.5200 N	18º 27.2050 W	19/05/2009 14:55	19º 39.7133 N	18º 42.9017 W
65988	18/05/2009 11:05	19º 43.0183 N	18º 26.5517 W	22/05/2009	19º 17.3500 N	19º 15.3917 W
82879	19/05/2009 06:15	19º 44.5267 N	18º 37.9583 W	21/05/2009 07:00	19º 33.2500 N	18º 55.5083 W
82881	19/05/2009 19:30	19º 43.5883 N	18º 42.5859 W	22/05/2009 10:57	19º 26.4067 N	19º 5.9050 W

82879	21/05/2009 15:15	19º 33.9500N	18º 59.3567 W	22/05/2009 14:55	19º 26.3367 N	19º 9.3867 W

a)



b)



c)

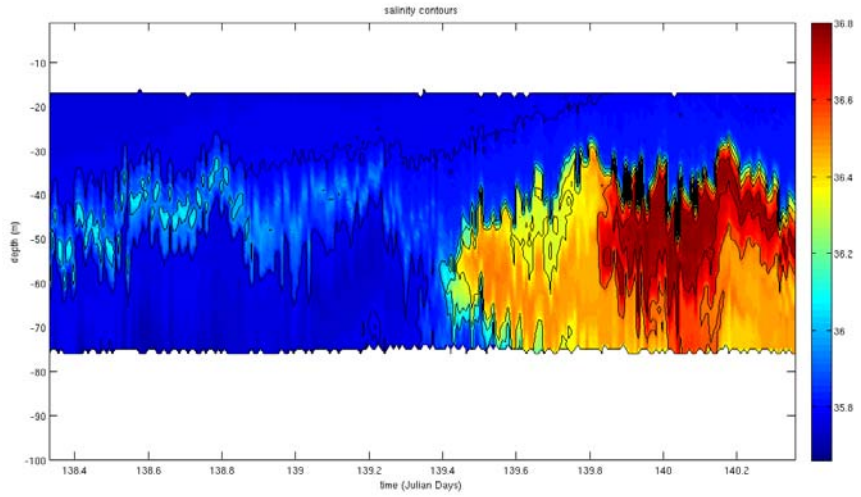


Figure 5 Example of a two day wirewalker record from patch 3. The depth range covered by the instrument was 18m to 76m. From top to bottom, a) density, b) temperature and c) salinity. Only ascending profiles have been used. On average, one vertical profile was recorded every 10min. The sensors recorded data at 6Hz.

Turbulence measurements

Ricardo Torres, Beatriz Barreiro, Thomas Mournier, Dan Comben, Kevin Smith and Dave Teare

Plymouth Marine Laboratory, West Hoe, Plymouth, UK, Instituto Investigaciones Marinas (CSIC), Vigo, Spain and National Marine Facilities-Sea Systems, National Oceanography Centre, Southampton, UK

In this section we cover the deployment and data analysis of the MSS turbulence profiler model MSS90L, serial 035 from the NMF equipment pool has been carried out during D338.

Summary of turbulence stations on D338

This is, to the best of our knowledge the third or fourth cruise in which the MSS90L has been used in a large RVS since its acquisition. Using the experience of previous cruises (D306 and D321) it was decided that at least 5 profiles per station (or one hour of continuous profiling) would be conducted wherever possible on D338. This is because analysis of previous data have revealed the turbulent diffusivities to be log-normally distributed (if not worse) with the causative mixing being intermittent. Therefore, 5 are viewed as the smallest practical number of profiles to calculate profiles of mean turbulent diffusivity**.**

Turbulence stations were only conducted during the three lagrangian phases of the cruise, generally interspersed throughout the day (6:30 am to 20:00 pm) with a nominal one hour slot four times a day. Due to the constraints of all of the other daily events and recovery and deployment of drifters within the SF_6 patch, turbulence stations have not been regular, ranging from only one station a day to the four stations originally planned. A list of all of the stations is presented in **Error! Reference source not found.**.

The oceanographic setting of the turbulence stations have been very varied. During the first lagrangian experiment, the stations covered the shelf environment under active upwelling, progressively sampling deeper waters (as the SF_6 was advected offshore) ending with stations that could potentially have been in or around the northern density front from the sampled offshore flowing upwelling filament (see Figure 6 for the geographical distribution of all stations). The second lagrangian experiment started during a period of upwelling relaxation. The site chosen for the deployment of the SF_6 still had the surface signature of an upwelling filament (colder surface temperatures than oceanic offshore waters) but from the drifter behavior and the ADCP data it was later apparent that the filament was in the decaying phase. Offshore velocities were only measured at the frontal regions and the filament shape and width changed dramatically over the few days that the lagrangian experiment lasted. The experiment lasted less time than expected due to the rapid subduction of surface SF_6 as it drifted towards one of the multiple frontal areas that developed within the filament region. As a consequence, many of the turbulence stations were located in or near areas of active subduction. This will have to be evaluated during the post-cruise data analysis.

The third lagrangian experiment was undertaken in a filament during its growing phase. The SF_6 patch was successfully laid in the core of the filament, a good distance from any frontal areas. The turbulence stations were consistently in the core of the filament and should be representative of the mixing undergone by surface upwelled waters as they travel the main axis of an upwelling filament. Again, these assertions will have to be validated in conjunction with all of the other data collected during the third patch.

Profiler description

During the Discovery cruise D338, the microstructure profiler MSS90L, serial number 35 was used for microstructure measurements. The profiler is produced by Sea and Sun Technology GmbH in co-operation with ISW Wassermesstechnik.

The MSS profiler is an instrument for simultaneous microstructure and precision measurements of physical parameters in marine and limnic waters. It is designed for vertical profiling within the upper 500m. The data are transferred via electrical cable to an on-board unit which pipes the data to a laptop PC.

The main housing of the MSS90L profiler comprises a cylindrical titanium tube of length 1250mm and diameter 90mm. The housing is pressure tight to 5MPa (500m). Weights and buoyancy rings can be added to the top and bottom of the robe respectively. This allows the user to tune the sinking velocity by altering the buoyancy.

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

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

Background to microstructure shear measurement

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

Deployment and operation of the microstructure measuring system

The NMFS laptop that comes with the MSS profiler was used for logging the data at the beginning of the cruise. The first four profiles were intended as sinking velocity tests to assess the current configuration of the profiler and its suitability for the conditions encountered during D338. However, the profiles could not be processed due to unknown reasons at the time. A more recent version of the software was installed in the NMFS laptop (SDA v1.97 and MSSpro v1.04) as provided by Dr H. Prandke himself in his recent visit to the University of Plymouth. While the data all looked good in the scrolling table of the SDA software, the graphical display of the raw data in MSSpro and attempts to process the raw profiles into diffusivities were unsuccessful. Both the project and probe files used with the SDA software for engineering unit conversion seemed to correspond to the sensors installed in the MSS90L but somehow a mistake must have been done somewhere in the processing chain. After careful examination of all of the calibration sheets and MSS installed sensors it was spotted that the third calibration coefficient for the pressure sensor didn't correspond with that in the calibration sheet (which was zero, the reason why this mistake was not observed earlier). Although this was corrected, and the project and probe files updated and reloaded several times, the raw binary files always suffered from the same problems. At the end, we were forced to export the binary files into ascii tabular (*.tob) files using the SDA software on a different laptop and unticking the option to use the coefficients included in the binary files.

For vertical sinking measurements, the profiler was balanced with negative buoyancy which gave it a sinking velocity of 0.6-0.68m/s up until profile n^{o} 57. Once we were able to process the data one steel ring was added reducing the sinking speed to 0.56-0.58 m/s.

The MSS was operated via a winch SWM1000, mounted on the port stern quarter of the vessel. In addition to the fastening provided by the construction of the mounting plate, the plate was further secured to the bulwark with a steel bolt which ran through bulwark and plate and with a pair of G clamps .

During the MSS measurements, the ship was moving with speed approx. 0.5-1.0 knots with respect to the water against the wind and predominant swell. Disturbing effects caused by cable tension (vibrations) and the ship's movement were minimized by maintaining slack in the cable – as a rule of thumb two "loops" should always be visible just below the sea surface.

A minimum of 5 profiles or one hour of continuous operation was performed during each turbulence station. The profiler was generally deployed to a nominal depth of 200m, although the actual depth of each profile depended on the amount of slack in the cable, sometimes reaching 240m. From our previous experience with upwelling filaments, we were expecting to be able to identify "filament waters" to a maximum depth of 300m. Such depth would have taken too long to reach so instead we decided to sample to the maximum depth that we could and still being able to acquire 5 profiles per station. The average profile took 10 min to perform. Only during the diel experiment in the last lagrangian experiment did we reduce the maximum depth of the profiles to a nominal 100m. Most of the other biogeochemical measurements were limited to the top 70m of the water column and we decided to prioritize number of profiles over vertical depth.

Data collection and archiving

The raw data from the MSS profiler are transmitted via RS485 data link to the on board interface unit of the measuring system. Details relating to each station were noted in an XL file. For data acquisition, on-line display and storage of data the software package SDA 197 (Sea & Sun Technology GmbH) was used. The icon on the laptop desktop has label SSsda_197. The rawdata/ directory in which the raw data from each profile are stored, can be found in C:sst_sda/. The raw data are stored in the MRD (microstructure raw data) binary format.

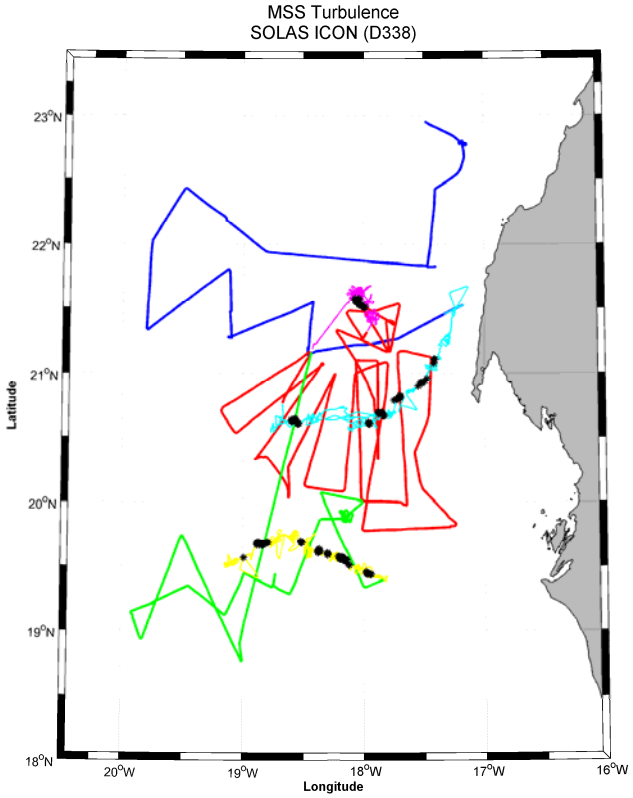


Figure 6 Location of all turbulence stations during all three patches. Cyan corresponds to patch 1, magenta with patch 2 and yellow to patch 3 cruise tracks.

Calibration and sensor tests

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

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

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

The latest calibration of all of the instrument sensors was carried out prior to D338 cruise on February 2009 by ISW Wassermesstechnik.

Processing steps:

All of the profiles were processed as advised by Dr H. Prandke and the batch files used were his own versions rather than the NOC versions present in the NMFS laptop.

The basic processing steps undertaken while on board have been:

1. Reprocessing of MRD files into ascii files- this was required due to the error in the pressure sensor calibration. The SDA 197 software was used to this account.
2. Trimming profiles-Bad data was graphically removed from the bottom part of each profile if they showed any contamination from vibrations in the cable. These are clearly apparent in the shear and acceleration sensors as oversized spikes.
3. Calculations of shear – The batch file shear_c.msb was used.
4. Calculations of turbulent dissipation rates (Epsilon), Pseudo-epsilon, Salinity, Density, N, N^2, Thorpe scale, Cox diffusivity and diffusivity estimates from the fast temperature sensor. All quantities were averaged to 1m resolution.
5. Calculations of turbulent diffusivities at 1m resolution.

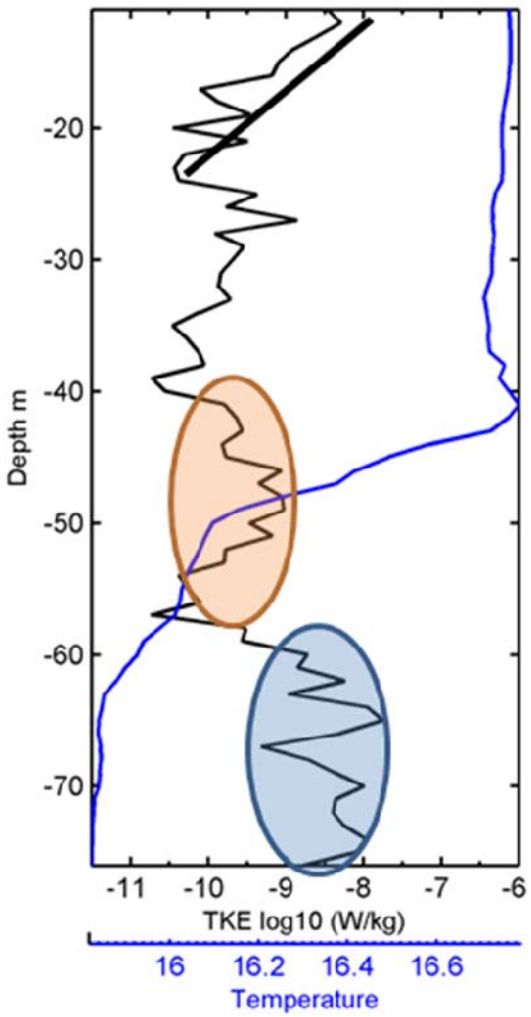


Figure 7 Example of MSS turbulence profile from the shelf. Highlighted are the surface mixing layer, the pycnocline and the bottom boundary layer.

Conclusions

Although the data have all been preliminary processed to diffusivities, no quality control has been performed on the data. Therefore, only very generic conclusions can be drawn from it. Throughout the data set, the mixing layer (depth of active mixing driven by surface processes) could be identified. On visual inspection it seems that the depth was generally shallower than that of the mixed layer and it will be compared with the 1% light and mixed layer depth. The shape of the mixing layer can be assumed to follow an exponential function and so diffusivities could be extrapolated to the surface providing valuable information on the conditions under which air-sea exchange was measured during the cruise. The other region with enhanced mixing was the pycnocline. The process driving such mixing is generally assumed to be internal waves of which there were substantial evidences in the wirewalker records (see

report on drifters). These measurements will allow closing the nutrient budget during the lagrangian experiments and therefore help explain the changes that had been seen in the biogeochemistry of the water column. Furthermore, a well developed bottom boundary layer was also evident in the turbulence stations on the shelf.

CTD

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A 'standard' stainless steel CTD frame was used for this cruise fitted with a Seabird 9 plus and associated equipment. 20 litre OTE water bottles were used in all but two positions on the carousel i.e. positions 2 and 19, where 10 litre bottles were substituted.

CTD configurations (see below for details)

The stainless CTD package comprised of the following instruments:

Seabird 911+ CTD with dual pumped temperature and conductivity sensors. The secondary sensor pair were vane mounted to reduce salinity spiking.

A Seabird SBE 43 oxygen sensor was fitted in the primary duct.

Seabird carousel type SBE 32.

Chelsea instruments Alphatracka (transmissometer).

Aquatracka (fluorometer).

PML 2pie PAR light sensors for up welling and down welling light (fitted for casts 2-41 inclusive only).

Benthos altimeter type 915T.

Wet-Labs light back scatter sensor.

300kHz RDI Workhorse LADCP (downward looking).

Equipment performance.

The CTD system worked flawlessly for the entire cruise with a total of 102 profiles. For casts 6 – 10, 13 – 15, and 100 – 102 there were no water samples taken as the bottles were removed (cast numbers are inclusive). The 20 litre water bottles had a 'sealing failure' rate averaging less than one bottle per cast.

CTD configuration:

Instrument configuration file: C:\Program Files\Sea-Bird\SeasaveV7\D338\Data\0720.con

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : No
Scan time added : No

1) Frequency 0, Temperature
Serial number : 4151
Calibrated on : 16 jan 09
G : 4.39943740e-003
H : 6.70271720e-004
I : 2.53842116e-005
J : 2.10039683e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity
Serial number : 2450
Calibrated on : 13 jan 09
G : -1.02039549e+001
H : 1.62649835e+000
I : -1.97143544e-003
J : 2.45546890e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC
Serial number : 90573
Calibrated on : 20 Oct 2008
C1 : -4.666978e+004
C2 : -2.615846e-001
C3 : 1.373870e-002
D1 : 3.884300e-002
D2 : 0.000000e+000

T1 : 3.015158e+001
T2 : -3.442071e-004
T3 : 4.048350e-006
T4 : 2.094500e-009
T5 : 0.000000e+000
Slope : 0.99987000
Offset : -0.40170
AD590M : 1.280800e-002
AD590B : -9.338280e+000

4) Frequency 3, Temperature, 2
Serial number : 2919
Calibrated on : 16 jan 09
G : 4.31713202e-003
H : 6.44781935e-004
I : 2.30582135e-005
J : 2.19322194e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2
Serial number : 2571
Calibrated on : 13 jan 09
G : -1.02759150e+001
H : 1.59466006e+000
I : -1.28494531e-004
J : 1.20013784e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43
Serial number : 0709
Calibrated on : 28 may 08
Equation : Sea-Bird
Soc : 4.29400e-001
Offset : -4.95700e-001
A : 1.33110e-003
B : 1.51160e-004
C : -3.22560e-006
E : 3.60000e-002
Tau20 : 1.58000e+000
D1 : 1.92630e-004
D2 : -4.64800e-002
H1 : -3.30000e-002
H2 : 5.00000e+003

H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Altimeter
Serial number : 112522
Calibrated on : 1 mar 04
Scale factor : 15.000
Offset : 0.000

9) A/D voltage 3, Fluorometer, Chelsea Aqua 3
Serial number : 088195
Calibrated on : 27 May 2008
VB : 0.175800
V1 : 2.072600
Vacetone : 0.272400
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor
Serial number : 5
Calibrated on : 14 apr 08
M : 0.49580100
B : 0.99722200
Calibration constant : 100000000000.00000000
Multiplier : 0.99990000
Offset : 0.00000000

11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2
Serial number : 1
Calibrated on : 18 nov 08
M : 0.45817400
B : 1.56845000
Calibration constant : 100000000000.00000000
Multiplier : 0.99820000
Offset : 0.00000000

12) A/D voltage 6, User Polynomial
Serial number : 167
Calibrated on : 13 may 08
Sensor name : BBRTD
A0 : 0.00040222
A1 : 0.00338000
A2 : 0.00000000
A3 : 0.00000000
13) A/D voltage 7, Transmissometer, Chelsea/Seatech/Wetlab CStar
Serial number : 161048

Calibrated on : 28 may 08
M : 23.6477
B : -0.4966
Path length : 25.000

Platform Systems

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Data Logging: Techsas.

The Techsas software is installed on an industrial based system with a high level of redundancy. The operating system is Red Hat Enterprise Linux Edition Release 3. The system itself logs data on to a RAID 0 disk mirror and is duplicated on an external hard disk. The Techsas interface displays the status of all incoming data streams and provides alerts if the incoming data is lost. The ability exists to broadcast live data across the network via UDP. Techsas stores the logged data in NetCDF data files, which can be changed on a daily basis to keep file sizes manageable.

The Techsas data logging system was used to log the following instruments:

Trimble GPS 4000 DS Surveyor (gps_4kl)

Chernikeef EM speed log (log_chfl)

Ships Gyrocompass (gyrol)

Simrad EA500 Precision Echo Sounder (ea500l)

NMFD Surface-water and Meteorology (surfmetl)

NMFD Winch Cable Logging And Monitoring CLAM (winch)

Ashtech GPS G12 integral to the FUGRO Seastar DGPS receiver (gps_g12l)

Seabird 38/45 TSG & SST sensors (Logged as part of Surfmet)

Conversion from Techsas to Level C was accomplished using fromtechsas, a program which listens for Techsas UDP broadcasts on the network, and populates the Level C data files.

Level C: The Solaris based processing system.

The Level C system used to be part of the RVS/UKORS/NMF Level A/B/C computing system. The A and B parts have now been replaced by Techsas. Level C consists of a comprehensive set of processing utilities to edit, process and manipulate data on live data streams historically known as rvs data files.

Processed Data Files:

Relmov, Bestdrf, Bestnav. These files take in multiple navigation sources to produce a navigation file that best represents the ship's location, heading and speed.

Protsg:

Takes the Thermosalinograph data and produces salinity (although this is now done on-the-fly by the Seabird 45 TSG).

Surfmet: Surface Water and Meteorological Instruments

Surfmet consists of the following instruments:

Mounted on forward mast.

GIll Windsonic: Sonic anemometer.

Vaisala HMP45A: Temperature & Humidity Sensor.

2 x Skye SKE510: PAR sensors.

2 x Kipp & Zonen CMB6B: TIR sensors.

Vaisala PTB100: Barometric Pressure Sensor.

Located in the water bottle annex.

Seabird 45: Thermosalinograph.

Wetlabs Wetstar: Fluorometer.

Wetlabs CStar: Transmissometer.

Located near non-toxic inlet in forward hold.

Seabird 38: Sea Surface Temperature Sensor.

Seabird 38 and 45 sensors are logged directly to the Techsas logging system. Surfmet displays the UDP broadcast from Techsas, displays the information, and combines it with the Surfmet data and sent back to Techsas.

Simrad EA500 Echo Sounder

This system utilises 2 sets hull mounted transducers and a PES fish for sounding depths. Only one set of transducers can be used at a time. Best results are usually obtained by using the PES fish which is lowered over the side to a depth of approximately 9 metres.

During the cruise the PES fish performance started to decline. It was immediately brought onboard for investigation. It was found that the sealed transducer housing was leaking oil (insulating oil to prevent water ingress, and for pressure balance). Despite there being a spare set of transducers and housing, the oil necessary to refill was unavailable, rendering the PES fish out of service. The hull transducers were used for the remainder of the cruise satisfactorily.

Cruise Data Storage & Backup

Drobo: A Data Storage Robot (Network attached storage)

Drobo is a device that allows data to be securely stored and access over the network. It contains an intelligent and redundant array of SATA hard drives that automatically store the data as to prevent loss of data in the event of drive failure.

Drobo acts as a central storage hub for all cruise data, as it can be accessed 24 hours a day from any computer with a network connection. The 2TB storage capacity allows for future expansion by simply swapping in larger hard drives.

Additional safely measures include a daily backup of the cruise folder on Drobo to LTO tape.

Other data stored on the Level C was backed up on a daily basis to LTO tape also.

The two Macs backup automatically to Drobo using Time Machine®.

Onboard Web Pages

A cruise webpage was added to the Discovery web page collection. This included a copy of the cruise diary, plots of data, and the complete collection of satellite images used during the cruise.

Platform Systems Log

See separate document ‘Platform Systems Log.rtf’ on the ‘D338 Docs’ DVD submitted to BODC, for a running commentary on daily activities, in draft form.

Tracer release, 'patch' tracking and dual tracer (SF_6 and ^3He) gas exchange experiment

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Objectives:

1. Release and real time measurement of SF_6 to enable Lagrangian experiments
2. Dual tracer experiment in order to determine rates of air-sea gas transfer.
3 Measurements of surfactants and related variables in sea surface microlayer
4 To estimate rates of vertical mixing for comparison with estimates from turbulence profiling, L-ADCP and fine-scale temperature gradients.

Introduction

The main focus of this work was to provide the Lagrangian framework for the ICON experiment via the deliberate and controlled release of sulphur hexafluoride as a tracer followed by near-real time measurement of SF_6 using an automated analytical system in order to be able to map the SF_6, track the 'marked' water and determine where to undertake vertical profiling studies.

The other primary aim of this work was to determine rates of air-sea gas transfer using the dual tracer technique. The rate of air-sea gas exchange is a dominant or important term in many global biogeochemical cycles yet it remains one of the major uncertainties. Important issues requiring accurate estimates of gas exchange rates include anthropogenic CO_2 uptake by the oceans and climate forcing involving other marine biogenic gases such as DMS and iodocarbons. Current gas exchange parameterizations have uncertainties of at least a factor of 2 at intermediate wind speeds, and much larger uncertainties at high wind speeds. Significantly reducing these uncertainties is centrally important to both international and UK SOLAS. From the perspective of global change understanding the physical and biogeochemical controls of air-sea gas exchange is urgent, being essential to support the development of predictive biogeochemical models needed to quantify regional and global scale trace gas fluxes and feedbacks. Although the past several years have seen substantial advances in our understanding of air-sea gas exchange these are still insufficient to adequately parameterise the fundamental controlling processes. The dual tracer method for estimating k_w is based on the time-dependant change in the concentration ratio of the inert gaseous tracers SF_6 and ^3He and has been pioneered by PML.

A secondary aim was to investigate surfactant concentrations in the sea surface microlayer (ssm) and their possible role in air-sea gas transfer. It has long been known that surfactants can significantly retard gas exchange in laboratory experiments but evidence of their importance in the field is lacking. Surfactants can influence gas transfer in at least two ways, their presence as a monolayer at the *ssm* can act as an extra barrier to air-sea gas transfer and secondly by altering the hydrodynamic properties of the sea sureface and

hence the transfer of turbulent energy. The impact of insoluble surfactants at sea is thought to be very limited but the role of soluble surfactants has been poorly investigated.

Finally, the SF_6 data will also be used to estimate diapycnal diffusivity, K_z, to aid quantifying cross-thermocline dissolved gas and nutrient fluxes and for comparison with the estimates made by Ricardo Torres using L-ADCP, turbulence profiling and fine scale temperature measurements.

Tracer Preparation

Approximately 5.7 m^3 of seawater contained within a steel tank was saturated with SF_6 over a total of about 24 hours but spread over 2-3 days during periods when the vessel was steaming head to wind. The SF_6 was pumped at ~ 500 ml min^{-1} into the headspace contained within a glass dome (3 litres) and vented into seawater over the stern of RRS *Discovery* in order to minimise contamination of the ship and laboratories. The headspace was rapidly re-circulated through the seawater via 3 steel metal air-stones and using a leak-tight 110V diaphragm pump at a flow rate of ~1 litre min^{-1}. Seawater samples were collected during the saturation procedure from the tank using a glass syringe and analysed by thermal conductivity detection - gas chromatography (TCD-GC) in order to ascertain when full saturation had been achieved (0.17 mol m^{-3}). As well as determining SF_6 concentrations relative to a 0.2% SF_6 standard, the decline in oxygen levels was also monitored as an independent check on when saturation had been achieved. Helium-3 (^3He) was added to the tank immediately prior to the tracer release by first minimising the headspace in the glass dome and closing the vent on the tank. A total of 10 litres of ^3He was added directly to the headspace, in aliquots of ~ 2 litres and after each aliquot the headspace was re-circulated for ~15 mins as the ^3He dissolved into the tank water more rapidly than

SF_6 was displaced. Water samples were collected in order to establish the amounts of ^3He added, SF_6 remaining (TCD-GC) and to check for air leaks based on the analysis of residual oxygen. The process was repeated until the desired levels of both SF_6 and ^3He were observed (see Table 1).

Tracer Release

Three separate tracer 'patches' were released during the course of the ICON experiment as summarised below.

Patch	Starting Conc (mol m^{-3})	Final Conc (mol m^{-3})	Mass Released (mol)	Initial Patch Area (m^3)	Estimated Depth (m)	Initial target conc (fmol dm^{-3})	1st CTD (fmol dm^{-3})	Max Underway (fmol dm^{-3})
1. SF6	0.16		0.87	$9*10^6$	30	3100	350	540
1. 3He								
2. SF6	0.15	0.11	0.26	$16*10^6$	20	500	170	>1800
2 3He	0.048		0.082			160		

3. SF6	0.11		0.28	$8 * 10^6$		870	>650	>2000
3. 3He								

Underway measurements

Underway measurements were made by a custom built automated analytical system (BERT) that returned an integrated measurement over 4 minute periods from seawater taken from the 'non-toxic' pumped seawater supply. Analysis was via ECD-GC and calibration was achieved by comparison with both high precision discrete samples determined on ERNIE and gas standards. SF_6 data were merged with the ship's GPS position but with a delay of 8 minutes to correct for delays in the pipes and analysis time. The system worked well with very little downtime. Measurement periods are summarised below.

Patch 1	Day	Time
	23 April	19:20 – 00:00
	24 April	00:00 - 09:33
		18:50 - 00:00
	25 April	00:00 - 13:25
		19:04 - 00:00
	26 April	00:00 - 10:29
		18:48 - 00:00
	27 April	00:00- 09:26
		11:13 – 11:33
		12:34 – 14:17
		18:47 - 00:00
	28 April	00:00- 10:28
		12:47 – 16:09
		19:07 - 00:00
	29 April	00:00 – 13:02
		18:16 - 00:00

	30 April	00:00 – 09:25
		14:04 – 14:39
Patch 2	8 May	08:45 – 10:21
		16:29 - 00:00
	9 May	00:00 – 13:29
		15:25 - 00:00
	10 May	00:00 – 13:21
		16:29 – 19:28
Patch 3	15 May	13:02 - 00:00
	16 May	00:00 – 09:23
		17:58 - 00:00
	17 May	00:00 – 09:43
		11:09 – 12:09
		16:29 - 00:00
	18 May	00:00 – 10:16
		11:16 – 12:31
		18:38 - 00:00
	19 May	00:00 – 12:24
		19:11 – 00:00
	20 May	00:00 - 08:44
		09:09 - 00:00
	21 May	00:00 – 12:01
		16:58 - 00:00
	22 May	00:00 – 06:39

Vertical Profiles

High precision measurements of SF_6 were made on CTD casts in order to estimate the vertical extent of the tracer patch and for use in the estimating gas transfer and K_z. Analysis was achieved using a vacuum sparge system and an ECD-GC. Again the system worked well with high sample precision (most measurements made in the surface layer were duplicated) and little drift was apparent from calibrations. Casts sampled are summarised below.

Cast	Depth Range (m)	Heliums collected?
22	67 – 5	
23	46 – 2	
24	2	
26	83 – 2	Y
27	2	
30	2	
31	203 – 3	Y
32	6	
33	2	
34	3	
35	202 -3	Y
36	7	Y
37	2	
38	3	
39	203 – 4	Y
40	8	
41	204 – 8	Y
42	7	
43	3	
44	2	

45	202-3	Y
46	3	
47	6	
49	111 – 2	Y
50/51?	4	Y
56	60 -2	Y
57	300 – 2	
59	200 – 5	
60	200 – 5	Y
61	200 - 5	
66	200 – 2	
70	200 – 2	Y
71	2	
72	50 -2	Y
75	200 -2	Y
76	Non-toxic only	
79	65 – 5	
80	120 -2	Y
81	2	
84	200 - 1	Y
Diel	Non-toxic hourly	
94	102 – 2	
95	37 – 4	Y
98	62 – 2	Y
99	3	

Helium sampling

Samples for dissolved ^{3}He analysis were routinely collected from the 9-00am casts and stored in specially commissioned sealed copper tubes for subsequent mass spectrometric analysis by the transient tracer group at the University of Bremen, Germany. As funding for this work is limited, samples will be prioritised based primarily upon their accompanying SF_6 concentrations. A full summary of samples collected is included in the table above.

Microlayer Sampling

Samples were collected using a specially constructed Garrett Screen (Matt Salter Univ Newcastle) to coincide with the firing of the surface 5m bottle at the mid-day cast. Typically 15mls of sample were collected from each dip suggesting that the averaghe sampling depth was less than 20 microns. Samples were collected primarily from the bow of the ship where, due to the angle from the ship's freeboard to the hull, samples were typically collected from 5-6m from the hull of the ship. As the ship was head to wind, and usually heading into the swell, there was generally little reflection of water from the hull onto the sampler and all samples except those identified in the table below, are thought to be 'clean' although as winds were generally strong there was some loss of sample during retrieval of the sampler. The sampler was cleaned by immersion the bulk several times prior to each collection. Duplicate unfiltered samples were collected in 15ml centrifuge tubes and stored in the dark at 4C for the analysis of total surfactants via polarography on return to PML. Large volume (typically 10-15 dips) samples were collected and filtered by Gavin Tilstone for analysis of CDOM on board, and for DOC (Acheterberg NOC-S), 3D fluorescence technique (Paul Mann NUT/PML) and total surfactants (Matt Salter NUT/PML). Co-inident to the ssm sampling, samples were also collected from the surface bottle of the midday cast for comparative purposes.

Date	Exact Time Fired/collected	Cast	Depth	Depth m	Samples collected
25-Apr	16:30		ulayer		2 tubes for SA 2 tubes for Gavin
26-Apr	13:30	36	surf	7.7	Gavin (1 amber bottles) + 2 * unfiltered SA
	12:40		ulayer		Gavin (1 amber bottles) + 2 * unfiltered SA
27-Apr	13:34	40	surf	8.4	Gavin (1 amber bottles) + 2 * unfiltered SA
	13:30		ulayer		Gavin (1 amber bottles) + 2 * unfiltered SA

29-Apr	14:20	46	surf	3.3	Gavin (1 amber bottles) + 2 * unfiltered SA
	14:30		ulayer		Gavin (1 amber bottles) + 2 * unfiltered SA
09-May		57	surf		Gavin (1 amber bottles) + 2 * unfiltered SA
			ulayer		Gavin (1 amber bottles) + 2 * unfiltered SA
15-May	14:00	67	surf		Gavin (1 amber bottles) + 2 * unfiltered SA
	13:35		ulayer		Gavin (1 amber bottles) + 2 * unfiltered SA
	13:50		ulayer - bow		Gavin (1 amber bottles) + 2 * unfiltered SA
16-May	13:00		ulayer - bow		Gavin (1 amber bottles) + 2 * unfiltered SA
	13:15	71	surf		Gavin (1 amber bottles) + 2 * unfiltered SA
17-May	13:00		ulayer - bow		Gavin (1 amber bottles) + 2 * unfiltered SA
	12:45	76	surf		Gavin (1 amber bottles) + 2 * unfiltered SA
18-May	15:00	81	ulayer - bow		Gavin (1 amber bottles) + 2 * unfiltered SA
	15:05		surf		Gavin (1 amber bottles) + 2 * unfiltered SA
19-May	12:45	85	ulayer - bow		Gavin (1 amber bottles) + 2 * unfiltered SA
	12:50		surf		Gavin (1 amber bottles) + 2 * unfiltered SA
20-May	14:15	95	ulayer - bow		Gavin (1 amber bottles) + 2 * unfiltered SA
	14:15		surf		Gavin (1 amber bottles) + 2 * unfiltered SA

Optics

Tim Smyth

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Aims and objectives

Prior to the cruise and as part of SOLAS INSPIRE I had been developing a coupled atmospheric in-water UV optical model. The model required measurements of chlorophyll and CDOM to extrapolate the signal measured in the visible (400 – 700 nm) to the UV (300 – 400 nm). On this cruise I hoped to take measurements of spectral inherent optical properties (using an ac-9) with which to better parameterise, and coincidental in-water spectral UV with which to validate the model. The atmospheric component of the model would be validated against the deck measured incident UV measurements. The final aim, which fits into the larger picture of ICON, is to include chemistry to investigate the photo-dissociative effects of UV on climatically important gases.

In addition I have taken measurements of phytoplankton physiology using an FRRF; PAR, to determine the light levels through the water column for the various incubation experiments; and opportunistic measurements of aerosol optical depth for the NASA AERONET project.

Methodology

In-water optics

On the optics rig the following instruments were deployed: Wet Labs ac-9; Wet Labs flow cells; Fast Repetition Rate Fluorometer (NMF supplied); Satlantic UV sensor; Seabird SBE19+ CTD (see appendix for instrument details).

The optics rig was deployed from the starboard aft quarter of the ship using a winch / crane combination on 300 m of 6 mm black plastic coated wire generally at 12.30 pm daily, but also at other times of the day. Optical protocols state that deployments should be on the sunward side of the ship; the prevailing wind direction and orientation of the sun meant that this criterion was generally met apart from the few mid-late afternoon casts. The instruments were switched on and the instrument package lowered into the water and kept at the surface for four minutes. The rig was then lowered at a fairly fast rate (0.5 m/s) down to a predetermined depth (generally around 100 m depending on the bathymetry). The upcast is the important part of the deployment and this was carried out at 0.1 m/s. Two casts made up each deployment: the first had Supracap 0.2 µm (for the first patch 0.1 µm were used) filters attached to the ac9; the second had no filters. The filtered cast was to determine the absorption by coloured dissolved organic matter (CDOM); the unfiltered was to determine total absorption.

Upon recovery, data from the instruments was downloaded: hyperterminal was used to download the FRRF and WLHost the ac-9, UV sensor and CTD combination.

The FRRF data was processed using V6 of the Sam Laney (WHOI) Matlab code. This requires the FRRF to be characterised using 0.2 µm filtered water, at each of the gain settings (0, 1, 4, 16, 64, 256) for both the light

and dark chambers, in a black bucket. This was done once during the first patch experiment. The primary outputs of the FRRF data stream were the maximum fluorescence (Fm) and the ratio of the variable to maximum fluorescence (Fv/Fm); the PAR output was used to determine the percentage light levels for the following day's pre-dawn CTD casts. This was done by bespoke IDL routines written on the cruise. The final FRRF data product will consist of the phytoplankton physiological parameters binned to 2 m depth resolution.

The ac-9 data was pre-processed using the Wetlabs WAP (v4.28a) software which essentially extracts the separate data streams from the instrument binary and then merges the different datastreams back into ascii format. The ac9 data need to be corrected for the effects of temperature, salinity and scattering (Zanefeld et al. scheme) which was done using bespoke IDL routines. The ac-9 also needs to have regular field calibrations done by running 0.1 µm filtered milliQ water through a thoroughly cleaned instrument (methanol used to clean optics and tubes). This was done on two occasions and the necessary offsets removed. The final ac-9 product will consist of the spectral ac-9 signal merged with the Satlantic UV-sensor (4 channels); CTD and flow cells.

Atmospheric optics

Surface UV measurements

A Trios Rameses ACC UV sensor was setup on the roof of the CTD winch cab and configured to log hyperspectal UV between 200 and 500 nm at 2.5 nm resolution every 5 minutes through daylight hours. The data can either be kept as hyperspectral (to force e.g. in-water light field models) or integrated over broadband (UV-A and UV-B) ranges (this was done on the cruise using bespoke IDL routines). Data is available for 38 days of the cruise.

Microtops sun photometer

A Solar light Co. microtops sunphotometer was opportunistically used to determine the spectral aerosol optical thickness at 340, 440, 675 and 870 nm as part of the NASA AERONET project. The instrument was used on 38 days of the cruise and data processing done by Dr. Sasha Smirnov.

Results

Date	Begin	End	Patch	Cast ID	Filter	FRRF	Lat	Lon	Depth 1	Depth 2	Comments
16/04/2009	-	-	-	OPT001	u	Y	23.040 N	17.514 W	200	-	Shakedown station; battery problems no logging
23/04/2009	13:01	13:40	1	OPT002	fu	Y	21.125 N	17.398 W	70	70	ac9 not logged as not in right mode
23/04/2009	14:45	15:05	1	OPT003	fu	Y	21.125 N	17.398 W	70	70	patchy cloud; moderate sea
24/04/2009	12:41	13:11	1	OPT004	fu	Y	20.942 N	17.491 W	70	70	Ac str; Ci str; mod sea
25/04/2009	12:33	13:37	1	OPT005	fu	Y	20.819 N	17.688 W	250	250	8/8 Cs; bright sun; mod sea
26/04/2009	12:29	13:10	1	OPT006	fu	Y	20.676 N	17.840 W	100	100	8/8 Cs/As hazy sun
27/04/2009	12:32	13:17	1	OPT007	fu	Y	20.617 N	17.958 W	100	100	clear sky; large swell
28/04/2009	12:34	13:20	1	OPT008	fu	Y	20.715 N	18.300 W	100	100	clear sky; rough sea
29/04/2009	12:34	13:11	1	OPT009	fu	Y	20.629 N	18.551 W	120	140	clear sky; mod/rough sea
09/05/2009	12:33	13:16	2	OPT010	fu	Y	21.566 N	18.044 W	100	100	0.1 um filter
09/05/2009	13:20	13:37	2	OPT011	f	Y	21.574 N	18.048 W	120		0.2 um filter only
10/05/2009	12:31	13:37	2	OPT012	fu	Y	21.608 N	18.033 W	200	200	moderate sea; clear sky
15/05/2009	09:09	09:50	3	OPT013	fu	Y	19.427 N	17.929 W	100	100	some Ci; residue on “c” tube
15/05/2009	12:28	13:20	3	OPT014	fu	Y	19.438 N	17.960 W	100	100	some Ci; moderate sea
15/05/2009	15:40	16:20	3	OPT015	fu	Y	19.462 N	17.982 W	100	100	inc cloud during cast
16/05/2009	09:10	09:40	3	OPT016	fu	Y	19.542 N	18.140 W	100	100	Ci on horizon; moderate sea
16/05/2009	12:30	13:10	3	OPT017	fu	Y	19.543 N	18.156 W	100	100	clear sky; moderate sea
17/05/2009	09:14	09:40	3	OPT018	fu	Y	19.608 N	18.309 W	60	60	8/8 Sc; clearing on 2nd cast
17/05/2009	12:32	12:45	3	OPT019	f	Y	19.613 N	18.358 W	100	100	batteries failed during 1st cast
18/05/2009	12:47	13:40	3	OPT020	fu	Y	19.722 N	18.444 W	100	100	clear sky; rough sea
19/05/2009	12:28	13:00	3	OPT021	fu	Y	19.750 N	18.656 W	100	100	4/8 Sc Ac
20/05/2009	08:31	08:48	3	OPT022	u	Y	19.682 N	18.811 W	100		4/8 Ac cas; Ci; mod sesa
20/05/2009	12:33	13:10	3	OPT023	fu	Y	19.674 N	18.843 W	100	100	clear sky; moderate sea
20/05/2009	16:38	17:04	3	OPT024	u	Y	19.682 N	18.868 W	100		4/8 Ac str; moderate sea
20/05/2009	20:30	20:55	3	OPT025	u	Y	19.686 N	18.884 W	100		slight sea; dark
21/05/2009	12:33	13:13	3	OPT026	fu	Y	19.578 N	18.971 W	100	100	6/8 variable cloud; mod sea
22/05/2009	14:05	14:46	3	OPT027	fu	Y	19.442 N	19.153 W	100	100	chaotic sky; mod sea

Table 1: Description of the optics stations sampled. The filter order is given as e.g. fu for filtered followed by unfiltered. A simple yes (Y) and no (N) is given for the presence of usable FRRF data; meteorological and sky conditions are recorded in log book. The latitude and longitude are expressed as decimal degrees.

Table 1 shows the details of the optics stations sampled during the ICON cruise with associated information on the sea and sky state and other observations concerning the health of the instrumentation.

Figures 1 – 3 show the FRRF parameters associated with the various SF_6 seeded patches. The Fm parameter (maximum fluorescence) gives an idea about the amount of biomass present whereas Fv/Fm is a measure of the health of PSII. The theoretical maximum of Fv/Fm is 0.65 so the phytoplankton community is generally healthy in the top mixed layer away from the strongly illuminated surface. This zone varies between patches with patch 1 being dominated by high biomass in a thin layer; patch 2 with lower biomass but spread over 50 m; patch 3 moderately high biomass but with a sharp peak in Fv/Fm around 10 – 15 m. The PAR profiles are distinct between patches with patch 1 having a slope change around 30 m; patch 2 having a fairly uniform drop off in PAR through the water column and patch 3 an inflection below around 40 m below the biomass. The cross section of PSII (sigma) shows little variation with depth for patch 1 and increasing variability for the other two patches. It is possible the lack of variability in patch 1 is caused by the phytoplankton population being generally of one type (diatoms associated with fresh upwelling). The other patches were in water that was at least 3 – 4 days old.

Figures 4 - 6 show the spectral UV light penetration through the water column and show that the penetration depth of UV was greatest in patch 2 followed by patch 3 and patch 1 was generally the most opaque to UV. This is consistent with higher levels of biomass within patch 1. This pattern is followed for all the wavelengths measured: 305 and 325 nm being within the UV-B and having the shallowest penetration depths (between 3 – 10 m) and 340 and 380, within the UV-A region having deeper penetration depths (up to 20 m). These penetration depths may be related to the quenching of the FRRF signal in the top few metres of the water column.

Figures 7 and 8 show the attenuation and absorption respectively at four out of the nine ac9 wavelengths in patch 3. The difference between the filtered and unfiltered curves shows the amount of absorption / attenuation caused by particles and phytoplankton; the difference between the attenuation and absorption curves (unfiltered) gives the amount of scatter throughout the water column. It is therefore possible, using this optical configuration to describe the whole suite of IOPs (absorption (a); scatter (b) and attenuation (c)) and attempt to partition what is causing it. The top surface layer is dominated by high attenuation (up to 0.8 m^{-1}) and absorption (0.15 m^{-1}) consistent with high biomass in patch 3. There is very little in the way of CDOM absorption (seen throughout the cruise). There is an interesting feature in the absorption profile (still requires some correction as 'a' cannot exceed 'c') with a sharp peak at all wavelengths around 50 m. This will require further correction and subsequent investigation.

Figures 9 and 10 show the contrast between a clear day and one affected by high loadings of aerosol (cf. figure 11 described later). The tropics generally have variable ozone concentrations, which serves to absorb UV through the stratosphere. Aerosols also have a role to play in the attenuation of UV. Figure 9 shows that at noon on a clear day (27th April) the maximum UV radiation was approximately 30 Wm^{-2}. However on 2nd May the maximum UV radiation was only 20 W m^{-2}. The variability in ozone is unlikely to explain this large difference and indeed the AOT at 340 nm shows a change from 0.3 on 27th April to 0.8 on 2nd May. During the cruise the skies were predominantly clear and maximum surface irradiances were in the north around Tenerife just after departure. The profile from 27th April is generally typical of those seen on the cruise.

Finally, figure 11 shows the aerosol optical depth derived from the sun photometric measurements. The time-series shows two distinct dust events around the 2nd and 14th May (serial days 122 and 134 respectively) with elevated AOTs. There is some spectral variability as well. These data were collected as part of the NASA AERONET project and the data sent daily to Dr Sasha Smirnov for processing and including in their web database.

Integration:

The UV modelling work will be integrated with the photo-chemical measurements to produce a coupled chemical – radiative transfer model.

Other activities:

During the cruise I also wrote some software to automatically ingest CTD data and send it to the BODC via email. This is part of the National Centre for Ocean Forecasting and will allow the data to be ingested by the UK Met Office in its operational forecasting. I also helped with the deployment of the drifters and fixing the software to track them as needed. I will also look at processing the optics data from the MVP.

Datasets produced:

In water optics:

i) Merged dataset of ac9, UV and CTD; 27 deployments divided into 2 casts (filtered and unfiltered), median binned into 2 m depth intervals. Filenaming convention: D338_OPTSSS_ac9_SUV_CTD_fff_yymmdd.txt where SSS is the cast ID (e.g 001); ac9 (ac9), SUV (Spectral UV), CTD (CTD), fff is flt (filtered) or unf (unfiltered), yy (year), mm(month), dd (day).

ii) ii) Binned dataset of FRRF parameters into two separate casts (where appropriate). Filenaming convention: D338_OPTSSS_frrf_castx_yymmdd.csv

Atmospheric measurements:

i) Single spreadsheet of aerosol optical depth measurements taken opportunistically during the cruise.

ii) Daily 5 minute wavelength integrated totals of UVA and UVB from the 5 minute hyperspectral data.

Figures

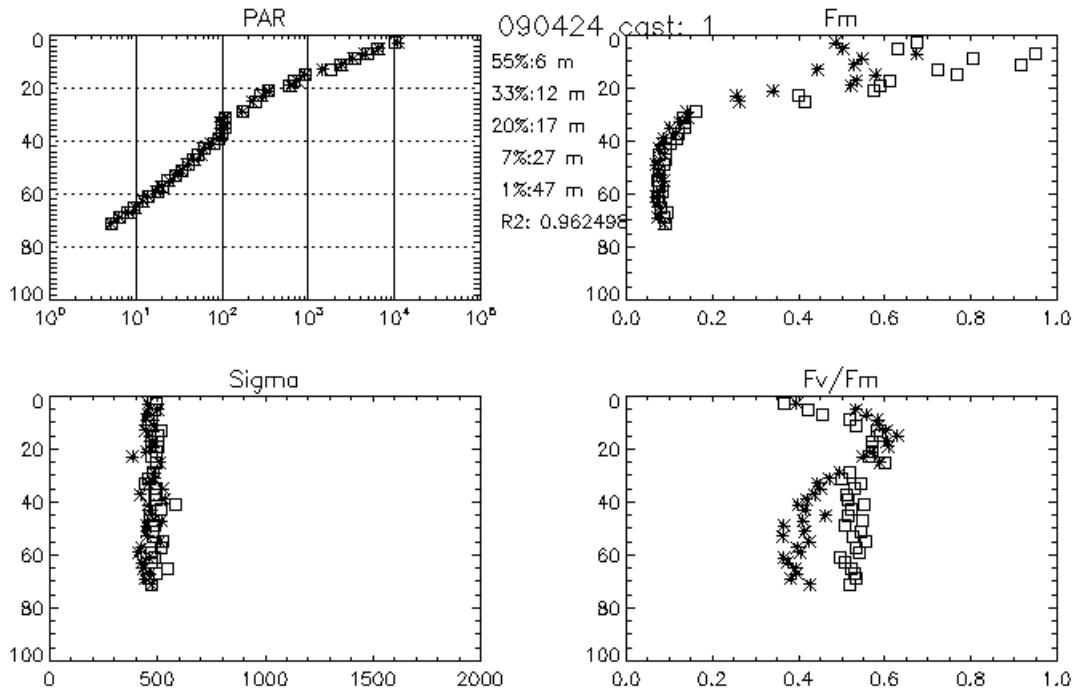

Figure 1: FRRF parameters typical of patch 1

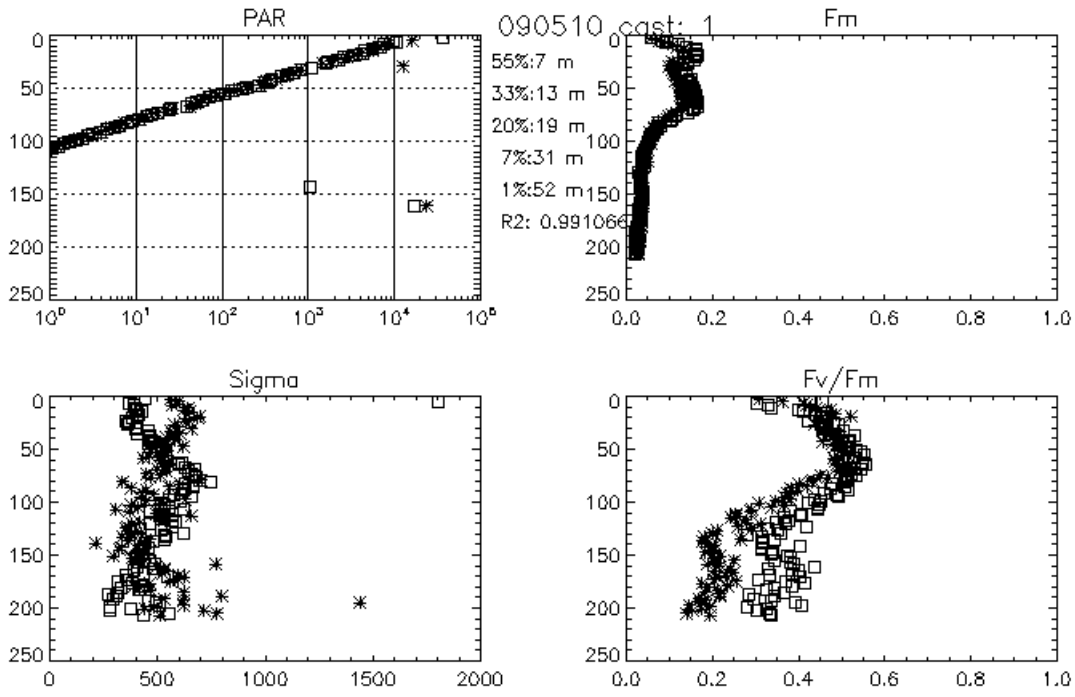

Figure 2: FRRF parameters typical of patch 2

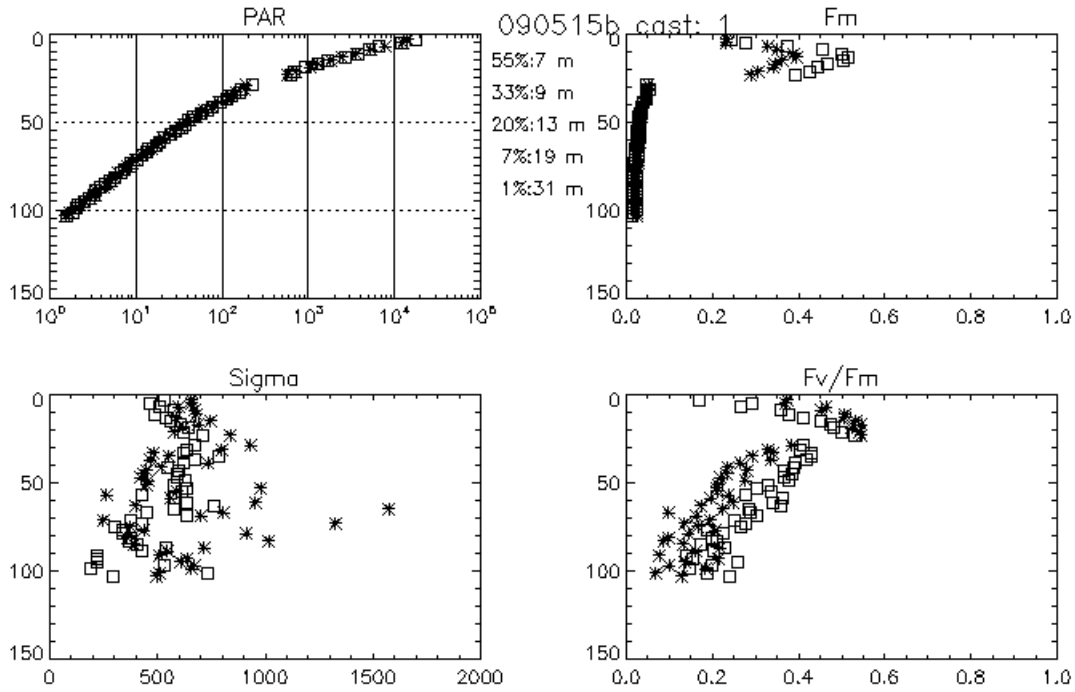

Figure 3: FRRF parameters typical of patch 3

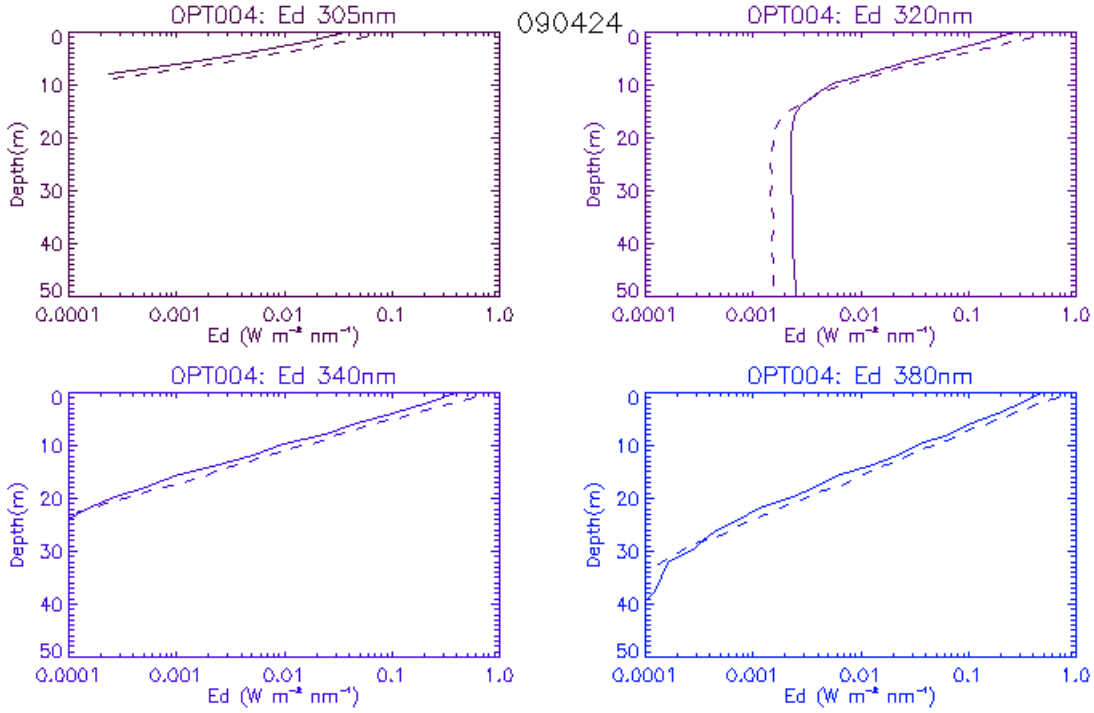

Figure 4: Spectral UV typical of patch 1; solid line is cast 1, dashed line is cast 2.

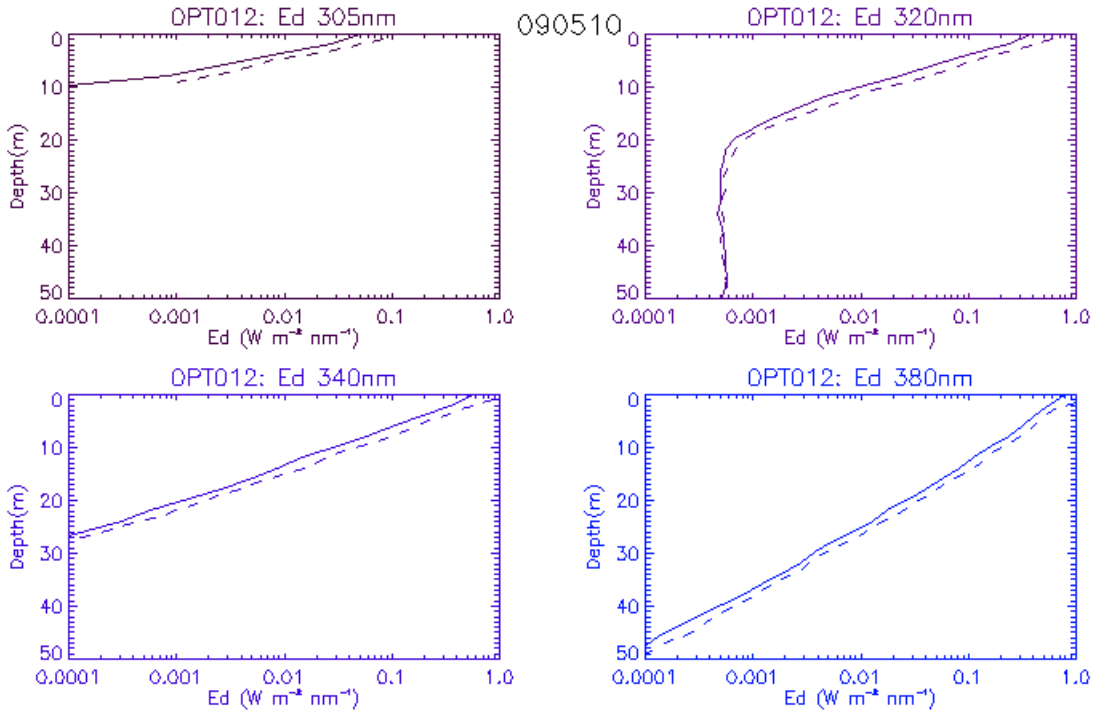

Figure 5: Spectral UV typical of patch 2.

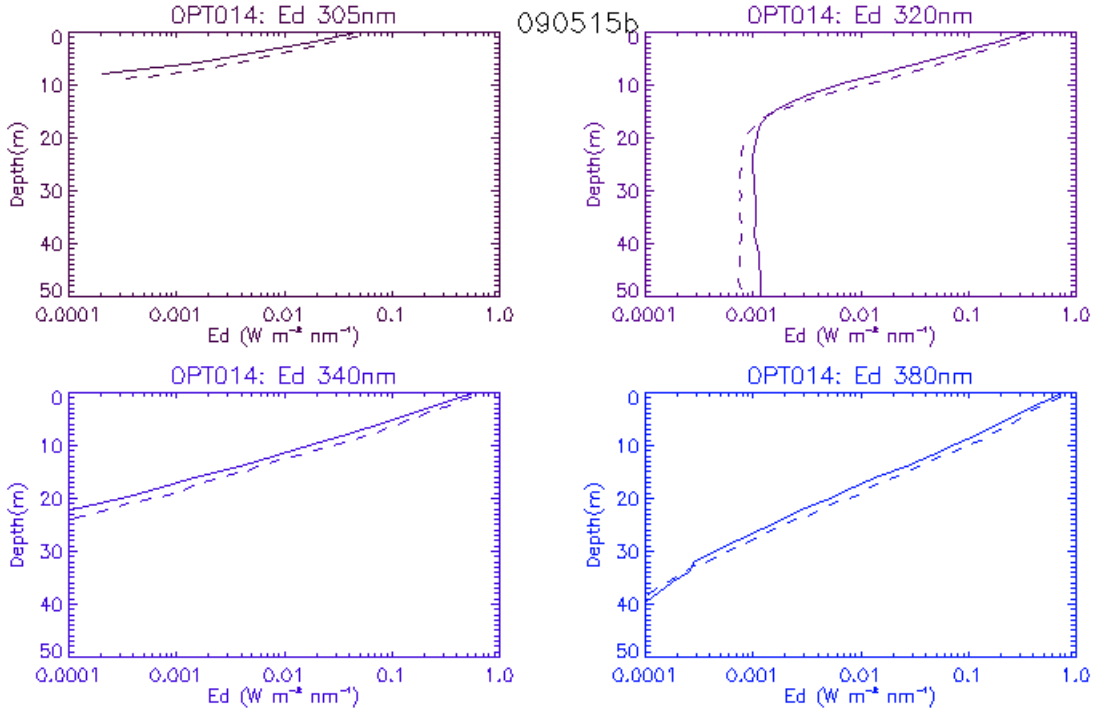

Figure 6: Spectral UV typical of patch 3; cast 1 is solid line, cast 2 is dashed.

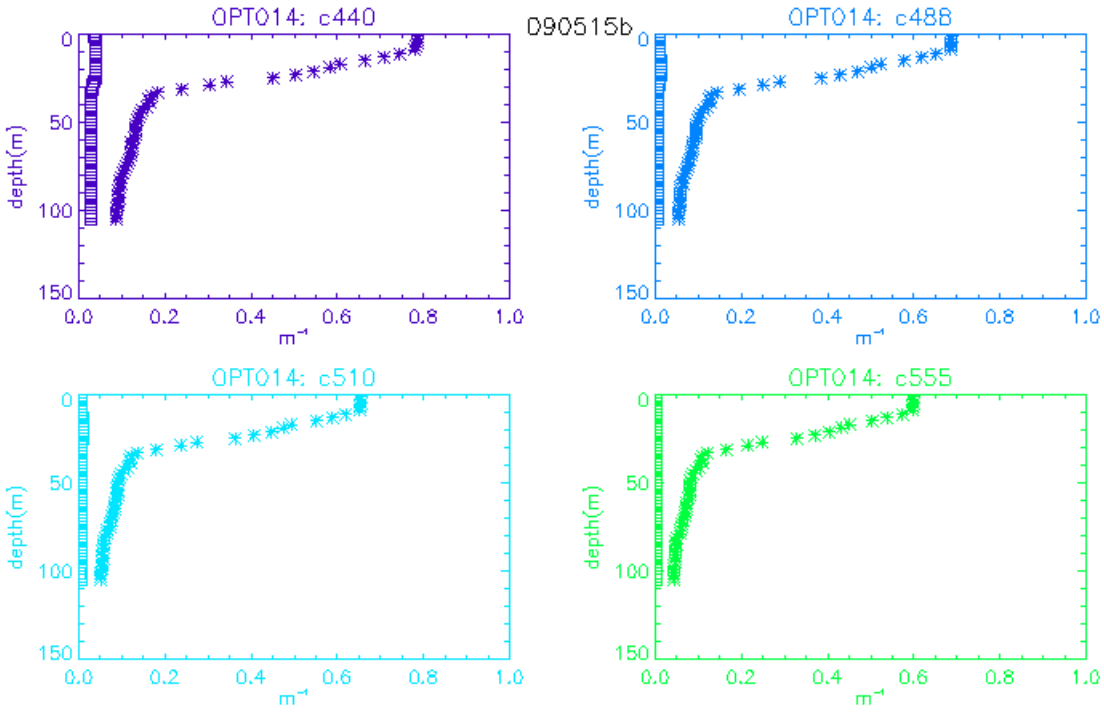

Figure 7: Attenuation at 440, 488, 510 and 555 nm measured using the ac9 in patch 3. Open squares represent a filtered cast through 0.2 um supracaps and represent the CDOM signal. Crosses show the unfiltered cast and show total (not including pure water) attenuation.

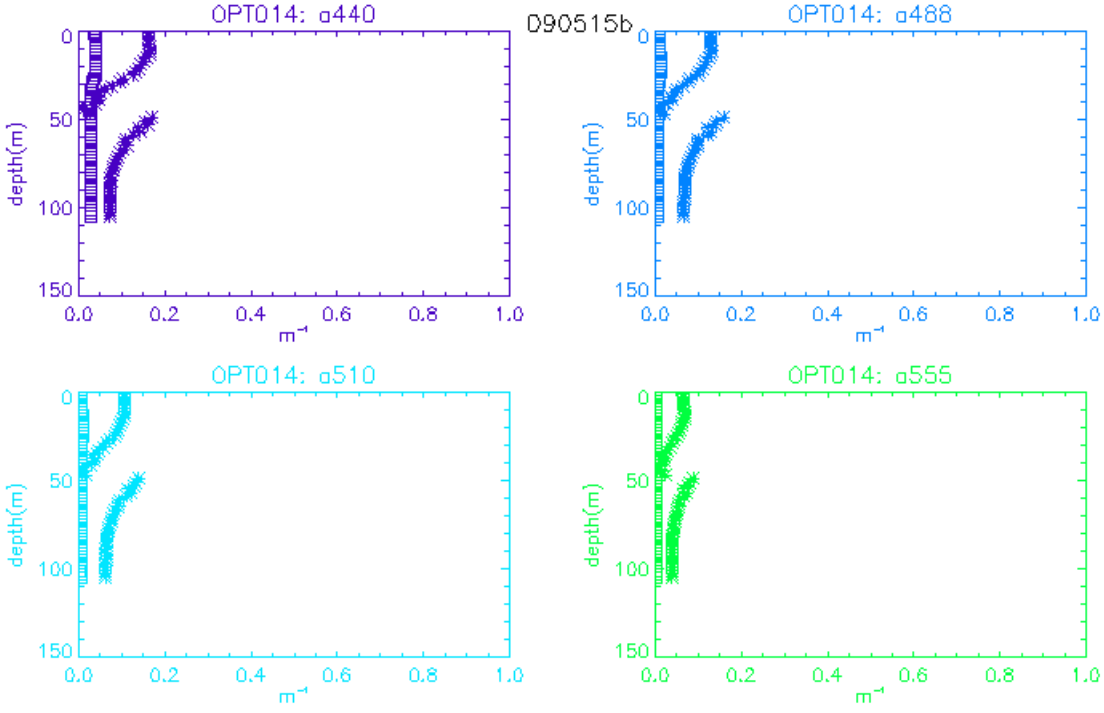

Figure 8: As for figure 7 but absorption.

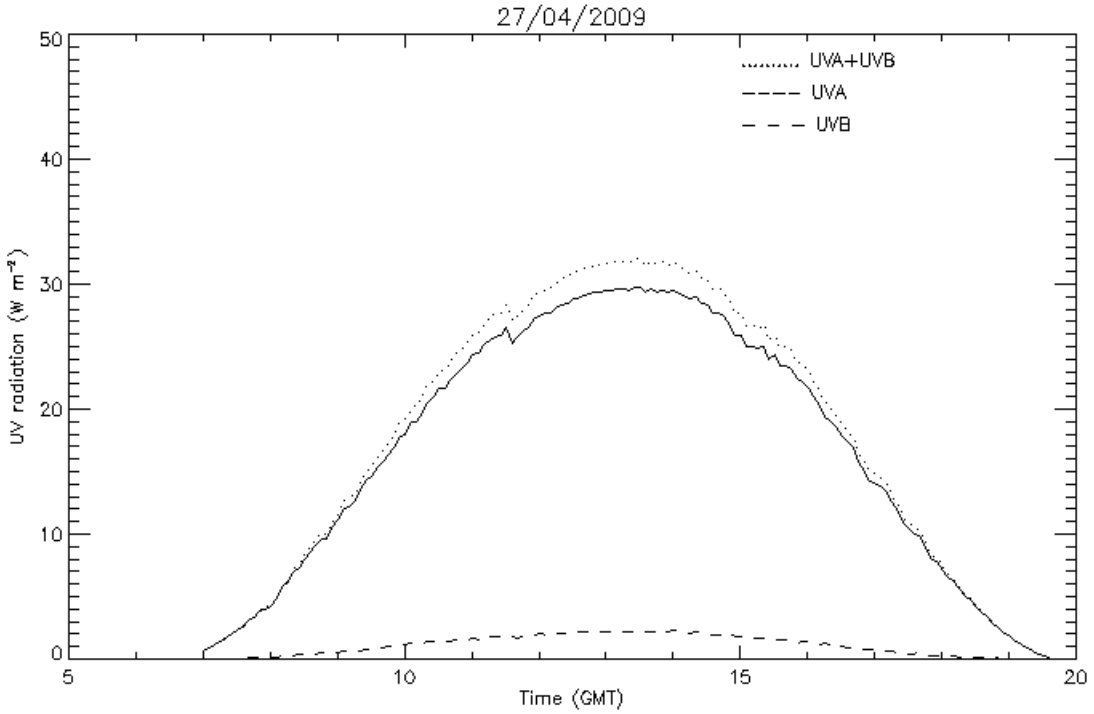

Figure 9: Typical surface UV light levels during patch 1

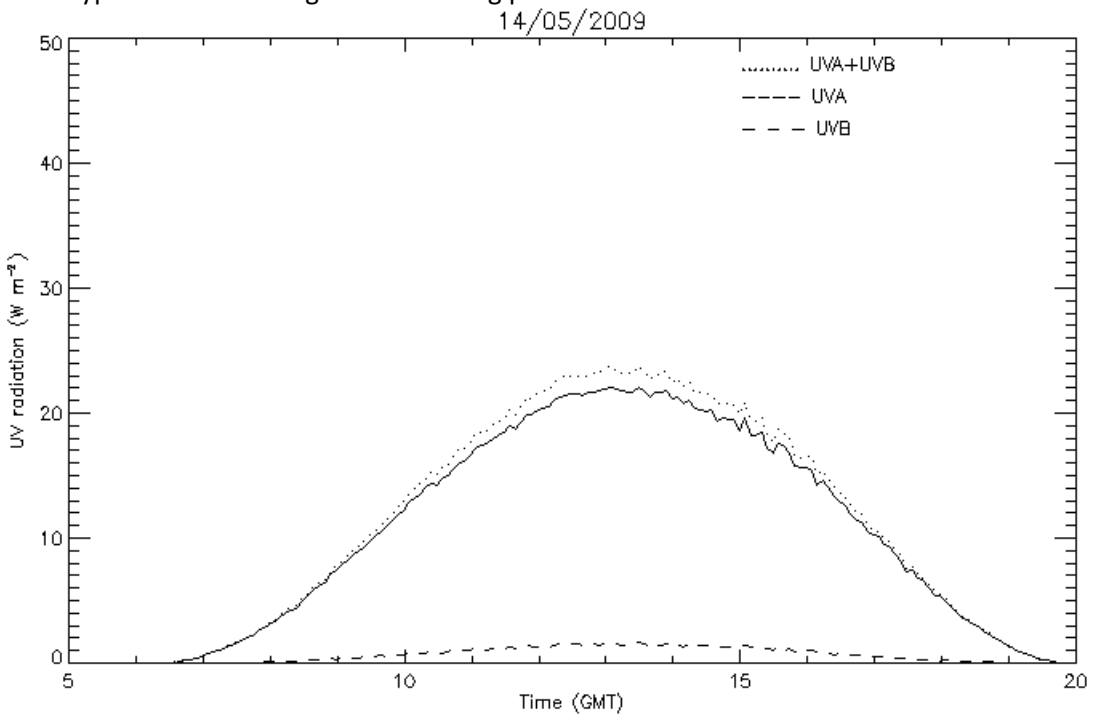

Figure 10: Surface UV light levels during aerosol outbreak

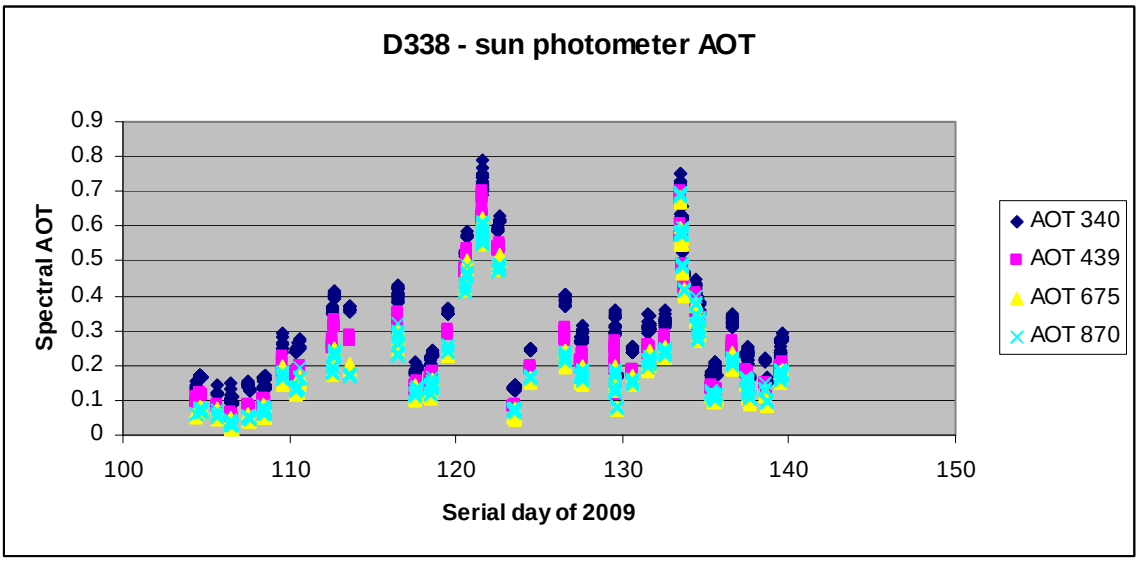

Figure 11: Aerosol optical depth measurements over the duration of the cruise. Blue squares – 340 nm; pink squares 439 nm; yellow triangles 675 nm; cyan crosses 870 nm.

Appendix

Measurement	Instrument	Manufacturer	Model	Serial number	Calibration
In-water UV (305, 320, 340, 380 nm)	UV sensor	Satlantic	507-UV	168	19th Feb 2009 Satlantic
phytoplankton phys.	FRRF	Chelsea	FRRF 1	182041	March 2009 Chelsea
PAR	PAR sensor	Chelsea	0046-3097	046058	March 2009 PML
Depth	Depth sensor	Druck	1830	1265903	not known
Temperature, Salinity	CTD	SeaBird	SBE19+	19P27903-4180	12th Dec 2001 Seabird
absorption / attenuation at 412,440, 488,510,532,555,650,676, 715 nm	ac-9	Wetlabs	ac9+	ac90277P	27th Feb 2009 Wetlabs
Incident UV (200 – 500 nm at 2.5 nm resolution)	Hyperspec.UV sensor	Trios	ACC2 UV	010-05-501F	24th March 2009 TrioS
Aerosol Optical Depth	sunphotometer	SOLAR light co.	microtops II	03759	not known but regularly calibrated at Goddard.

Table 2: description and serial numbers of instruments used. Highlighting is used to show instruments used as a unit.

Inorganic nutrients

Malcolm Woodward

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OBJECTIVES:

To investigate the spatial and temporal variations of the micromolar nutrient species Nitrate, Nitrite, Silicate, Ammonium and Phosphate during the research cruise to the Eastern Tropical Atlantic studying the coastal upwelling areas of Mauritania and Western Sahara. The overall objective was to identify an upwelled filament of water, rich in nutrients, label a patch with SF_6 and then track the movement of this patch, and hence the filament of water, as it moved with the general water body and out towards the Atlantic Ocean. We also intended to carry out in conjunction with Gavin Tilstone and Vasilis Kitidis, a series of photo-production experiments using in-lab light incubators to study various aspects of production where my contribution would be the ammonium photo-production rates over 24 hour periods.

SAMPLING and ANALYTICAL METHODOLOGY:

The micro-molar analyser was a Bran and Luebbe AAIII segmented flow, colorimetric, autoanalyser, and classical proven analytical techniques were used. Water samples were taken from a 24 x 20 litre stainless steel CTD/Rosette system (SeaBird). These CTD bottles were sub sampled into acid clean 60 mls HDPE (nalgene) sample bottles and analysis for the nutrient samples was in most cases complete within 3-4 hours of sampling. Clean handling techniques were employed to avoid any contamination of the samples, particularly for the ammonium samples. No samples were stored. Samples were also analysed from the clean sampling 'fish' deployed over the starboard quarter. These were taken when any mapping exercises were carried out. As a way to guarantee the quality and accuracy of the analyses I also analysed daily Reference Materials for the nutrients Nitrate, Phosphate and Silicate. These were kindly provided by Dr Michio Aoyama from the KANSO company in Japan. These samples are close to being globally certified and the exercise is part of a global exercise for nutrient intercomparability study of which I am part of the steering committee.

CTD SAMPLES ANALYSED.

Three separate SF_6 patches were seeded and followed with CTD's taken to study the water chemistry.

Date	CTD	CTD Bottles analysed
18th April	003	1,3,4,5,7,10,11,13,17,20,22
19th April	005	1,2,3,4,5,8,9,11,13,15,21,24
20th April	011	1,2,3,4,5,8,9,12,17,18,23
21st April	017	1,2,3,6,7,9,12,16,20,24

22nd April	019	1,4,7,10,13,16,17,24
23rd April	021	1,4,7,10,13,16,21,22
23rd April	022	2,4,7,10,12,14,16,18,20,23
23rd April	023	2,4,6,7,10,12,13,16,18,19,22
24th April	025	2,4,7,10,13,16,21,24
24th April	026	1,4,6,10,12,13,16,19,23
24th April	027	2,3,6,8,10,12,14,16,18,29,22
25th April	030	2,4,7,10,13,16,21,24
25th April	031	2,4,6,7,10,12,14,15,19,22
25th April	032	3,5,7,9,11,14,15,18,19,22
26th April	034	1,2,3,4,7,10,13,16,21,24
26th April	035	2,6,8,10,13,15,17,19,21,23
26th April	036	1,3,5,8,10,12,14,16,18,20,23
27th April	038	1,2,3,7,10,13,16,21,24
27th April	039	2,5,7,9,12,14,16,18,21,24
27th April	040	2,4,6,8,10,12,14,16,18,19,22
28th April	041	2,6,8,10,13,14,16,19,21,23
28th April	042	2,4,5,8,10,12,14,16,17,18,19,20,21,23
29th April	044	2,3,4,7,10,13,16,21,22
29th April	045	2,4,5,6,8,11,13,14,16,18,20,23
29th April	046	10,11,13,14,15,16,17,18,19,20,21,22,23
30th April	048	2,3,5,8,11,14,17,21,24
8th May	053	2,3,4,7,10,13,16,21,22
9th May	055	2,3,4,7,10,13,16,21,22
9th May	056	2,4,6,8,11,13,16,19,22
9th May	057	2,4,6,8,10,12,14,16,18,19,21,23,24
10th May	059	2,4,5,7,10,13,16,21,23

10th May	060	2,4,5,7,10,13,16,21,23
10th May	061	2,4,6,8,10,12,14,16,18,20,22,24
12th May	062	2,4,9,15,18,22
13th May	063	2,4,6,10,14,18,22
14th May	065	2,3,4,7,10,13,16,20,22
15th May	066	3,4,7,9,11,13,18,22
15th May	067	2,4,6,8,10,12,14,16,17,19,21,23
16th May	069	2,3,4,5,7,10,13,16,20,22
16th May	070	3,4,5,6,7,10,12,14,16,18,24
16th May	071	2,4,6,8,10,12,14,16,18,20,22,24
17th May	074	1,3,4,5,7,10,13,16,20,22
17th May	075	3,4,5,6,7,8,12,14,16,18,22
17th May	076	1,4,6,8,10,12,14,16,18,20,22,24
18th May	078	2,3,4,5,7,10,13,16,20,22
18th May	080	2,4,5,6,7,9,11,14,16,18,22
18th May	081	2,4,6,8,10,12,14,16,18,20,22,24
19th May	083	2,3,4,5,7,10,13,16,20,22
19th May	084	3,4,5,6,7,8,11,15,16,18,22
19th May	085	2,4,6,8,10,12,14,16,18,20,22,24
20th May	087	2,3,4,5,7,10,14,16,20,22
20th May	088	2,3,4,5,6,9,10,22,24
20th May	089	1,3,5,7,10,13,16,18,22
20th May	090	1,4,5,7,10,13,16,18,22
20th May	091	1,4,5,8,10,13,16,18,22
21st May	093	2,3,4,5,7,10,16,20,22
21st May	094	3,5,7,8,11,13,15,19,22
21st May	095	2,4,6,8,10,11,14,16,18,20,22,23

22nd May	097	1,2,3,5,8,11,14,17,22
22nd May	099	2,4,6,8,10,12,14,16,18,20,22,24

Ammonium Photoproduction Experiments:

Photo-Ox 1 – 23rd April
Photo Ox 4: 24th April – 25th April
Photo Ox 5: 25th -26th April
Photo Ox 6: 27th – 28th April
Photo Ox 7: 29th – 30th April
Photo Ox 8: 30th April - 1st May
Photo Ox 9: 8th - 9th May
Photo Ox 10: 9th – 10th May
Photo Ox 11: 10th – 11th May
Photo Ox 12: 14th – 15th May
Photo Ox 13: 16th – 17th May
Photo Ox 14: 17th – 18th May
Photo Ox 15: 18th – 19th May
Photo Ox 16: 19th – 20th May
Photo Ox 17: 20th – 21st May
Photo Ox 18: 21st – 22nd May
Photo Ox 19: 22nd-23rd May

For details of the entire Photo-production experiments and set up etc, see cruise report of Gavin Tilstone.

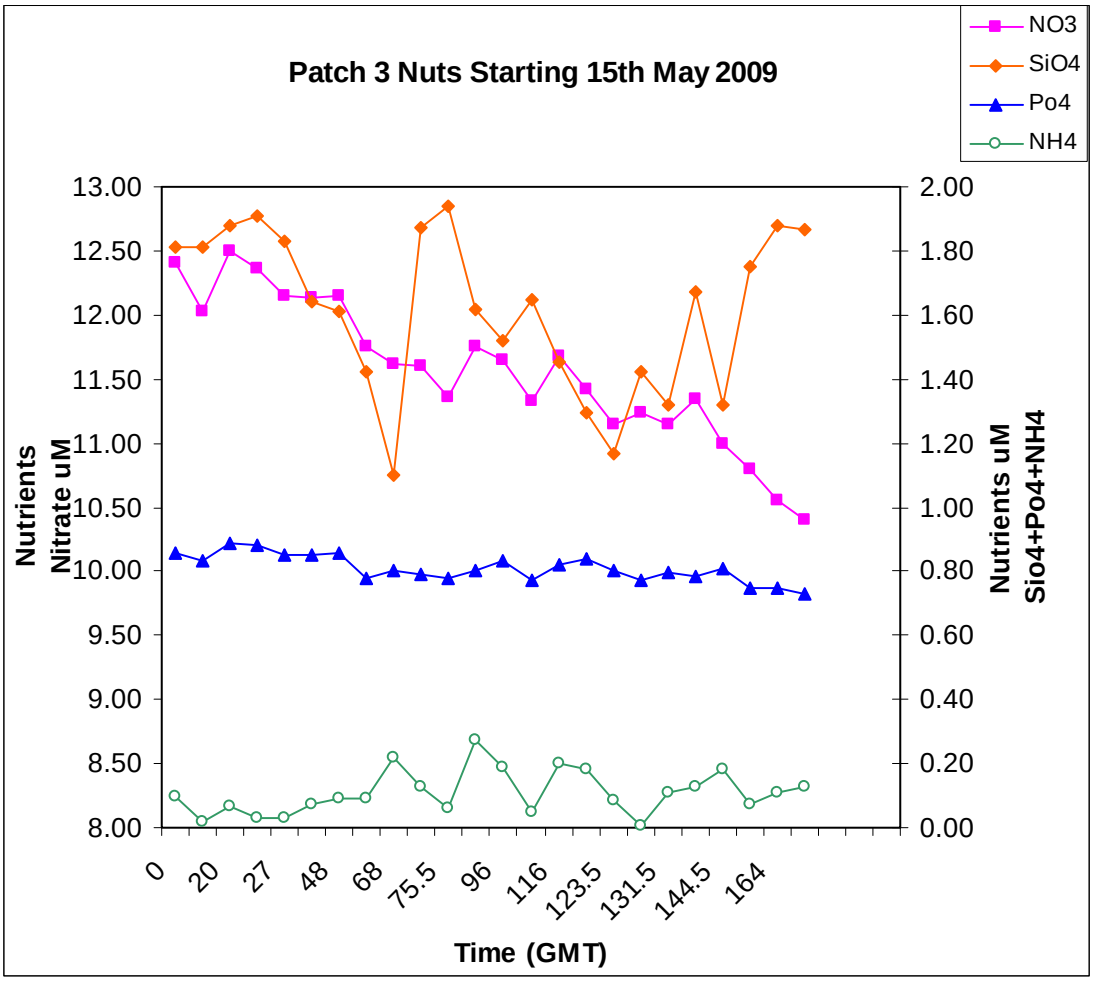
Underway sampling from 'clean-sampling' fish

April 20th: 0600, 0800-2135: 12 samples
April 21st: 0658-1140: 11 samples
May 3rd: 0851-1630: 16 samples
May 12th: 1855 – May 13th 0200: 27 samples
May 12th: 1137-1352: 12 samples
May 13th: 1214-1922: 19 samples

CRUISE RESULTS and SUMMARY

The autoanalyser worked generally very well, although some problems with the software caused a number of lost hours, however what potentially would have meant the loss of the analyser and hence all nutrient information for the cruise because of the repeated software 'hang-ups' was overcome thanks to investigations by Martin Bridger of NMF who identified the problem and effected a 'repair'. This highlighted a very simple problem that potentially could have meant the loss of any further nutrient information. Many thanks to Martin for his assistance and repairs. The nutrient concentrations were all worked up to an initial phase of readiness to allow interpretation of the progress of the upwelled filaments as they moved Offshore. Results shown here are for the third filament showing the nitrate dropping over the survey time from over 12 uM to just 10 uM at the end. Similarly the phosphate dropped over the time but the silicate was very varied and this will probably be very dependent on the biology of the system which was varying

daily. It was a pity the experiment could not continue for longer as this would probably finally resulted in the continued depletion of the nitrate and phosphate closer towards oligotrophic waters and to changes in the biological community to species and size classes more associated to these types of low nutrient waters.



Many thanks to Simon Thomas for this help with first class bottle washing and all round general help whenever he had spare time from his other duties, he was an invaluable pair of hands. Also to Carol Robinson, Andy Rees, Jo Dixon, John Stephens and others I maybe don't know about for collection and analysis of samples during surveys that were conducted to decide the strength of the nutrient upwelling signal and to help with the cruise decision making process.

Primary production and chlorophyll *a*

Claire Widdicombe

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In order to address Objective 3 of the SOLAS ICON project "To determine the impact of nutrient enriched upwelled water on the spatial and temporal variability of plankton community structure and activity and resultant influence on biogenic gas flux" a series of experiments and measurements were made specifically to:

i) Determine phytoplankton production in the particulate and dissolved fraction during Lagrangian surveys
ii) Determine seawater chlorophyll *a* concentrations and calibrate against the TSG fluorometer

Carbon Fixation: Seawater collected from 6 light depths (97% - 1%) was distributed into triplicate 60 ml polycarbonate bottles and inoculated with ~ 10 µCi ^{14}C-bicarbonate. Incubations were performed in on-deck incubators under simulated in-situ light conditions and temperature controlled by surface seawater. Experiments were terminated by filtration through 0.2µm polycarbonate filters for DOC production and sequential filtration through 2 and 0.2µm Supor 200 membrane filters for POC production. Samples were fumed with HCl prior to onboard liquid scintillation counting.

Chlorophyll concentration: Seawater samples (50 - 100 ml) were filtered onto 47mm 0.2µm polycarbonate filters, extracted in 90% acetone at -20°C overnight and Chlorophyll *a* determined according to the method of Welschmeyer (1994) using a Turner instruments fluorometer.

Preliminary Results: Primary productivity was highest at the beginning of the study (8gCm^{-2}d^{-1}) and the >2µm particulate fraction dominated production throughout this study (Fig. 1). Three chlorophyll calibrations were performed against the TSG fluorometer at the beginning, middle and end of the cruise and the results compared well suggesting little or no change in the sensitivity of the fluorometer (Fig. 2).

Acknowledgements: Many thanks to Jo and Andy for their advice and set-up of the ^{14}C method and Simon, Frankie, Susan, Bea, Thomas and Riqui for their valuable help in collecting chlorophyll samples for the TSG calibrations.

Table 1. Sampling and experimental details

Date	CTD#	^{14}C Primary production	***Chla***
20/4/09	12	POC & DOC – 24 h	1-35m
21/4/09	17	POC & DOC – 24 h	1-35m
22/4/09	19	POC & DOC – 24 h	1-35m

23/4/09	22	POC & DOC – 24 h	1-35m
23/4/09	23	POC – 4 h	5 & 8m
24/4/09	25	POC & DOC – 24 h	1-34m
24/4/09	26	POC – 4 h	5 & 8m
25/4/09	30	POC & DOC – 24 h	1-35m
26/4/09	34	POC & DOC – 24 h	1-40m
26/4/09	35	POC – 4 h	5 & 10m
27/4/09	38	POC & DOC – 24 h	1-40m
27/4/09	39	POC – 4h	5 & 10m
29/4/09	44	POC & DOC – 24 h	1-50m
29/4/09	45	POC – 4h	7 & 12m
30/4/09	49	POC & DOC – 24 h	1-60m
30/4/09	50	POC – 4h	8 & 14m
8/5/09	53	POC & DOC – 24 h	1-40m
9/5/09	55	POC & DOC – 24 h	1-40m
10/5/09	59	POC & DOC – 24 h	1-40m
14/5/09	65	POC & DOC – 24 h	1-40m
14/5/09	66	POC – 4h	8 & 14m
16/5/09	69	POC & DOC – 24 h	1-25m
17/5/09	74	POC & DOC – 24 h	1-25m
18/5/09	78	POC & DOC – 24 h	1-40m
19/5/09	83	POC & DOC – 24 h	1-35m
20/5/09	87	POC & DOC – 24 h	1-35m
21/5/09	93	POC & DOC – 24 h	1-35m
22/5/09	97	POC & DOC – 24 h	1-35m

Table 2. Chlorophyll calibrations for the TSG fluorometer and Diel cycle

Date	Sample	Purpose
17/4 – 23/4/09	Non-toxic	TSG calibration
3/5 – 6/5/09	Non-toxic	TSG calibration
15/5 – 23/5/09	Non-toxic	TSG calibration
20/5/09	FISH	Diel cycle

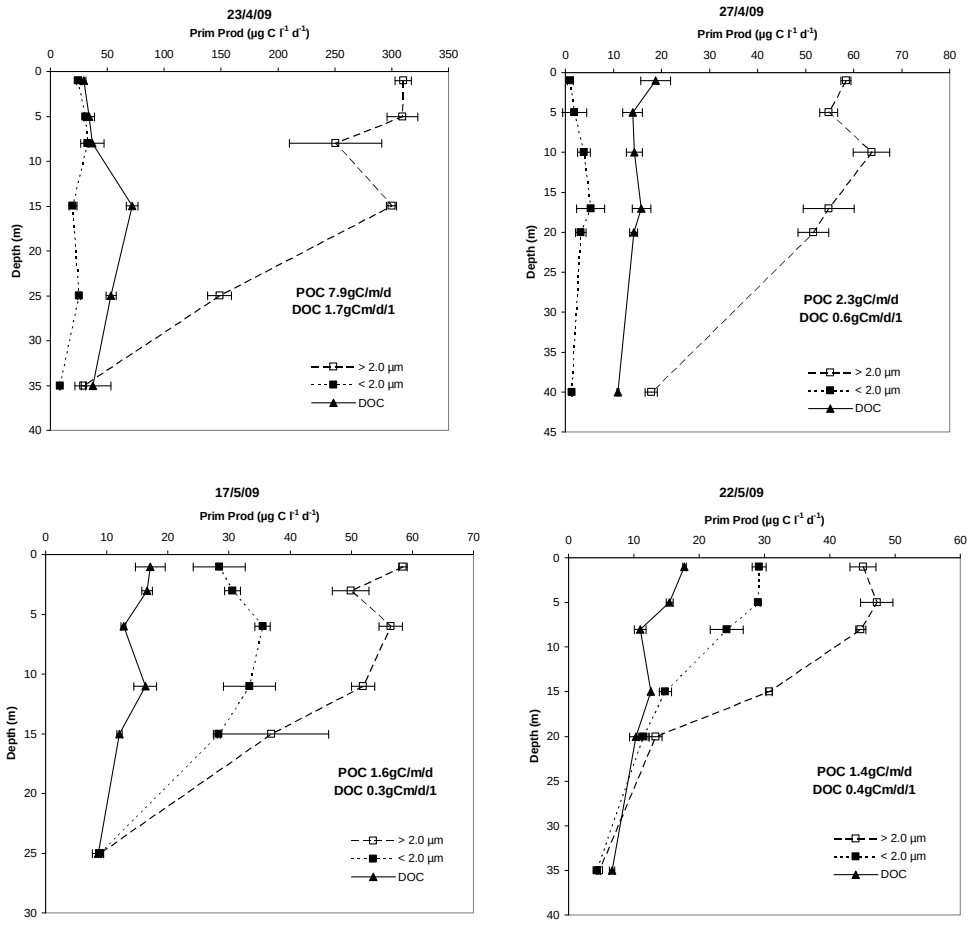

Fig. 1. Depth profiles of POC and DOC primary production

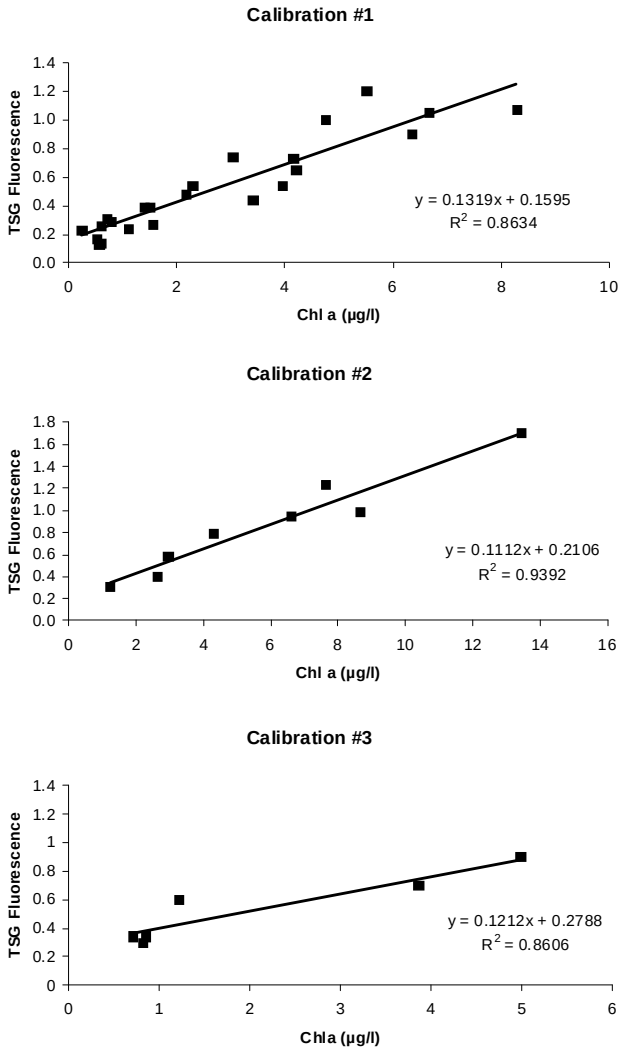

Fig. 2. Chlorophyll calibration against the TSG fluorometer

DMS dynamics

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Dimethylsulfide (DMS) is a climate-active biogenic gas produced in the marine environment and of great relevance for climate modellers. DMS is produced from dimethylsulfoniopropionate (DMSP), a metabolic compound found in various groups of phytoplankton, Biological and photochemical production of trace gases such as dimethyl sulphide (DMS) are enhanced by the elevated productivity and shift in plankton community structure associated with upwellings. Recently developed, mechanistic models of DMS production illustrate the crucial need to understand the controls on DMSP production, the fate of that production through loss factors such as grazing or lysis and yield of dissolved DMS and DMSP. Within the context of a Lagrangian SF_6 tracer experiment we determined the impact of upwelled water on DMS and DMSP production, and assessed the fate of the DMSP production through grazing. We also determined the temporal change in DMSPp and DMS within the upwelled water compared to adjacent waters, the taxa responsible for DMSP production, microzooplankton grazing impact on DMSP-specific phytoplankton, and the intracellular synthesis of DMSP in relation to physiological stress (decreasing nutrients).

Specific Aims and Objectives

1) Measure the concentrations of DMS and DMSP along and across the filament of upwelled water in comparison with adjacent non-upwelled conditions.
2) Determine grazing-induced mortality of DMSP-specific phytoplankton groups using 2 independent methods: (1) by serially saturating seawater samples with surrogate prey (beads) and (2) measuring phytoplankton growth rates in time course grazing dilution experiments.
3) Examine the potential antioxidant role of DMSP by measuring the temporal changes in intracellular DMSP production in relation to increased nutrient stress.
4) Test utility of saturation experiments mentioned above for analysing production of DMSP through grazing.
5) Flow cytometric sorting of specific sub-populations of the phytoplankton community to determine cellular DMSP content.

(1) Determining the temporal and spatial distribution of dimethyl sulphide (DMS) and dimethylsulphoniopropionate (DMSP) concentrations in upwelled water:

The DMS and DMSP analysis is based around a Varian 3800 GC with pulsed flame photometric detector (PFPD). A manual purge-and-trap approach was the main mode of operation using seawater supplied from a towed fish, generally at < 2m depth for transect and mapping work and discrete CTD depths for vertical profile structure. DMSP samples were taken manually for CTD casts but for high resolution sampling during mapping and transects a Beeline robotic sampler was used. The samples were fixed using H_2SO_4 for later analysis. DMS analyses were carried out within one hour of sampling, the samples being stored cool in sealed bottles in the dark. DMSP analyses were carried out on the preserved samples by hydrolysing the sample with 10M NaOH to reduce the DMSP to DMS and then treated as DMS samples. Some CTD cast DMSP samples were collected both as total and particulate fraction (DMSP(t) and DMSP(p)) to give an estimate of how the DMSP is distributed in the water column.

Table 1: CTD casts sampled for DMS, DMSP(t) and DMSP(p)

CTDs Sampled for DMS, DMSP(T) & DMSP(P)

CTD Cast	Date	Latitude N	Longitude W	No. Depths	Species measured		
CTD17	21.April.2009	21 29.94 N	17 14.56 W	6		DMSP(T)	
CTD19	22.April.2009	21 25.90 N	17 15.82 W	6		DMSP(T)	
CTD 22	23.April.2009	21 25.90 N	17 15.82 W	7	DMS	DMSP(T)	
CTD 25	24.April.2009	21 00.44 N	17 28.31 W	6	DMS	DMSP(T)	
CTD 26	24.April.2009	20 57.95 N	17 28.77 W	5	DMS	DMSP(T)	
CTD 30	25.April.2009	20 52.04 N	17 37.66 W	6	DMS	DMSP(T)	
CTD 31	25.April.2009	20 49.43 N	17 40.82 W	6	DMS	DMSP(T)	DMSP(P)
CTD 34	26.April.2009	20 41.47 N	17 47.71 W	6	DMS	DMSP(T)	
CTD 35	26.April.2009	20 40 08 N	17 48.88 W	7	DMS	DMSP(T)	DMSP(P)
CTD 38	27.April.2009	20 39.79 N	17 54.47 W	6	DMS	DMSP(T)	
CTD 39	27.April.2009	20 37.47 N	17 56.29 W	8	DMS	DMSP(T)	DMSP(P)
CTD 41	28.April.2009	20 43.31 N	18 15.58 W	8	DMS	DMSP(T)	
CTD 44	29.April.2009	20 38.77 N	18 27.90 W	6	DMS	DMSP(T)	
CTD 45	29.April.2009	20 37.75 N	18 31.05 W	9	DMS	DMSP(T)	DMSP(P)
CTD 46	29.April.2009	20 38.24 N	18 33.77 W	5	DMS	DMSP(T)	DMSP(P)
CTD 49	30.April.2009	20 38.05 N	18 40.84 W	6	DMS	DMSP(T)	
CTD 50	30.April.2009	20 35.77 N	18 42.82 W	8	DMS	DMSP(T)	DMSP(P)
CTD 53	08.May.2009	21 25.47 N	17 56.01 W	6	DMS	DMSP(T)	
CTD 55	09.May.2009	21 31.25 N	17 59.43 W	6	DMS	DMSP(T)	
CTD 56	09.May.2009	21 30.82 N	18 00.25 W	6	DMS	DMSP(T)	DMSP(P)
CTD 59	10.May.2009	21 37.43 N	18 02.05 W	6	DMS	DMSP(T)	
CTD 60	10.May.2009	21 37.43 N	18 02.05 W	6	DMS	DMSP(T)	DMSP(P)
CTD 61	10.May.2009	21 36.13 N	18 01.71 W	4	DMS	DMSP(T)	DMSP(P)
CTD 65	14.May.2009	19 52.19 N	18 09.80 W	7	DMS	DMSP(T)	

CTD 66	15.May.2009	19	25.61 N	17	55.65 W	7	DMS	DMSP(T)	DMSP(P)
CTD 67	15.May.2009	19	26.12 N	17	57.33 W	5	DMS	DMSP(T)	DMSP(P)
CTD 69	16.May.2009	19	30.78 N	18	06.17 W	6	DMS	DMSP(T)	
CTD 70	16.May.2009	19	31.89 N	18	07.58 W	6	DMS	DMSP(T)	DMSP(P)
CTD 74	17.May.2009	19	35.51 N	18	17.65 W	6	DMS	DMSP(T)	
CTD 75	17.May.2009	19	36.57 N	18	18.82 W	6	DMS	DMSP(T)	DMSP(P)
CTD 78	18.May.2009	19	40.53 N	18	27.87 W	6	DMS	DMSP(T)	
CTD 80	18.May.2009	19	43.13 N	18	26.15 W	6	DMS	DMSP(T)	DMSP(P)
CTD 83	19.May.2009	19	44.39 N	18	37.61 W	6	DMS	DMSP(T)	
CTD 84	19.May.2009	19	45.55 N	18	38.84 W	6	DMS	DMSP(T)	DMSP(P)
CTD 87	20.May.2009	19	41.27 N	18	46.77 W	6	DMS	DMSP(T)	
CTD 93	21.May.2009	19	38.12 N	18	54.31 W	6	DMS	DMSP(T)	
CTD 94	21.May.2009	19	35.05 N	18	56.08 W	6	DMS	DMSP(T)	
CTD 97	22.May.2009	19	31.10 N	19	06.73 W	6	DMS	DMSP(T)	

Fish Sampling for DMS, DMSP(T)

DMS sampling for SF_6 Patch Mapping

Robot sampling for DMSP(T)

Date	Patch_01	Sampling period	No. samples		Sampling period	No. samples	
24.04.2009	Grid_01	20 mins	14	DMS	15mins	30	DMSP(T)
25.04.2009	Grid_02	20 mins	17	DMS	15mins	34	DMSP(T)
26.04.2009	Grid_03	20 mins	11	DMS	15mins	20	DMSP(T)
27.04.2009	Grid_04	20 mins	11	DMS	15mins	24	DMSP(T)
29.04.2009	Grid_05	20 mins	11	DMS	15mins	22	DMSP(T)
30.04.2009	Grid_06	20 mins	10	DMS	15mins	24	DMSP(T)

Date	Patch_02	Sampling period	No. samples				
10.05.2009	Grid_07	20 mins	13	DMS	15mins	18	DMSP(T)

Date	Patch_03	Sampling period	No. samples				
16.05.2009	Grid_08	20 mins	14	DMS	15mins	18	DMSP(T)
17.05.2009	Grid_09	20 mins	14	DMS	15mins	21	DMSP(T)
18.05.2009	Grid_10	20 mins	14	DMS	15mins	20	DMSP(T)
19.05.2009	Grid_11	20 mins	14	DMS	15mins	18	DMSP(T)
20.05.2009	Grid_12	20 mins	14	DMS	15mins	20	DMSP(T)
22.05.2009	Grid_13	20 mins	14	DMS	15mins	20	DMSP(T)

Trans-filament Transects & Diel Cycle DMS, DMSP(T) & DMSP(P) Measurements (Fish)

Transect 1	03.05.2009	20 mins	27	DMS	15 mins	38	DMSP(T)
Transect 2	11.05.2009	20 mins	21	DMS	10mins	40	DMSP(T)

Diel Cycle	20.05.2009	1 hour	27	DMS			
		1 hour	30	DMSP(T)			
		1 hour	14	DMSP(P)			

Experimental incubations:

(2) (*i*) *Grazing saturation experiments*

The rationale behind these experiments is that the established method for measuring grazing using a dilution approach to dilute natural seawater to uncouple grazing fom phytoplankton growth involves filtering large volumes of water which, because of the filtration process are likely to contain enhanced nutrients and other dissolved compounds. This means that if one wants to measure compounds such as

dimethylsulphoniopropionate (DMSP) then there is the possibility that the experimental setup itself will affect the concentrations of the compounds which are the subject of study. Therefore it is desirable to find an alternative method involving as little manipulation of the seawater to be studied as possible. During the cruise we have been developing and testing an approach which involves the addition of beads at different concentrations to act as prey for grazers. As the bead concentration increases, the grazers are saturated with bead 'prey' and don't come into contact (and therefore eat) as many phytoplankton prey, thus allowing the phytoplankton to grow. Figure 1 provides an overview of the expected results when cell populations are quantified at the beginning and end of a time course experiment. There were several questions inherent with trying to use this approach: Will grazers ingest the beads (are they selective)? Are the beads toxic to prey/grazers? Do the saturation levels chosen actual saturate grazing? Do beads contain DMSP?

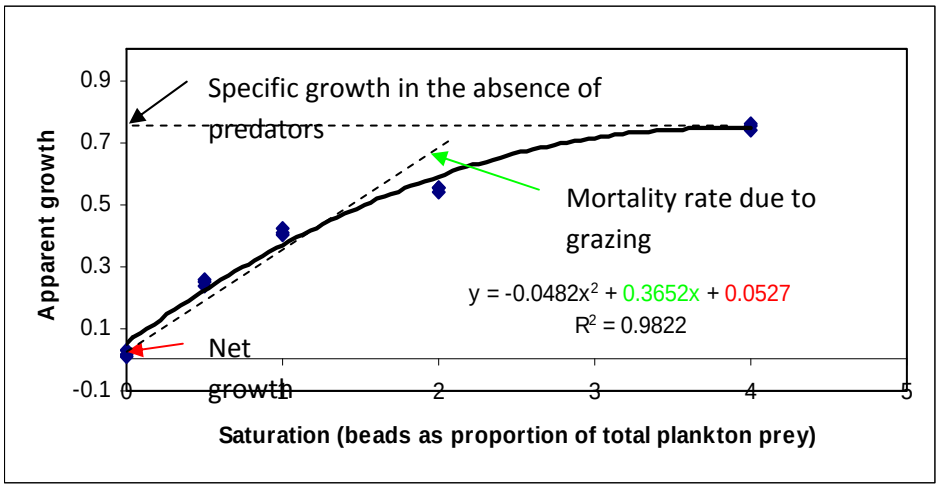

Figure 1: Theoretical results from saturation grazing experiment using beads as surrogate prey: phytoplankton growth/mortality

Experiments were set up using 2, 3 and 6 µm beads to mimic picophytoplankton and nanophytoplankton prey. 10 x 1 L clean polycarbonate bottles were filled to the neck (approx. 1.25 L) with 200 µm filtered seawater from the 55% light depth from predawn (approx 0430 GMT) CTDs. 1 bottle acted as a control, with no beads added. A second control bottle contained beads in 0.2 µm filtered seawater (i.e. no phytoplankton) to see if beads disappeared in the absence of grazing. The other bottles had beads added according to the abundance estimates for plankton from the predawn CTD analysed on the previous day, ranging from 25% to 700% of ambient phytoplankton abundance. Samples from each of the bottles were taken for immediate analysis of pico- and nanophytoplankton by flow cytometry. Samples were also fixed and stained with Sybr Green I DNA stain to quantify heterotrophic nanoflagellates. Additional samples were also taken for DMSP and FIRe analysis of photosynthetic capacity to see if the beads had any effect on the phytoplankton physiology. Once the samples had been taken the experimental bottles were topped up with filtered seawater and placed in an on-deck incubator with non-toxic seawater from 4.5 m running through and a 55% light screen on top. Bottles were incubated for a total of 24 hours. During the hours of darkness a cover was placed over the incubator to prevent any influence from the ship's lights. After 24 h, samples were again analysed to quantify pico- and nanophytoplankton, heterotrophic nanoflagellates and beads to calculate grazing/growth rates for picoeukaryotes and nanoeukaryotes and bead disappearance.

A total of 8 bead saturation experiments were carried out during the cruise (summarised in Table 2). Data will be analysed after the cruise.

Table 2: CTD casts sampled for saturation grazing experiments

EXPT	DATE	JULIAN DAY	TIME ON DECK GMT	CAST	DEPTH (m)
S2	20 Apr	110	03:30	11	10
S3	22 Apr	112	03:25	18	5
S4	24 Apr	114	03:49	24	5
S5	26 Apr	116	04:04	33	5
S6	29 Apr	119	03:53	43	7
S7	16 May	136	04:23	68	3
S8	18 May	138	04:45	77	5
S9	22 May	142	04:31	96	5

(2) (*ii*) *Dilution grazing experiments:*

To set up dilution incubations, fresh seawater collected at the 55 % light level (depth varied with site location) was siphoned into clean 10 L polypropylene carboys through a 200 µm mesh, which removed large grazers. Dilution experiments were set-up using diluent filtered through a 0.2 µm pore size filter. The diluent and whole water were added to 4 L polycarbonate carboys in the correct proportions to create the t0 dilutions, i.e., 20, 40, 70 and 100 % whole water. These dilutions created a gradient of grazing pressure. Triplicate 500 ml polycarbonate bottles were filled from each t0 carboy and placed into the on-deck incubators with neutral density screening providing 55 % light.

Live samples from dilution grazing experiments were analysed at the beginning and end (T24 hours) of experiments to determine autotrophic phytoplankton abundance by flow cytometry. See Phytoplankton Community Structure section for flow cytometry details. 3.5 mL samples were analysed live for between 5 and 15 minutes, depending on the dilution. Samples were also taken, preserved, stained with Sybr Green I and analysed for quantification of heterotrophic grazers in experimental bottles. Samples from each of the bottles were taken for immediate analysis of pico- and nanophytoplankton by flow cytometry. Samples were also fixed and stained with Sybr Green I DNA stain to quantify heterotrophic nanoflagellates. Additional samples were also taken for FIRe analysis of photosynthetic capacity to see if the experimental conditions had any effect on the

phytoplankton physiology, and for DMSP. Once the samples had been taken the experimental bottles were placed in an on-deck incubator with non-toxic seawater from 4.5 m running through and a 55% light screen on top. Bottles were incubated for a total of 24 hours. During the hours of darkness a cover was placed over the incubator to prevent any influence from the ship's lights. After 24 h, samples were again analysed and grazing rates and phytoplankton growth rates were determined from changes in phytoplankton abundance in the 500 ml experimental bottles between t0 and t24.

A total of 10 grazing dilution experiments were carried out during the cruise (summarised in Table 3). Data will be analysed after the cruise.

Table 3: CTD casts sampled for grazing dilution experiments

EXPT	DATE	JULIAN DAY	TIME ON DECK GMT	CAST	DEPTH (m)
GD1	20 Apr	110	03:30	5	10
GD2	22 Apr	112	03:25	18	5
GD3	24 Apr	114	03:49	24	5
GD4	26 Apr	116	04:04	33	5
GD5	29 Apr	119	03:53	43	7
GD6	09 May	129	04:27	54	8
GD7	16 May	136	04:23	68	3
GD8	18 May	138	04:25	77	5
GD9	20 May	140	04:23	86	5
GD10	22 May	142	04:31	96	5

(4) DMSP synthesis experiments:

DMSP production was assessed by examining in-vivo changes in DMSP-biosynthesis using stable-isotope incorporation. Daily experiments were conducted during the Lagrangian periods where a 12 L carboy of 200 µm filtered seawater at the 55 % light level (depth varied with site location) was collected and treated with the stable isotope 13C, which is incorporated through photosynthesis into DMSP. The change in ratio of labelled versus non-labeled DMSP in time is a measure of the *de novo* DMSP production. Twelve 1 L polycarbonate bottles were subsequently filled from the carboy and placed into the on-deck incubators with neutral density screening providing 55 % light. At 4-hourly time points (starting with T0) triplicate bottles were sacrificed and

sampled for phytoplankton community assessment, FIRe analysis of photosystem II functioning , oxidative stress (flow cytometry), DMSP profile using PTR-MS analysis (samples were frozen at -20°C for later analysis) and DMSP content (total and particulate) using the GC purge-and-trap method. A total of 20 DMSP synthesis experiments were carried out during the cruise (summarised in Table 4). Data will be analysed after the cruise.

Table 4: CTD casts sampled for DMSP synthesis experiments

EXPT	DATE	JULIAN DAY	TIME ON DECK GMT	CAST	DEPTH (m)
DS1	20 Apr	110	03:30	5	10
DS2	21 Apr	111	03:30	16	5
DS3	22 Apr	112	03:25	18	5
DS4	23 Apr	113	03:25	18	5
DS5	24 Apr	114	03:49	24	5
DS6	25 Apr	115	05:12	30	5
DS7	26 Apr	116	04:04	33	7
DS8	29 Apr	119	04:27	43	7
DS9	30 Apr	120	04:23	48	8
DS10	08 May	128	04:25	52	5
DS11	09 May	129	04:25	54	8
DS12	10 May	130	04:25	58	5
DS13	14 May	134	04:25	64	4
DS14	16 May	136	04:25	68	5
DS15	17 May	137	04:25	73	5
DS16	18 May	138	04:25	77	5
DS17	19 May	139	04:25	82	5
DS18	20 May	140	04:23	86	5

DS19	21 May	141	04:23	89	5
DS20	22 May	142	04:31	96	5

(5) Flow cytometric sorting of specific sub-populations of the phytoplankton community to measure their DMSP content and determine cellular DMSP content:

Approx. 38 L seawater samples were collected from predawn (approx. 04:30) CTDs at the 55% light depth and gravity filtered through a 0.2 µm Pall Acropak 1000 cartridge filter, which was kept full of water. The filter itself was then carefully inverted and then decanted into a polycarbonate bottle to provide approx. 100 mL of concentrated plankton for flow cytometric sorting. The flow cytometer was set up with 0.2µm filtered seawater as sheath fluid and the cell sorting mechanism of the flow cytometer was left to warm up for at least 15 minutes. Samples of filtrate, unconcentrated seawater and concentrate were analysed by flow cytometry and phytoplankton sub-population sorting gates decided upon. In general, *Synechococcus* spp., picoeukaryotes, nanoeukaryotes, cryptophytes and bacteria were sorted. To check the purity and efficiency of sorting, samples of sorted phytoplankton were first re-analysed on the flow cytometer and then, for each group a series of 5 sorts was conducted, with each sort containing higher numbers of cells (e.g. 1000, 2000, 3000, 4000, 5000 cells). Sorted cells, diluted in sheath fluid were dripped onto a 25 mm Whatman GFF filter and very gently vacuum filtered. Filters with sorted cells were then placed in glass vials containing dilute sulphuric acid to preserve them for GC analysis of their DMSP content back in the laboratory.

Table 5: CTD casts sampled for DMSP sorting experiments

EXPT	DATE	JULIAN DAY	TIME ON DECK GMT		DEPTH (m)
DSort1	10 May	130	04:21	58	7
DSort2	14 May	134	05:08	64	4
DSort3	15 May	135	09:36	66	5
DSort4	17 May	137	04:26	73	5
DSort5	19 May	139	04:22	82	5
DSort6	21 May	141	04:20	92	5

Many thanks to the Captain, crew, and my scientific colleagues on Discovery (D338) for their help and great comradeship, which made this research cruise a very enjoyable experience.

Gross primary production (GPP), dark community respiration (DCR) and net community production (NCP)

Size-fractionated (> 0.8 μm, 0.8-0.2μm) respiration

Dissolved oxygen concentration (incl. CTD & underway optode calibrations)

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RATIONALE

Dissolved Oxygen (O_2) in seawater is produced by photosynthesis and consumed by respiration and photochemical reactions in the surface. Equilibrium between dissolved O_2 in seawater and the atmosphere is maintained through air-sea gas exchange. Determination of the O_2 concentration in the seawater is important to ascertain the spatial and temporal variability of plankton community activity, and the role of microbial activities on the dynamics of climatically important gases (e.g., N_2O). Determination of the dynamics of dissolved O_2 in the seawater allows calculation of the plankton metabolism (gross photosynthetic production and respiratory consumption of O_2). During the ICON cruise, O_2 dynamics have been studied at different time and spatial scales, including *in situ* changes during several days, and diel variability in the Lagrangian water bodies, and *in vitro* changes after 2-24 hours incubations.

OBJECTIVES

- To measure the dissolved oxygen concentration in the seawater.
- To calibrate the oxygen sensors on the CTD profiler and the non-toxic supply of seawater.
- To determine the daily balance of gross primary production (GPP) and community respiration (CR), and to relate it to community structure and nutrient supply.
- To determine the temporal variability of community respiration during the 24 h incubations, and to relate it to changes in community structure.
- To apportion respiration to microbial plankton size-classes (> 0.8 μm; 0.8-0.2 μm).

METHODS

Seawater samples for dissolved oxygen concentration were directly collected from the Niskin bottles, at least from the pre-dawn and 12:00 casts everyday. Seawater was siphoned into 125 ml borosilicate glass bottles, using silicone tubing and overflowing 2-3 times the bottle volume, and samples were immediately fixed. Measurements of dissolved oxygen were made within the following 24 h., using automated Winkler titration systems with photometric endpoint detection (Williams and Jenkinson 1982). The concentration of thiosulphate was calibrated every 2 days. Oxygen saturation was calculated from the equations for

solubility in seawater of Benson and Krause (1984). In order to calibrate the optode of the non toxic supply of seawater (NTS), whenever possible, seawater samples were also taken from the NTS, concurrently with the closing of the surface Niskin bottle of the corresponding vertical cast (see Brown et al. This report).

GPP, net community production (NCP) and dark CR were determined from *in vitro* changes in dissolved oxygen concentration after 24 hours light and dark incubations. Seawater samples were collected from the pre-dawn depth profile into 10L polypropylene aspirators from depths equivalent to ca. 97%, 55%, 33%, 14%, 7% and 1% of surface irradiance. The water was then siphoned from each aspirator into 12 125 ml borosilicate glass bottles, and four zero time replicates were fixed immediately for each depth. Two further sets of 4 replicates were incubated for 24 hours in surface water cooled deck incubators. One set was incubated in the dark (wrapped in aluminium foil), the other set in light of equivalent irradiance to that found at the *in situ* depth. This was controlled using polycarbonate screens incorporating neutral density acrylic of differing transmission (Joint et al. 1993, Donald et al. 2001). During hours of darkness, the incubators were covered with opaque screens. Community respiration (CR) was calculated as O_2 consumption in the dark samples (Zero-Dark). Net community production was calculated as O_2 production in the light samples (Light-Zero). Gross primary production (GPP) was calculated as the sum of NCP+CR (Light-Dark). To test for potential changes in community structure during the incubations, three additional samples were incubated as for O_2 NCP. After the 24 h incubation, subsamples were collected for the determination of pico and nanoplankton abundances by flow cytometry (see Tarran et al. This report), and for phytoplankton cell countings (see Widdicombe et al. This report).

CR was also determined from *in vitro* changes in dissolved oxygen concentration continuously measured by an oxygen microprobe (Unisense Micro-respiration system) and recorded by a computer every 10 seconds. A seawater sample was collected from depths equivalent to ca. 55% of surface irradiance from the pre-dawn depth profiles into a 10L polypropylene aspirator. After the subsampling of the 12 125 ml glass bottles for the GPP, NCP and CR incubations (see above), the water was siphoned from the aspirator into 3 85 ml borosilicate glass chambers. The 3 chambers were incubated in the dark in a temperature controlled water bath at in situ temperatures ($\pm$ 1ºC). The oxygen microprobe was maintained continuously in one of the chambers, the other two replicates being measured at regular intervals. The oxygen consumption by MR electrodes is extremely low (4.7 to 47 x 10^{-7} mmol O_2 h-1. Briand et al. 2004) but the measurement is very sensitive to temperature. To control for both electrode O_2 consumption and temperature variability, a filtered sample was concurrently measured at regular intervals during every incubation. To test for potential changes in community structure during the incubations, after the 24 incubation, subsamples were collected from the three chambers for determination of pico and nanoplankton abundances by flow cytometry (see Tarran et al. This report).

Size fractionated respiration (> 0.8 μm; 0.8-0.2 μm) was determined from the *in vivo* electron transport system (ETS) activity after 2 h dark incubations, following the procedure in Martínez-García et al. (in press). A seawater sample was collected from depths equivalent to ca. 55% of surface irradiance from the pre-dawn depth profiles into a 10L polypropylene aspirator. After the subsampling of the 12 125 ml glass bottles for the GPP, NCP and CR incubations, and the 3 85 ml glass chambers for the electrode measurements (see above), the water was siphoned from the aspirator into 4 250 ml polypropylene bottles. 1 replicate was immediately fixed by adding formaldehyde (2% w/v final concentration) and used as killed-control. After 15 minutes, the four samples were inoculated with a solution of 8 mM 2-para (iode-phenyl)-3(nitrophenyl)-5(phenyl) tetrazolium chloride (INT) to a final concentration of 0.6 mM. The solution was freshly prepared every two days using sterile filtered MilliQ water. The water samples were incubated for 2 hours in the dark in a temperature controlled water bath at in situ temperatures ($\pm$ 1ºC). After

incubation, the three live samples were fixed by adding formaldehyde (2% w/v final concentration). After 15 minutes, samples were filtered through 0.8 and 0.2 μm pore size polycarbonate filters, and stored frozen for further processing.

SAMPLES COLLECTED

51 vertical profiles of 516 samples were collected for *in situ* oxygen concentration and for the calibration of the CTD oxygen sensors.

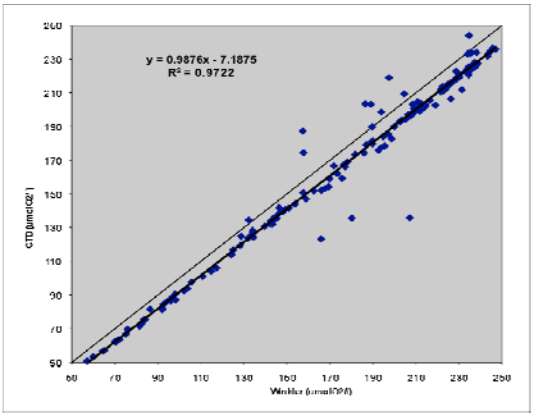
20 vertical profiles of six depths were sampled daily from the pre-dawn cast (ca. 04:00, ship time) for GPP/DCR rates.

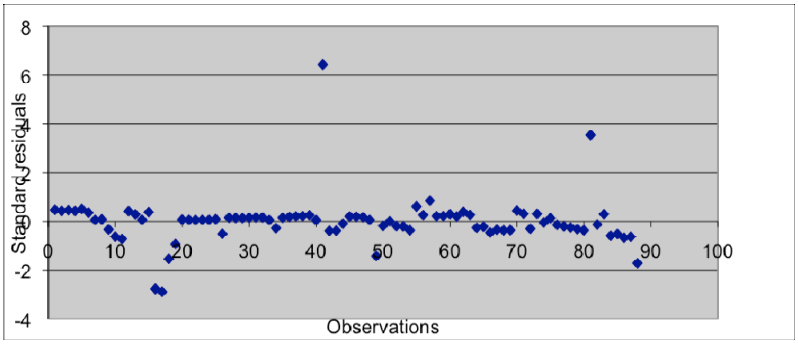
15 incubations for continuous oxygen consumption (electrode) were run from the 55% light depth of the pre-dawn casts.

15 incubations for *in vivo* ETS activity were run from the 55% light depth of the pre-dawn casts.

RESULTS SUMMARY

The complete calibration procedure of CTD sensors will be undertaken at BODC, but preliminary calibrations carried out onboard suggest that no relevant "drift" of the SBE sensor occurred on this cruise. The calibration is well constrained with standard residuals well within the limits advised by BODC (Fig. 1).





Productivity and respiration analyses were all performed on board, but data will be processed on return. It is expected that all O_2, GPP, NCP and DCR data will be deposited at BODC by October 2009

Table 1: Station log for samples collected for dissolved O_2.

Cast	Depth	Niskin	Cast	Depth	Niskin	Cast	Depth	Niskin
3	2	22		30	7		45	6
	7	20		45	4		60	4
	12	17		50	1		80	3
	22	14	21	2	22	27	2	22
	29	12		5	21		5	19
	50	10		8	16		8	18
	60	7		15	13		13	16
	70	5		20	10		21	14
	100	4		37	7		26	12
	150	3		50	4		36	10
	250	1		65	1		42	8
5	5	24	22	5	23		52	6
	10	21		7	20		62	3
	18	15		10	18		77	2
	32	13		14	16	28	2	24
	45	10		17	14		5	22
	75	8		22	12		8	20
	85	5		38	10		15	18
	150	3		42	7		20	16
	200	2		52	4		25	14
	250	1		67	2		30	12
12	5	23	23	2	22		35	10
	10	19		5	19		45	8
	18	17		8	18		60	6

	32	13		15	16		70	4
	44	10		20	13		92	2
	75	8		27	12	30	2	24
	85	5		35	10		5	21
	95	4		45	7		8	15
	125	3		55	6		15	12
	175	2		65	4		20	9
	275	1		75	2		35	6
17	2	24	25	2	24		65	3
	5	20		5	21		90	1
	8	16		8	16	31	5	22
	15	12		15	13		7	20
	20	9		20	10		20	19
	35	6		34	7		40	15
	40	3		55	4		50	14
	47	2		80	2		55	12
	52	1	26	2	23		60	10
19	2	24		5	19		80	7
	5	17		10	16		100	6
	8	16		15	13		200	4
	15	13		25	12		360	2
	20	10		35	10			

Cast	**Depth**	**Niskin**	**Cast**	**Depth**	**Niskin**	**Cast**	**Depth**	**Niskin**
32	5	22	39	2	24		60	8
	15	19		5	21		80	6
	24	18		10	18		200	2

	40	15		17	16	46	2	23
	50	14		23	14		20	21
	80	11		40	12		50	19
	120	9		80	9		80	16
	180	7		100	7		250	13
	240	5		120	5		250	13
	300	3		200	2		350	11
	500	1	40	5	22		350	11
34	2	24		20	19		400	10
	5	21		40	18		400	10
	10	16		60	16		500	9
	17	13		80	14		500	9
	23	10		100	12		800	8
	40	7		150	10		800	8
	80	4		200	8		1200	5
	110	3		240	6		1500	3
	160	2		400	4		2000	2
	200	1		680	2	49	2	24
35	2	23	42	2	22		8	21
	8	21		11	21		14	17
	13	19		20	20		26	14
	20	17		34	19		35	11
	26	15		53	18		60	8
	43	13		80	17		110	3
	102	10		110	16		200	2
	202	8		180	14	53	2	22
36	5	23		300	12		5	21

	15	20		450	10		10	16
	40	18		700	8		17	13
	50	16		1000	5		23	10
	60	14		1200	4		40	7
	100	12		1460	2		50	4
	150	10	44	2	22		100	3
	220	8		10	21		200	2
	300	5		15	16	55	2	22
	400	3		23	13		8	21
	555	1		30	10		14	16
38	2	24		50	7		26	13
	5	21		80	4		35	10
	10	16		100	3		60	7
	17	13		200	2		70	4
	40	10	45	2	23		110	3
	80	7		7	20		200	2
	110	3		12	18	57	2	24
	160	2		22	16		8	23
	200	1		29	14		20	21
				50	11		40	19

Cast	**Depth**	**Niskin**	**Cast**	**Depth**	**Niskin**	**Cast**	**Depth**	**Niskin**
57	60	18		2240	2		50	12
	80	16	69	2	22		70	10
	100	14		7	20		100	8
	180	12		10	16		200	6
	300	10		15	13		300	4
	600	8		30	10		500	1

	900	6		35	7	78	2	22
	1200	4		45	5		5	20
	1500	2		80	4		10	16
59	2	23		100	3		17	13
	7	21		200	2		23	10
	12	16	71	2	24		40	7
	22	13		4	22		45	5
	29	10		7	20		50	4
	50	7		17	18		90	3
	60	5		30	16		120	2
	100	4		40	14	81	2	24
	200	2		50	12		10	22
61	2	24		60	10		17	20
	7	22		100	8		23	18
	12	20		200	6		40	16
	22	18		300	4		50	14
	50	16		500	2		100	12
	120	14	72	2	24		300	10
	200	12		7	22		500	8
	300	10		15	20		1000	6
	600	8		20	18		1500	4
	900	6		25	15		2530	2
	1200	4		30	14	83	2	22
	1430	2		35	12		5	20
65	2	22		40	10		8	16
	4	20		50	8		15	13
	7	16		70	6		20	10

	13	13		100	3		35	7
	17	10	74	2	22		50	4
	30	7		5	20		70	3
	40	4		8	16	85	2	24
	50	3		15	13		5	22
	150	2		20	10		15	20
67	4	23		35	7		20	18
	10	21		45	5		35	16
	20	19		55	4		40	14
	35	17		85	3		50	12
	40	16		120	1		100	10
	70	14	76	2	24		250	8
	100	12		10	22		300	6
	300	10		20	20		500	2
	500	8		35	18	87	2	20
	1000	6		40	16		8	16
	1500	4		45	14		17	14

Cast	**Depth**	**Niskin**	**Cast**	**Depth**	**Niskin**
87	23	10		55	18
	35	7		85	16
	40	5		155	14
	50	4		265	11
	70	3		500	10
	120	2		800	8
88	2	22		1500	6
	5	18		2000	4
	25	16		2932	2

	40	13	97	2	22
	50	10		5	17
	75	7		8	14
	90	4		15	11
	110	1		20	8
89	2	22		35	5
	5	18		60	3
	20	16		80	2
	40	10		100	1
	50	7	99	2	24
	70	5		5	22
	90	3		25	20
	120	1		50	18
90	2	22		70	16
	5	18		100	14
	10	16		150	12
	30	10		200	10
	40	7		300	8
	60	5		350	6
	90	4		400	4
91	2	22		500	2
	5	18			
	20	16			
	30	13			
	40	10			
	50	8			
	80	5			

	100	4
92	2	22
	5	20
	8	16
	15	13
	20	10
	35	7
	55	5
	70	4
	90	3
	110	2
95	2	23
	20	22
	35	20

Table 2: Station log for samples collected for production/respiration of O_2.

Cast	Depth	Niskin	Light level	Start time	Duration
12	5	23	97	6:30	24
	10	18	55		
	18	17	33		
	32	13	14		
	44	10	7		
	75	8	1		
17	2	24	97	6:30	24
	5	20	55		

	8	13	33		
	15	10	14		
	20	8	7		
	35	4	1		
19	2	24	97	6:30	24
	5	17	55		
	8	16	33		
	15	13	14		
	18	10	7		
	34	7	1		
21	2	24	97	6:30	24
	5	21	55		
	8	16	33		
	15	13	14		
	20	10	7		
	37	7	1		
25	2	24	97	6:30	24
	5	21	55		
	8	16	33		
	15	13	14		
	20	10	7		
	34	7	1		
30	2	24	97	6:30	24
	5	21	55		
	8	16	33		
	15	13	14		
	20	10	7		

	35	7	1		
34	2	24	97	6:30	24
	5	21	55		
	10	16	33		
	17	13	14		
	23	10	7		
	40	7	1		
38	2	24	97	6:30	24
	5	21	55		
	10	16	33		
	17	13	14		

Cast	**Depth**	**Niskin**	**Light level**	**Start time**	**Duration**
38	23	10	7	6:30	24
	40	7	1		
44	2	23	97	6:30	24
	7	18	55		
	12	17	33		
	22	14	14		
	29	10	7		
	50	5	1		
49	2	24	97	6:30	24
	8	21	55		
	15	17	33		
	25	12	14		
	35	10	7		
	60	7	1		
53	2	23	97	6:30	24

	5	18	55		
	10	16	33		
	17	13	14		
	23	10	7		
	40	7	1		
55	2	24	97	6:30	24
	8	18	55		
	14	17	33		
	26	14	14		
	35	11	7		
	60	8	1		
59	2	24	97	6:30	24
	7	18	55		
	12	17	33		
	22	14	14		
	29	11	7		
	50	8	1		
65	2	24	97	6:30	24
	5	21	55		
	8	17	33		
	14	14	14		
	18	11	7		
	31	8	1		
69	3	22	97	6:30	24
	6	21	55		
	9	15	33		
	14	14	14		

	18	11	7		
	28	8	1		
74	2	24	97	6:30	24
	5	21	55		
	8	15	33		
	15	14	14		
	20	11	7		
	35	8	1		
Cast	**Depth**	**Niskin**	**Light level**	**Start time**	**Duration**
78	2	24	97	6:30	24
	5	21	55		
	10	15	33		
	17	14	14		
	23	11	7		
	40	8	1		
87	2	24	97	6:30	24
	8	21	55		
	10	15	33		
	17	14	14		
	23	11	7		
	35	8	1		
93	2	24	97	6:30	24
	5	21	55		
	8	15	33		
	15	14	14		
	20	11	7		
	35	8	1		

97	2	24	97	6:30	24
	5	18	55		
	8	13	33		
	15	12	14		
	20	9	7		
	35	3	1		

Table 3: Station log for samples collected for electrode respiration of O_2.

Cast	Depth	Niskin	Light level	Start time	Duration
25	5	21	55	8:00	24
34	5	21	55	8:00	24
38	5	21	55	8:00	24
44	7	18	55	6:30	24
49	8	21	55	6:30	24
53	5	18	55	6:30	24
55	8	18	55	6:30	24
59	7	18	55	6:30	24
65	5	21	55	6:30	24
69	6	21	55	6:30	24
74	5	21	55	6:30	24
78	5	21	55	6:30	24
87	8	21	55	6:30	24
93	5	21	55	6:30	24
97	5	18	55	6:30	24

Table 4: Station log for samples collected for *in vivo* ETS activity.

Cast	Depth	Niskin	Light level	Start time	Duration
25	5	21	55	8:00	24
34	5	21	55	8:00	24
38	5	21	55	8:00	24
44	7	18	55	6:30	24
49	8	21	55	6:30	24
53	5	18	55	6:30	24
55	8	18	55	6:30	24
59	7	18	55	6:30	24
65	5	21	55	6:30	24
69	6	21	55	6:30	24
74	5	21	55	6:30	24
78	5	21	55	6:30	24
87	8	21	55	6:30	24
93	5	21	55	6:30	24
97	5	18	55	6:30	24

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Oxygenated volatile organic compounds (OVOCs) in sea water and atmospheric samples

Rachael Beale

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Aim: To measure concentrations of selected OVOC compounds in both atmosphere and naturally occurring upwelling filaments; specifically methanol, ethanol, propanol, acetaldehyde and acetone.

Analysis Methods

OVOC by Membrane Inlet (MI) Proton Transfer Reaction / Mass Spectrometry (PTR/MS):

Sea water Analysis;

OVOCs are extracted from sea water samples across a semi-permeable membrane into a supply of clean gas flowing directly into the PTR/MS inlet. PTR/MS is operated in Multiple Ion Detection (MID) mode to analyse the gas for protonated molecular OVOC weights. Calibration is carried out through production of water standards.

Atmospheric Analysis;

Atmospheric samples are pumped through FEP tubing positioned above the ships bridge. The end of the atmospheric line (~70m) is connected directly to the inlet of the PTR/MS. OVOC concentrations are calculated according to the PTR/MS internal calibration.

OVOC by Gas Chromatography /Flame Ionisation Detection (GC/FID):

Sea Water Analysis;

OVOCs are extracted from water samples by purging with a clean gas supply and trapping directly onto Markes tubes. Markes tube is then dry purged to remove water and desorbed directly to a refocusing trap before being injected into the carrier flow of a gas chromatograph. Peaks are separated using a suitable column and detected by flame ionisation detection (FID). Calibration is achieved through purge and trap of spiked water samples.

Sampling Methods

Vertical profiles were performed using water collected from the titanium CTD rosettes at specified depths. Water was sampled by use of Tygon tubing directly into blacked out glass bottles.

Incubation experiments were also performed using water collected from CTD.

Diel experiments & filament transects were performed using seawater collected from a towed fish at a depth of approximately 2m.

Sampling Log

Date /Time	Station	Description of Activities
19/04/09		**Low production station**
08:03	CTD 5	OVOC analysis by MI-PTR/MS at surface depth only.
20/04/09		**Medium production Station**
03:00	CTD 11	OVOC analysis by MI-PTR/MS at surface depth only.
		Atmospheric OVOC analysis performed 16:00-18:00
21/04/09		**High production station**
03:00	CTD 16	OVOC analysis by MI-PTR/MS at surface depth only.
23/04/09		**Lagrangian patch 1: T_o**
09:00	CTD 22	OVOC analysis by MI-PTR/MS at 3 depths, surface – 65m.
		OVOC analysis by GC/FID at surface only.
13:00	CTD 23	OVOC analysis by MI-PTR/MS at surface only.
24/04/09		**Lagrangian patch 1: T_1**
09:00	CTD 26	OVOC analysis by MI-PTR/MS at 3 depths, surface – 80m.
13:00	CTD 27	OVOC analysis by MI-PTR/MS at surface only.
		Atmospheric OVOC analysis performed 16:00-18:00
25/04/09		**Lagrangian patch 1: T_2**
11:30	CTD 31	OVOC analysis by MI-PTR/MS at 4 depths, surface – 360m.
		Atmospheric OVOC analysis performed 16:00-18:00
26/04/09		**Lagrangian patch 1: T_3**
09:00	CTD 35	OVOC analysis by MI-PTR/MS at 3 depths, surface – 400m.
		OVOC analysis by GC/FID at 400m only.
13:00	CTD 36	OVOC analysis by MI-PTR/MS at 3 depths, surface – 555m.
27/04/09		**Lagrangian patch 1: T_4**

09:00	CTD 39	Full Depth Profile; OVOC analysis by MI-PTR/MS at 9 depths, surface – 200m.
28/04/09		**Lagrangian patch 1: T_5**
10:13	CTD 41	OVOC analysis by MI-PTR/MS at 3 depths, surface – 200m.
14:00	CTD 42	OVOC analysis by MI-PTR/MS at 3 depths, surface – 1460m. Atmospheric OVOC analysis performed 16:00-18:00
29/04/09		**Lagrangian patch 1: T_6 (CTD DIEL)**
04:00	CTD 44	Full Depth Profile; OVOC analysis by MI-PTR/MS at 6 depths, surface – 100m.
09:00	CTD 45	Full Depth Profile; OVOC analysis by MI-PTR/MS at 6 depths, surface – 100m.
14:00	CTD 46	Full Depth Profile; OVOC analysis by MI-PTR/MS at 6 depths, surface – 100m.
19:30	CTD 47	Full Depth Profile; OVOC analysis by MI-PTR/MS at 6 depths, surface – 100m.
30/04/09		**Lagrangian patch 1: T_7**
09:00	CTD 50	Full Depth Profile; OVOC analysis by MI-PTR/MS at 8 depths, surface – 200m.
03/05/09		**Filament Transect**
	FISH	OVOC analysis by MI-PTR/MS
04/05/09	FISH	**Surface comparison**
11:00	NONTOXIC CTD 51	OVOC analysis by MI-PTR/MS
08/05/09		**Photochemical/Biological deck incubation experiment** (with Jo Dixon, PML)
04:00	CTD 53	

		OVOC analysis by MI-PTR/MS, surface & 200m.
09/05/09		**Lagrangian patch 2: T_1**
09:05	CTD 56	Full Depth Profile; OVOC analysis by MI-PTR/MS at 7 depths, surface – 200m. Atmospheric OVOC sampled.
10/05/09		**Diel experiment**
05:20	CTD 59	Full Depth Profile; OVOC analysis by MI-PTR/MS at 6 depths, surface – 200m.
09:09	CTD 60	OVOC analysis by MI-PTR/MS at 3 depths, surface – 200m.
13:00	CTD 61	OVOC analysis by MI-PTR/MS at 2 depths, surface & 200m.
15:01	FISH	OVOC analysis by MI-PTR/MS
17:00	FISH	OVOC analysis by MI-PTR/MS
19:00	FISH	OVOC analysis by MI-PTR/MS
11/05/09		**Filament Transect**
	FISH	OVOC analysis by MI-PTR/MS
15/05/09		**Lagrangian patch 3: T_1**
09:00	CTD 66	Full Depth Profile; OVOC analysis by MI-PTR/MS at 7 depths, surface – 200m. OVOC analysis by GC/FID at surface & 200m.
16/05/09		**Surface Diel**
	FISH	OVOC analysis by MI-PTR/MS
17/05/09		**Lagrangian patch 3: T_1**
	FISH	Surface diel repeat.
09:00	CTD 56	Full Depth Profile; OVOC analysis by MI-PTR/MS at 7 depths,

		surface – 200m. Atmospheric OVOC sampled.
18/05/09 10:00	CTD 80	**Lagrangian patch 3: T_2** Full Depth Profile; OVOC analysis by MI-PTR/MS at 7 depths, surface – 200m. Atmospheric OVOC sampled.
19/05/09 09:00 12:00	CTD 84 CTD 85	**Lagrangian patch 3: T_3** OVOC analysis by MI-PTR/MS at 5 depths, surface – 120m. OVOC analysis by MI-PTR/MS at 5 depths, surface – 100m. Atmospheric OVOC sampled.
20/05/09 Hourly from 04:00 – 06:00 on 21/05/09	FISH	**Surface Diel** OVOC analysis by MI-PTR/MS
21/05/09 09:00	CTD 94	**Lagrangian patch 3: T_5** Full Depth Profile; OVOC analysis by MI-PTR/MS at 7 depths, surface – 100m
22/05/09 05:30	CTD 97	**Photochemical/Biological deck incubation experiment** (with Jo Dixon, PML) OVOC analysis by MI-PTR/MS, surface water only.

Preliminary Results;

None to report at this stage.

Microbial turnover of selected oxygenated volatile organic compounds (OVOCs)

Joanna Dixon

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Objectives:

1. To determine the heterogenic spatio and temporal variability in the oxidation rates of methanol, acetaldehyde and acetone in highly productive upwelled waters

2. To determine the particulate uptake rates of methanol and acetaldehyde as a function of microbial productivity

3. To evaluate the biological turnover rates of methanol, acetone and acetaldehyde in productive upwelled waters

4. To determine the degree of photochemical versus biological production of acetone in surface waters

5. To assess the diel variability of selected OVOC oxidation rates

Methods

Heterotrophic Bacterial Production (HBP): 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 (6.8 µl) (as determined by a Vmax experiment carried out on 16/04/09) 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

OVOC oxidation rates: Total oxidation of ^{14}C labelled methanol, acetone and acetaldehyde to $^{14}CO_2$ were determined by pipetting 1 ml samples into 2 ml micro centrifuge tubes and adding 0.5 ml of $SrCl_2.6H_2O$ (1 M), to precipitate the product of the biological oxidation as $Sr^{14}CO_3$, 20 µl of NaOH (1 M), to neutralise the HCl produced from the previous reaction, and 100 µl of Na_2CO_3 (1 M), to ensure adequate pellet formation (Connell et al., 1997; Goodwin et al., 1998). After centrifugation, the supernatant was aspirated, the pellet washed twice with ethanol (70%) and resuspended in 1 ml NaOH solution (pH ~11.7), before addition of Optiphase HiSafe III to create a slurry. The samples were vortex mixed and stored in the dark for >24 h before being analysed on the scintillation counter.

OVOC particulate uptake: Particulate uptake of ^{14}C labelled methanol, acetaldehyde and acetone were determined using ~320 ml samples incubated in the dark at in situ temperature for between 4-6 hours. Incubations were terminated by gentle vacuum sequential filtration using 2.0 µm and 0.2 µm filters. The filters were washed twice with filtered seawater before a final rinse with 70% ethanol and dried overnight in a desiccators before the addition of Optiphase HiSafe III scintillation fluid and analysis using a Tricarb 2100 counter.

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Sampling Log

Date /Time	**Station**	**Description of Activities**
19/04/09 08:03	CTD 5	**Low production station** Heterotrophic bacterial production (HBP) and methanol oxidation (MO) from 8 depths (surface – 250m)
21/04/09 05:00	CTD 17	**High production station** HBP, MO & particulate methanol uptake (PMU) from 8 depths (surface – 52m)
23/04/09 09:00	CTD 22	**Lagrangian patch 1: T_o** HBP, MO, PMU & acetaldehyde oxidation (AO) from 7 depths (surface – 65m)
24/04/09 09:00	CTD 26	**Lagrangian patch 1: T_1** HBP, MO, PMU, AO and particulate acetaldehyde uptake (PAU) from 7 depths (surface – 80m) Time course for MO & AO (55%)
25/04/09 11:14	CTD 31	**Lagrangian patch 1: T_2** HBP, MO & AO from 3 depths (surface, 40m & 1360m) Time course for MO (surface)
26/04/09 09:00	CTD 35	**Lagrangian patch 1: T_3** HBP, MO & PMU from 7 depths (surface – 400m) Time course for MO (surface)
27/04/09		**Lagrangian patch 1: T_4**

09:05	CTD 39	HBP, MO & AO from 3 depths (surface, 40m & 200m) PMU (surface only)
28/04/09 10:13	CTD 41	**Lagrangian patch 1: T_5** HBP, MO & AO from 3 depths (surface, 40m & 200m) PMU (surface only)
29/04/09 09:10	CTD 45	**Lagrangian patch 1: T_6** HBP, MO, PMU, AO and PAU from 7 depths (surface – 200m) Time course for MO, AO & Acetone oxidation (AcO) (surface)
30/04/09 09:08	CTD 50	**Lagrangian patch 1: T_7** HBP, MO & PMU from 7 depths (surface – 200m)
04/05/09 11:41	CTD 51	**Turnover experiments** Methanol, Acetaldehyde & Acetone (surface only)
08/05/09 04:00	CTD 53	**Photochemical/Biological deck incubation experiment** HBP & [OVOC] analysed by R Beale (surface & 200m)
09/05/09 09:05	CTD 56	**Lagrangian patch 2: T_1** HBP, MO, PMU, AO and PAU from 7 depths (surface – 200m)
10/05/09 05:20 09:09 13:00 15:01	CTD 59 CTD 60 CTD 61 FISH	**Diel experiment** HBP, AO & AcO from 6 depths (surface – 200m). MO oxidation time series (surface only) HBP, AO & AcO from 6 depths (surface – 200m). MO oxidation time series (surface only) HBP, AO & AcO from surface. MO oxidation time series (surface only) HBP, AO & AcO from surface. MO oxidation time series (surface only) HBP, AO & AcO from surface. MO oxidation time series

		(surface only)
17:00	FISH	
		HBP, AO & AcO from surface. MO oxidation time series (surface only)
19:00	FISH	
15/05/09		**Lagrangian patch 3: T_1**
09:14	CTD 66	HBP, MO, AO, AcO from 7 depths (surface – 200m). MO, AO & AcO time series (surface only)
18/05/09		**Lagrangian patch 3: T_2**
10:40	CTD 80	HBP, MO, AO, AcO from 7 depths (surface – 120m).
19/05/09		**Lagrangian patch 3: T_3**
09:09	CTD 84	HBP, MO, AO, AcO from 7 depths (surface – 120m). MO, AO & AcO time series (surface only)
20/05/09		**Lagrangian patch 3: T_4**
09:02	FISH	HBP, MO, AO & AcO time series (surface only)
12:32		HBP, MO, AO & AcO time series (surface only)
15:18		HBP, MO, AO & AcO time series (surface only)
18:32		HBP, MO, AO & AcO time series (surface only)
20:20		HBP, MO, AO & AcO time series (surface only)
21/05/09		**Lagrangian patch 3: T_5**
09:29	CTD 94	HBP, MO, AO, AcO from 7 depths (surface – 100m
22/05/09		**Photochemical/Biological deck incubation experiment** HBP, AcO & [OVOC] analysed by R Beale (surface only)
05:30	CTD 97	

Carbon monoxide

Vassilis Kitidis

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Rationale: Carbon monoxide (CO) is a climatically active trace gas in the atmosphere. CO is the primary sink for atmospheric hydroxyl radical (·OH) and therefore has a direct impact on the oxidative capacity of the atmosphere and consequently the concentration of other climate-active trace gases such as methane and halocarbons which are removed by ·OH. CO oxidation by ·OH is also involved in stratospheric ozone regulation. The global ocean is a net source of CO primarily through the photolysis of Dissolved Organic Matter (DOM), while microbial oxidation, sea-air exchange and vertical mixing represent the dominant sinks (Zafiriou et al., 2003).

Objectives: The overarching objective of this activity was to quantify relevant source-sink terms in the CO cycle of the Mauritanian upwelling system as part of the UK Surface Ocean Lower Atmosphere Study. Specifically:

1. To determine ambient concentrations of dissolved CO in seawater and concomitant atmospheric mixing ratios including diel cycles.
2. To determine the photochemical source of CO.
3. To determine the microbial sink of CO.
4. To determine sea-air gas exchange of CO

Methodology – Instrumentation:

Objective 1: Seawater samples were collected directly from Niskin bottles on selected CTD stations in 100 mL gas-tight glass syringes (Table 1). A CO-free headspace was injected into each syringe to give a phase ratio of 60 mL seawater to 40 mL headspace. The seawater-headspace CO was equilibrated by vigorous shaking for 8 minutes and the headspace was subsequently injected into a gas chromatograph (GC-RGD) [on loan from Dr. C. Law (NIWA: National Institute of Water and Atmospheric Research, New Zealand)], equipped with a mercury-vapour reduction gas detector (Ametek Inc., model TA 3000; serial no 05416). Ambient air samples were collected regularly from the ship's bow in 100 mL gas-tight glass syringes and injected directly into the GC-RGD (Table 2).

Objective 2: Further samples were collected from 1 L quartz flasks previously irradiated under artificial light (see Tilstone et al., this report) (Table 3). The GC-RGD was fitted with a 1 mL sampling loop and calibrated daily using gravimetric gas standards (BOC gases Ltd; 100 ppbv, 500 ppbv and 1000 ppbv CO in air mixtures).

Objective 3: microbial CO oxidation was determined on one occasion by collecting replicate samples from a Niskin bottle and incubating these in a dark incubator held at ambient sea-surface temperature.

Objective 4: Estimates of the source-sink balance of CO and sea-air fluxes in the Mauritanian upwelling will be carried out post-cruise by applying turbulent diffusion models (e.g. Nightingale et al., 2000)

Post-cruise processing: CO mixing ratios (units: parts per billion by volume) from headspace-equilibrated seawater samples will be processed into ambient CO concentration (units: nmol L^{-1}), based on the

seawater-headspace phase ratio, equilibration temperature and Bunsen solubility of CO at ambient seawater temperature and salinity (Wiesenburg and Guinasso, 1979).

Preliminary observations: Depth profiles of CO showed a clear diurnal pattern of increasing CO in near-surface waters during the daytime and subsequent decrease from late afternoon. These observations are consistent with a phochemical source. Photochemical experiments confirmed that this process is a strong source of CO.

References:

Nightingale, P.D., Malin, G., Law, C.S., Watson, A.J., Liss, P.S., Liddicoat, M.I., Upstill-Goddard, R.C., 2000. In-situ evaluation of air–sea gas exchange parameterisations using novel conservative and volatile tracers. Global Biogeochemical Cycles 14 (1), 373–388.

Wiesenburg, D.A., Guinasso, N.L., 1979. Equilibrium solubilities of methane, carbon monoxide, and hydrogen in water and sea water. Journal of Chemical and Engineering Data 24, 356–360.

Zafiriou, M.C., Andrews, S.S., Wang, W., 2003. Concordant estimates of oceanic carbon monoxide source and sink processes in the Pacific yield a balanced global ‘‘blue-water’’

CO budget. Global Biogeochemical Cycles 17 (1), 1015–1027.

Table 1:

Dissolved CO station log Vassilis Kitidis (PML; vak@pml.ac.uk)

Cast	Niskin	Depth
45	23	5
	14	29
	8	60
	2	200
57	24	5
	23	8
	21	20
	19	40
66	22	2
	18	6.5
	14	9
	11	16
	9	21

	7	36
67	23	5
	21	10
	19	20
	17	35
	15	40
	13	70
70	24	2
	18	4
	16	7
	14	13
	12	17
	10	30
71	24	2
	22	4
	20	7
	18	17
	16	30
	14	40
72	24	2
	22	7
	20	15
	18	20
	15	25
	14	30
75	22	2
	16	6
	12	15
	8	25
80	22	2

	18	5
	16	8
	14	15
	11	20
	9	35
88	23	2
	20	5
	17	25
	14	40
89	23	2
	20	5
	17	20
	14	30
90	23	2
	20	5
	16	10
	14	20
91	23	2
	20	5
	15	20
	14	30
94	22	2
	15	7
	13	13
	11	17

Table 2:

CO atmospheric measurements station log

Vassilis Kitidis (PML; vak@pmlac.uk)

Date	**Time**
	GMT
25/04/09	17:45:00
28/04/09	13:35:00
29/04/09	11:15:00
30/04/09	15:40:00
01/05/09	11:00:00
01/05/09	12:15:00
08/05/09	10:22:00
09/05/09	15:16:00
14/05/09	16:10:00
15/05/09	11:01:00
15/05/09	15:51:00
16/05/09	11:11:00
16/05/09	13:58:00
16/05/09	16:28:00
16/05/09	21:41:00
17/05/09	10:29:00
18/05/09	13:23:00
20/05/09	10:49:00
20/05/09	14:15:00
20/05/09	19:05:00
21/05/09	11:31:00

Table 3:

CO photochemistry station log Vassilis Kitidis (PML; vak@pml.ac.uk)

Cast	Niskin	Depth	Start	Duration (hours)
37	24	2	10:00:00	24
43	24	2	09:50:00	24
48	24	2	15:39:00	18.5
52	24	2	10:30:00	28
54	24	2	10:44:00	28
58	24	2	13:40:00	3.25
64	24	2	10:10:00	4.5
68	24	2	10:15:00	4.1
73	24	2	12:25:00	3.25
77	24	2	09:55:00	4.5
82	24	2	10:55:00	4
86	24	2	11:10:00	4.1
92	24	2	11:10:00	4.1
96	24	2	09:45:00	24

Photo-oxidation of dissolved organic material

Gavin Tilstone, Vasilis Kitidis & Malcolm Woodward

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OBJECTIVES.

Coloured dissolved organic matter (CDOM) impacts the optical properties of coastal seawater and affects nitrogen and carbon cycling on a global scale. Light absorption by CDOM influences nutrient cycling, trace gas production and control of light penetration in the water column (Goldstone et al. 2004, White et al. 2003). Recent research shows that photobleaching of CDOM commonly occurs in surface waters (Del Vecchio & Blough 2004), linked to the photodegradation of the hydroxyl radical in CDOM. CDOM photobleaching can result in a deeper penetration of light at all wavelengths in the water column, which can affect phytoplankton photosynthesis (Cullen & Neale 1992, Whitehead et al. 2000) and nitrate uptake (Behrenfeld et al. 1995) and may result in increased biogenic gas production. Mineralisation of dissolved organic carbon (DOC) to dissolved inorganic carbon and carbon monoxide has been identified as a major pathway for carbon flux. The overarching objective of this research was to link CDOM photobleaching with the photochemical transformation of NH_4, O_2, pH, DOC & AA.

Dissolved Organic Carbon and Nitrogen (DOC/N) in the ocean represent large pools of refractory and bioavailable carbon and nitrogen. The respective oceanic carbon and nitrogen reservoirs in DOC/N are in the order of 685 Pg C and 60 to 530 Pg N [1 Pg is 10^{15} g] and subject to active biogeochemical cycling resulting in significant, global fluxes of carbon and nitrogen. Amino acids (A.A.) comprise a small, but readily bioavailable fraction of DOC/N and are utilized by phytoplankton and bacteria for protein synthesis. DOC/N undergoes photolysis either directly, through the absorbance of solar radiation by the chromophoric fraction, or indirectly, through intermolecular charge transfer reactions from chromophoric to non-absorbing moeities (e.g. Moran et al., 2000). Photolytic transformations of DOC/N lead to the production of amino acids (Tarr et al., 2001) and consumption of dissolved oxygen. The latter gives rise to reactive oxygen species, peroxide, hydroxyl and super-oxide radicals, which induce oxidative stress in organisms and initiates a cascade of redox reactions in seawater (Zafiriou, 1974). The research objectives were:

1. To determine the distribution of CDOM, fDOM, DOC/N and A.A. in the Mauritanian upwelling filament.
2. To determine the impact of photochemical reactions on CDOM, fDOM, DOC/N, pH, NH_4 and A.A. production.
3. To determine the impact of photochemical reactions on dissolved Oxygen concentrations.

METHODS.

CDOM absorption coefficients ($a_{CDOM}(\lambda)$) & fluorescence of DOM (fDOM). Seawater samples from 4 to 8 depths in the water column were filtered through 0.2 μm 25mm Whatman Anodisc filters using acid cleaned glassware. The first two 0.25l of the filtered seawater were discarded. The absorption properties of the third sample were determined in an 10 cm quartz cuvettes from 350 to 750 nm relative to a bi-distilled MilliQ reference blank using a Perkin Elmer Lambda 35 spectrophotometers. $a_{CDOM}(\lambda)$ was calculated from the optical density of the sample and the cuvette path length. The slopes

(S_{CDOM}) of a_{CDOM}(350-650) and a_{CDOM}(250-650) were calculated using an offset exponential fit which corrects for water absorption effects >700 nm following the methods outlined in Tilstone et al. (2004). Samples were also taken to determine the fluorescence of dissolved organic matter (fDOM) following the methods of Kowalczuk et al. (2005).

Ammonium (NH_4^+) and pH. NH_4^+ was measured with a Technicon segmented flowcolorimetric auto-analyser following the methods of Mantoura and Woodward (1983). pH was determined by colorimetric spectrophotometry using 10μL thymol blue in 100mL of seawater.

Dissolved Organic Carbon (DOC), Amino Acids (AA) and Dissolved Oxygen demand (O_2).

Objective 1: For DOC/N, seawater samples were gravity filtered from Niskin bottles on selected CTD stations through 0.7 μm filters (Whatman GF/F) in a stainless steel filter holder and into 25 mL glass ampoules. Both the ampoules and glass fibre filters were previously ashed at 450 ^oC for 24 hours. Approximately 20 μL of 5 M HCl were added immediately to each sample and the ampoules were flame sealed using a gas torch. Sealed DOC/N samples were stored at 4 ^oC for later analysis onshore. A.A. samples were collected from the Niskin bottles in polycarbonate bottles previously rinsed with analytical grade water. The samples were filtered through 0.25 μm sterile filters and the filtrate collected in acid cleaned 10 mL polycarbonate bottles which were stored at -85 ^oC for later analysis onshore.

Objective 2: Samples were collected from quartz bottles during the course of irradiation experiments and treated as above.

Objective 3: Seawater samples for the determination of photochemical Oxygen demand (POD) were collected from the pre-dawn depth profile (1 depth) in a 25 L acid-washed glass vessel. The samples were sequentially filtered through 0.2 μm and 0.1 μm filters into a second 25 L acid-washed glass vessel. The filtrate was sub-sampled into 100 mL Quartz glass bottles and placed into artificial-light incubators for <24 h along with dark treatments. Additional subsamples were fixed and analysed at the start of the incubation ('zero' sub-samples) Light and dark (wrapped in Al foil) Oxygen bottles were removed from the incubators, fixed and analysed by automated Winkler titration with photometric end-point detection . The concentration of thiosulphate was calibrated every 2 days. Each treatment (Zero, Light and Dark) was replicated 4-6 times.

Post-cruise processing: All analysis of DOC/N and A.A. will be carried out onshore, post-cruise by Prof. Eric Achterberg's group at the National Oceanography Centre Southampton. Stored samples for DOC/N will be analysed by High Temperature Catalytic Oxidation (HTCO) with infra-red detection for Carbon and a Nitrogen chemiluminescence detector for Total Organic Nitrogen (TN). The concentration of Dissolved Inorganic Nitrogen (DIN) will be subtracted from the TN to give DON (Spyres et al., 2000). Stored A.A. Samples will be analysed by High Performance Liquid Chromatography (HPLC).

Water column profiles. Each of the above parameters was determined at 4 to 6 depths in the water column. Sampling depths were determined from Conductivity-Temperature-Density profiles and samples were taken 'pre-dawn' from 20L niskin bottles. One diel cycle was performed when water samples were taken from CTD casts four times a day to assess whether each parameter changes over the course of a day. Samples from the sea surface microlayer (SSM) were taken at some stations using a Garrett screen coincident with the 'mid-day' CTD cast when the surface of the water column was also

sampled. Samples were also taken for the determination of surfactants. For more details of these see the cruise report of Nightingale et al..

Photo-oxidation experiments of Coloured Dissolved Organic Material. 30litres of sea water was taken from the surface at 19 stations to determine the effect of UV on the parameters described above. The seawater was sequentially filtered through 0.2 & 0.1 μ Acropak PALL filters into 1 litre quartz or glass flasks which were exposed to the following treatments in solar simulators: 1.) PAR only; 2.) PAR + UVA + B; 3.) Dark. Each parameter was determined at the start of the experiment (T0), after 4 h (T4) and 24 h (TF) of exposure on replicate water samples. One time series experiment was conducted during which each parameter was determined after 3, 6, 12 & 24 hrs of exposure to the above treatments.

Results.

28 profiles of the absorption coefficient of coloured dissolved organic material from 200 to 800nm (a_{CDOM}(200-800)), fDOM, DOC & AA were made during three lagrangian experiments along the Mauritanian coast. 19 CDOM photo-oxidation experiments were conducted in which these parameters were exposed to dark, UV and visible light for varying periods to relate changes in the CDOM spectra to the photochemical transformation of NH_4, O_2, pH, DOC & AA..

Figure 1 shows a_{CDOM}(320) *and* S_{CDOM} profiles during the first lagrangian experiment. a_{CDOM}(320) were relatively high for typical case 1 open ocean waters compared to those values given in Bricaud et al. (1981). a_{CDOM}(320) was comparativley higher at CTD casts 20 to 34 from 23 to 26 April and 48 & 49 on 30 April (Table 1). The lowest surface a_{CDOM}(320) were during CTD casts 37 to 41 from 27 to 28 April which coincided with high S_{CDOM}, indicative of CDOM photo bleaching.

These measurements will be used to determine the photochemical fate of upwelled and recently produced dissolved organic matter (DOM).

Figure 1. $a_{CDOM}(320)$ and S_{CDOM} profiles during lagrangian experiment 1.

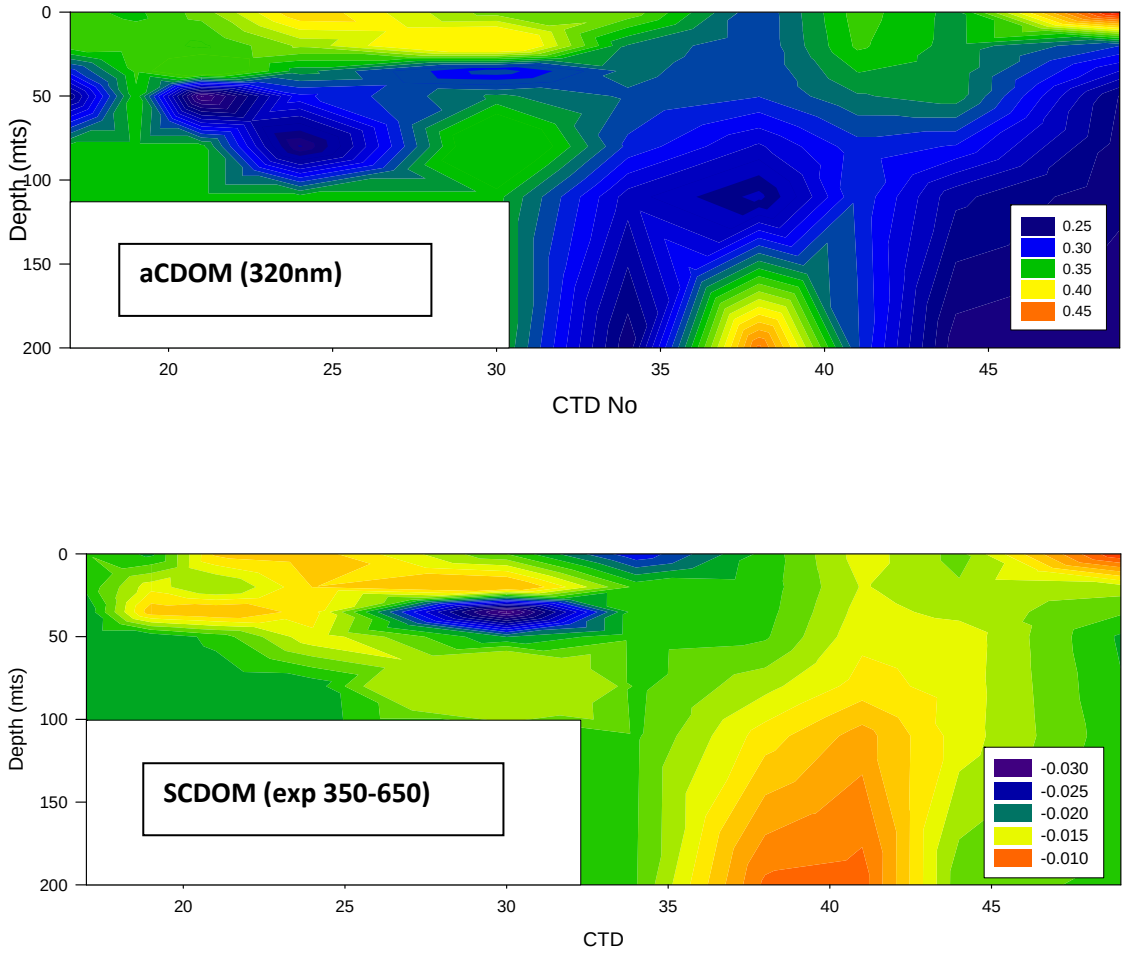

Table 1. *Measurements taken at station profiles & during photo-oxidation experiments.*

CTD No.	Date	Time In water GMT	Lat	Long	depths (m)	Measurements taken
001	16 April	16:13	23° 02.39'N	17° 30.84'W	0, 80, 150	CDOM, fDOM
002	18 April	04:01	22° 11.05'N	19° 08.10'W	0	Photo-ox 1 T0, UV, VIS, Dark, T6(5hrs) * 2 reps, TF(24hrs) * 3 reps CDOM, fDOM, pH, O2, DOC, AA

003	18 April	05:49	22° 11.24’N	19° 08.59’W	0, 50, 150	CDOM, fDOM, O2, DOC, AA
005	19 April	08:03	21° 28.80’N	19° 06.54’W	0	CDOM, fDOM
012	20 April	04:00	21° 12.25’N	18° 27.65’W	0, 44, 95	CDOM, fDOM, O2, DOC, AA
016	21 April	04:00	21° 29.97’N	17° 14.55’W	0	Photo-ox 2 T0, UV, VIS, Dark, TF(24hrs) * 3 reps ; CDOM, fDOM, pH, O2, DOC, AA
017	21 April	05:00	21° 29.94’N	17° 14.56’W	0, 20, 47	CDOM, fDOM, O2, DOC, AA
019	22 April	04:05	21° 25.90’N	17° 15.82’W	0, 8, 15, 20, 35, 50	CDOM, fDOM, O2, DOC, AA
020	23 April	03:31	21° 12.25’N	17° 21.72’W	0	Photo-ox 3 T0, UV, VIS, Dark, TF(24hrs) * 3 reps ; CDOM, fDOM, pH, O2, DOC, AA
021	23 April	03:31	21° 12.25’N	17° 21.72’W	0, 8, 20, 37, 50, 65	CDOM, fDOM, O2, DOC, AA
024	24 April	03:30	21° 00.90’N	17° 27.91’W	0	Photo-ox 4 T0, UV, VIS, Dark, TF(24hrs) * 3 reps ; CDOM, fDOM, pH, O2, DOC, AA
025	24 April	04:27	21° 00.44’N	17° 28.31’W	0, 8, 20, 34, 55, 80	CDOM, fDOM, O2, DOC, AA
029	25 April	03:46	21° 52.08’N	17° 37.11’W	0	Photo-ox 5 T0, Lost exp ; CDOM, fDOM, pH, O2, DOC, AA
030	25 April	04:45	20° 51.88’N	17° 37.44’W	0, 8, 20, 35, 65, 90	CDOM, fDOM, O2, DOC, AA

032	25 April	16:30	20° 51.88'N	17° 37.44'W	0, SSM	CDOM, fDOM, Surfactants
034	26 April	04:45	20° 41.47'N	17° 47.71'W	0, 23, 40, 80, 160, 200	CDOM, fDOM, O2, DOC, AA
036	26 April	12:30	20° 51.88'N	17° 37.44'W	0, SSM	CDOM, fDOM, Surfactants, DOC, AA
037	27 April	03:30	20° 40.36'N	17° 54.21'W	0	Photo-ox 6 T0, UV, VIS, Dark, TF(24hrs) * 3 reps; CDOM, fDOM, pH, O2, DOC, AA
038	27 April	04:36	20° 39.79'N	17° 54.47'W	0, 23, 40, 110, 160, 200	CDOM, fDOM, O2, DOC, AA
041	28 April	10:05	20° 43.33'N	18° 15.31'W	0, 19, 34, 80, 100, 200	CDOM, fDOM, O2, DOC, AA
043	29 April	03:31	20° 39.10'N	18° 27.13'W	0	Photo-ox 7 T0, UV, VIS, Dark, TF(24hrs) * 3 reps ; CDOM, fDOM, pH, O2, DOC, AA
044	29 April	04:26	20° 38.77'N	18° 27.90'W	0, 12, 22, 50, 100, 200	CDOM, fDOM, O2, DOC, AA
048	30 April	03:34	20° 38.18'N	18° 40.30'W	0	Photo-ox 8 T0, UV, VIS, Dark, TF(24hrs) * 3 reps ; CDOM, fDOM, pH, O2, DOC, AA
049	30 April	04:34	20° 38.05'N	18° 40.84'W	0, 14, 26, 60, 110, 200	CDOM, fDOM, O2, DOC, AA
052	08 May	04:05	21°25.57'N	14°55.73'W	0	Photo-ox 9 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA

053	08 May	05:02	21°25.47'N	17°56.01'W	0, 10, 23, 50, 100, 200	CDOM, fDOM, O2, AA
054	09 May	04:02	21°31.77'N	17°59.05'W	0	Photo-ox 10 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA
055	09 May	05:02	21°31.25'N	17°59.43'W	0, 14, 35, 60, 110, 200	CDOM, fDOM, O2, DOC, AA
057	09 May	12:30	21°31.25'N	17°59.43'W	0, SSM	CDOM, fDOM, AA, surfactants
058	10 May	03:59	21°39.08'N	18°02.22'W	0	Photo-ox 11 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA
059	10 May	04:59	21°39.08'N	18°02.22'W	0, 12, 29, 60, 100, 200	CDOM, fDOM, O2, DOC, AA
061	10 May	12:30	21°39.08'N	18°02.22'W	0, SSM	CDOM, fDOM, AA, surfactants
064	14 May	04:17	19°52.30'N	18°08.82'W	0	Photo-ox 12 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA
065	14 May	05:38	19°52.19'N	18°09.80'W	0, 7, 17, 30, 50, 150	CDOM, fDOM, O2, DOC, AA
066	15 May	09:00	19°25.61'N	17°55.65'W	0, 8, 15, 35, 50, 200	CDOM, fDOM, O2, DOC, AA
067	15 May	12:30	19°25.61'N	17°55.65'W	0, SSM	CDOM, fDOM, AA, surfactants
068	16 May	03:59	19°30.37'N	18°05.72'W	0	Photo-ox 13 T0, UV, VIS, Dark, T4(4hrs),

						TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA
069	16 May	04:55	19°30.37'N	18°05.72'W	0, 11, 25, 45, 70, 200	CDOM, fDOM, O2, DOC, AA
071	16 May	12:30	19°30.37'N	18°05.72'W	0, SSM	CDOM, fDOM, AA, surfactants
073	17 May	04:02	19°35.18'N	18°17.16'W	0	Photo-ox 14 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA
074	17 May	05:01	19°35.51'N	18°17.65'W	0, 8, 20, 35, 85, 120	CDOM, fDOM, O2, DOC, AA
076	17 May	12:30	19°35.51'N	18°17.65'W	0, SSM	CDOM, fDOM, AA, surfactants
077	18 May	04:01	19°40.60'N	18°27.55'W	0	Photo-ox 15 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA
078	18 May	04:59	19°40.53'N	18°27.87'W	0, 10, 23, 50, 90, 120	CDOM, fDOM, O2, DOC, AA
080	18 May	12:30	19°40.53'N	18°27.87'W	0, SSM	CDOM, fDOM, AA, surfactants
082	19 May	03:58	19°44.43'N	18°37.36'W	0	Photo-ox 16 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA
083	19 May	04:58	19°44.39'N	18°37.61'W	0, 15, 35, 50, 70, 120	CDOM, fDOM, O2, DOC, AA
085	19 May	12:30	19°44.39'N	18°37.61'W	0, SSM	CDOM, fDOM, AA, surfactants

086	20 May	04:01	19°41.62'N	18°46.03'W	0	Photo-ox 17 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 reps ; CDOM, fDOM, pH, O2, DOC, AA
088	20 May	08:30	19°40.90'N	18°48.60'W	0, 5, 25, 40	CDOM, fDOM, O2, pH
089	20 May	12:34	19°40.47'N	18°50.32'W	0, 5, 20, 30	CDOM, fDOM, O2, pH
090	20 May	16:39	19°41.02'N	18°52.12'W	0, 5, 10, 20	CDOM, fDOM, O2, pH
091	20 May	20:31	19°41.18'N	18°53.04'W	0, 5, 20, 30	CDOM, fDOM, O2, pH
092	21 May	03:57	19°38.33'N	18°53.95'W	0	Photo-ox 18 T0, UV, VIS, Dark, T4(4hrs), TF(24hrs) 2 rep ; CDOM, fDOM, pH, O2, DOC, AA
093	21 May	05:01	19°38.12'N	18°54.31'W	0, 8, 20, 35, 55, 75	CDOM, fDOM, O2, DOC, AA
094	21 May	12:30	19°38.12'N	18°54.31'W	0, SSM	CDOM, fDOM, AA, surfactants
096	22 May	04:00	19°31.41'N	19°06.18'W	0	Photo-ox 19 T0, UV, VIS, Dark, T3(3hrs), T6(6hrs), T12(12hrs), TF(24hrs) 2 rep ; CDOM, fDOM, pH, O2, DOC, AA
097	22 May	05:10	19°31.41'N	19°06.18'W	0, 8, 20, 35, 60, 100	CDOM, fDOM, O2, DOC, AA

T0 is start time, T4 & TF are after 4 & 24 hrs of exposure, respectively. UV is exposure using UV (280-400) & Visible (VIS ~400-700nm) radiation. SSM is sea surface microlayer.

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Nitrous Oxide & Methane

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Nitrous oxide and methane are biogenically produced trace gases whose atmospheric concentrations are increasing at a rate in the order of 0.7 ppbv y^{-1}. Both gases are radiatively active, contributing approximately 6% and 15% of "greenhouse effect" respectively, whilst N_2O contributes to stratospheric ozone depletion and CH_4 limits tropospheric oxidation capacity.

The oceans are generally considered to be close to equilibrium relative to the atmosphere for both gases, however oceanic source/sink distributions are largely influenced by oxygen and nutrient status and regulatory processes are complicated

and are currently not well understood. Ocean areas overlying sub-oxic waters and upwelling areas dominate the ocean source and saturations of up to 300% have been reported for other upwelling zones, though little is known for the area under study here.

Elevated N_2O in upwelled surface waters is assumed to result entirely from ventilation of intermediate sub-oxic waters, although in-situ production from nitrification and vertical diffusion may provide additional sources.

Aim:- *To perform vertical profiles of N_2O concentration and $^{15}N_2O$ signatures (to be considered in parallel with nitrification rates made by D. Clark) in order to discriminate between upwelling, diffusion and in situ production of N_2O in the filament*

Upwellings are often sites of high methane supersaturation and emission. The vertical advection of intermediate waters is not the direct source of methane in these systems. Either lateral advection of shelf water of high methane content (originating from sediment), and/or *in situ* production in near-surface water associated with elevated biological productivity, or combination of both.

Aim:- *to examine spatial variability in biological methane production and consumption along the upwelling filament, and to examine why upwelling systems are variable methane sources*

Methods

Samples were collected from CTD bottles at stations identified below. 1 litre samples were equilibrated with compressed air and headspace analysis performed onboard using FID-gas chromatography and ECD-gas chromatography for CH_4 and N_2O respectively. Atmospheric concentrations were determined by the same methods using a pumped supply from the ships monkey island.

Headspace samples for stable isotope analysis (to be performed at PML using continuous flow stable isotope mass spectrometry) following equilibration with CP grade helium were collected into evacuated 125ml amber bottles.

The oxidation of CH_4 was determined onboard following incubation with ^{14}C-CH_4 and liquid scintillation analysis.

N2O, CH4 sampling log

Date Time (z)	CTD	Position	**N_2O-CH_4** Depth (No.)	**CH_4Oxdn** Depth (No.)	**$^{15}N_2O$ -$^{13}CH_4$** Depth (No.)	Comments
18.04.09 0549	003	22° 11.24N 19° 08.59W	0 – 250 m (11)			
20.04.09 0400	012	21° 12.26N 18° 27.65W	0 – 275 m (10)			
21.04.09 0404	017	21° 29.94N 17° 14.56W	0 – 52 m (10)			
22.04.09 0405	019	21° 25.93N 17° 15.82W	0 – 50 m (7)		50 m	Day 1, Patch 1
23.04.09 0428	021	21° 11.75N 17° 22.02W	0 – 65 m (7)		37 m	
24.04.09 0427	025	21° 00.44N 17° 28.31W	0 – 80 m (8)	0, 34 m	5, 34, 80 m	
24.04.09 1255	027	20° 56.34N 17° 29.67W	0 – 77 m (6)			
25.04.09 0441	030	20° 51.79N 17° 38.12W	0 – 90 m (7)		5, 35, 90 m	
25.04.09 1309	032	20° 49.16N 17° 41.63W	0 – 500 m (8)		5, 35, 100 m	
26.04.09 0506	034	20° 41.47N 17° 47.11W	0 – 100 m (3)			
26.04.09	033			Surface		
26.04.09	036	20° 40.68N 17° 50.55W	0 – 555 m (11)			

27.04.09	038	20° 40N 17° 54W	0 – 110 m (3)		5, 40, 110 m	
27.04.09 1234	040	20° 37.03N 17° 57.50W	5 – 685 m (11)			
28.04.09 1225	042	20° 42.88N 18° 17.97W	0 – 1460 m (11)			
29.04.09 0426	044	20° 38.77N 18° 27.90W	7 – 200 m (5)		7, 50 m	
29.04.09	045			Surface		
29.04.09 1225	046	20° 37.81N 18° 32.95W	5 – 2000 m (11)			Last Day Patch 1
08.05.09 0502	053	21° 25.47N 17° 56.01W	0 – 200 m (9)			Day 1, Patch 2
09.05.09 0502	055	21° 31.25N 17° 59.43W	0 – 200 m (6)			
09.05.09	056			Surface		
09.05.09 1207	057	21° 33.84N 18° 02.54W	0 – 1500 m (10)			
10.05.09 0504	059	21° 37.43N 18° 02.05W	0 – 200 m (6)			
10.05.09	060			Surface		
Date Time (z)	CTD	Position	**N_2O-CH_4** Depth (No.)	**CH_4Oxdn** Depth (No.)	**$^{15}N_2O$ -$^{13}CH_4$** Depth (No.)	Comments
10.05.09 1148	061	21° 36.3N 18° 01.70W	0 – 1430 m (10)		0, 50, 300 m	Last Day Patch 2
14.05.09	065	19° 52.19N	0 – 150 m			

0538		18° 09.80W	(9)			
15.05.09 0900	066	19° 25.61N 17° 55.65W	0 – 200 m (6)	Surface		Day 1, Patch 3
15.05.09 1158	067	19° 26.12N 17° 57.33W	5 – 2240 m (10)			
16.05.09 0455	069	19° 30.76N 18° 06.16W	0 – 200 m (6)			
16.05.09 0903	070	19° 31.89N 18° 07.58W		Surface		
16.05.09 1208	071	19° 32.47N 18° 09.12W	0 – 500 m (10)		4, 300 m	
17.05.09 0507	074	19° 35.51N 18° 17.65W	0 – 120 m (6)			
17.05.09 0910	075	19° 36.49N 18° 18.50W		Surface		
17.05.09 1204	076	19° 36.7N 18° 21.3W	0 – 500 m (10)			
18.05.09 0459	078	19° 40.53N 18° 27.87W	0 – 120 m (6)			
18.05.09 1005	080	19° 43.09N 18° 26.03W		Surface		
18.05.09 1237	081	19° 43.34N 18° 26.54W	0 – 2530 m (10)			
19.05.09 0458	083	19° 44.39N 18° 37.61W	0 – 120 m (6)			
19.05.09 0858	084	19° 44.65N 18° 38.76W		Surface		
19.05.09	085	19° 45.03N	0 – 500 m		5, 40, 300 m	

1205		18° 39.27W	(11)			
20.05.09 – DIEL SURVEY. Samples collected for N2O/CH4 from underway fish at: 0400, 0500, 0600, 0700, 0800, 0900, 1020, 1110, 1225, 1308, 1424, 1525, 1715, 1840, 1910, 2015, 2105, 2205, 2300						
21.05.09 0501	093	19° 38.12N 18° 54.31W	0 – 120 m (6)			
21.05.09 0900	094	19° 34 N 18° 56 W		Surface 100 m		
21.05.09 1155	095	19° 35.02N 18° 58.13W	5 – 2930 m (11)		5, 50, 266 m	
22.05.09	096	19° 31.41N 19° 06.18W	5 m (6)	Surface		6 Replicates
22.05.09 0736	099	19° 29.69N 19° 08.35W	0 – 500 m (12)			

Dissolved Inorganic Carbon and Alkalinity

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The 250 ml samples were fixed with 50 µl of mercuric chloride and stored for later analysis at UEA.

The table below gives the details of each sample collected.

Bott No	Date	GMT	Lat	Long	CTD No	Niskin No	Depth
1	21/04/2009	04:04	21° 29.94N	17° 14.56W	17	24	0
2						23	0
3						20	5
4						16	8
5						12	15
6						9	20
7						6	35
8						3	40
9						1	52
10	22/04/2009	04:08	21° 25.87N	17° 15.84W	19	24	0
11						22	0
12						17	5
13						16	8
14						13	15
15						10	20
16						7	35
17						4	45
18						1	50
19	23/04/2009	04:28	21° 11.75N	17° 22.02W	21	22	0
20						22	0
21						21	5
22						16	8
23						13	15

24						10	20
25						7	37
26						4	50
27						1	65
28	24/04/2009	04:27	21° 00.44N	17° 28.31W	25	24	0
29						24	0
30						21	5
31						16	8
32						13	15
33						10	20
34						7	34
35						4	55
36						2	80
37	24/04/2009	19:10			28	24	0
38	25/04/2009	04:41	21° 51.88N	17° 37.94W	30	24	0
39						24	0
40						21	5
41						15	8
42						12	15
43						9	20
44						6	35
45						3	65
46						1	90
47							
48	26/04/2009		21° 40.68N	17° 50.55W	34	24	0
49						24	0
50						21	8
51						16	13
52						13	20
53						10	26.2
54						7	43
55						3	112
56						1	202
57	27/04/2009		21° 40.N	17° 54.W	38	23	0
58						23	0

59						21	5	
60						16	10	
61						13	17	
62						10	23	
63						7	40	
64						3	110	
65						1	200	possible misfire
66	29/04/2009	04:26	21° 38.76N	18° 27.03W	44	22	0	
67						22	0	
68						21	7	
69						16	12	
70						13	22	
71						10	29	
72						7	50	
73						3	100	
74						1	200	
75	29/04/2009	12:21	21° 37.67N	18° 32.87W	46	2	2000	
76						3	1500	
77						5	1200	
78						8	800	
79						9	500	
80						10	400	
81						11	350	
82						13	250	
83						16	80	
84						19	50	
85						21	20	
86						23	0	
87	30/04/2009	04:34	21° 38.05N	18° 40.84W	49	24	0	
88						24	0	
89						21	8	
90						17	14	
91						14	26	
92						11	35	
93						8	60	

94						3	110
95						1	200
96	08/05/2009	05:02	21° 25.47N	18° 56.01W	53	22	0
97						22	0
98						21	5
99						16	10
100						10	23
101						7	40
102						4	50
103						3	100
104						1	200
105	09/05/2009	06:55	21° 31.09N	17° 59.55W	55	22	0
106						22	0
107						21	8
108						16	14
109						13	26
110						10	35
111						7	60
112						3	110
113						1	200
114	10/05/2009	05:50	21° 37.21N	17° 02.25W	59	23	0
115						23	0
116						21	7
117						16	12
118						13	22
119						10	29
120						7	50
121						5	60
122						4	100
123						2	200
124	14/05/2009	06:10	19° 52.19N	18° 09.8W	65	22	0
125						22	0
126						20	4
127						16	7
128						13	13

129						10	17
130						7	30
131						4	40
132						3	50
133						1	150
134	15/05/2009	09:45	19° 25.61N	18° 55.65W	66	22	0
135						22	0
136						13	9
137						11	16
138						9	21
139						7	36
140						4	50
141						2	200
142	16/05/2009	06:10			69	22	0
143						22	0
144						20	3
145						16	6
146						13	11
147						10	15
148						7	25
149						5	35
150						4	45
151						1	20
152	16/05/2009	20:00	19° 34.88N	18° 12.9W	72	7	100
153						8	50
154						10	40
155						14	30
156						15	25
157						18	20
158						20	15
159						22	7
160						24	0
161	17/05/2009	06:00	19° 35.51N	18° 17.65W	74	22	0
162						22	0
163						20	5

164						16	8
165						13	15
166						10	20
167						7	35
168						4	55
169						1	120
170	18/05/2009	06:30	19° 40.53N	18° 27.87W	78	22	0
171						22	0
172						20	5
173						16	10
174						13	17
175						10	23
176						7	40
177						4	50
178						1	120
179	19/05/2009	05:40	19° 42.38N	18° 37.61W	83	22	0
180						22	0
181						20	5
182						16	8
183						13	15
184						10	20
185						7	35
186						4	50
187						3	70
188						1	120
189	20/05/2009	05:40	19° 41.27N	18° 46.77W	87	22	0
190						22	0
191						20	5
192						16	8
193						14	17
194						10	23
195						7	35
196						4	50
197						3	70
198						1	120

199	20/05/2009	08:31	19° 40.91N	18° 48.60W	88	1	110
200						4	90
201						7	75
202						10	50
203						13	40
204						16	25
205						18	5
206						22	0
207	20/05/2009	12:37	19° 40.47N	18° 50.32W	89	22	0
208						22	0
209						16	5
210						10	20
211						7	40
212						5	50
213						3	90
214						1	120
215	20/05/2009	16:39	19° 41.02N	18° 52.12W	90	22	0
216						18	5
217						16	10
218						10	30
219						7	40
220						5	60
221	20/05/2009	20:55	19° 14.18N	18° 53.04W	91	22	0
222						18	5
223						16	10
224						10	30
225						8	40
226						5	60
227	21/05/2009	05:01	19° 38.12N	18° 54.31W	93	1	110
228						3	90
229						5	55
230						7	35
231						10	20
232						13	15
233						16	8

234						20	5	
235						22	0	
236						22	0	
237	22/05/2009	05:05	19° 31.10N	19° 06.73W	97	3	60	
238						5	35	
239						8	20	
240						11	15	
241						14	8	
242								Bottle broken
243						17	5	
244						22	0	
245	22/05/2009	07:36	19° 29.69N	19° 08.35W	99	2	500	
246						4	400	
247						6	350	
248						10	200	
249						12	150	
250						14	100	

Underway pCO_2 and O_2

Ian Brown

Plymouth Marine Laboratory, West Hoe, Plymouth, UK

Aims: To provide continuous pCO_2 and O_2 measurements for the duration of the cruise

Water was run continuously through a General Oceanic equilibrator from the ships non toxic supply. Measurements were made from the vessel's departure from Falmouth until arriving in Tenerife upon the completion of the cruise. Measurements were recorded every 18 minutes using a Plymouth Marine Laboratory's LIVE pCO_2 system, manufactured by Dartcom on a LICOR 840. Oxygen readings were also recorded using an Aaderaa optode. The data is usually transmitted via an IRIDIUM modem back to the laboratory daily where it is updated onto the BODC website. Due to a technical issue the data wasn't automatically transmitted back to the laboratory but sent manually via email. The data was then transferred to the BODC website periodically throughout the week by Nick Hardman-Mountford.

Samples were taken by Pablo Serret, Vassilis Kitidis and Carol Robinson for calibration of the optode by Winkler oxygen titration. Winkler titration results from the non toxic seawater supply in the Chemistry Laboratory and concurrent oxygen optode data are given in the Appendices. Winkler oxygen samples were also collected from the surface Niskin bottle during most of the CTD profiles in order to calibrate the optode data and check for 'heterotrophy' in the non toxic seawater supply.

Nitrogen cycling

Darren Clark

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Overview: The kinetics of N-assimilation expressed by a phytoplankton assemblage is significantly related to its composition. The growth of phytoplankton modifies the inorganic nutrient environment to which future generations must acclimate. As nutrients deplete it may be expected that the assemblage is driven from larger cells with higher growth rates and lower nutrient affinities towards smaller cells with lower growth rates and substantially higher nutrient affinities. Consequently, investigations undertaken during ICON may demonstrate changes in assimilation rate, affinity, and preference for a specific N-source. Results may be related to the composition of the assemblage as demonstrated through microscopic examination and HPLC analysis of diagnostic pigments in conjunction with CHEMTAX.

Investigations of N-assimilation kinetics need to be corrected for isotope dilution since isotopic enrichment does not remain constant even within incubations of short (2-3hr) duration (a condition of the methods used). Models can be applied to correct for the isotopic dilution due to N-regeneration once regeneration rates, levels of enrichment and ambient concentrations are known. Consequently, a series of N-regeneration studies were conducted in parallel with kinetics investigations:

- NH_4^+ regeneration: Either micro/mesozooplankton excretion of NH_4^+ or bacterial degradation of dissolved organic N. The method does not separate the contribution from each of these processes. NH_4^+ regeneration rate changes with trophic status of the water mass. It also expresses diel variability in relation to DVM activity of zooplankton.
- NH_4^+ oxidation: The first step of the nitrification process producing NO_2^-. May be an important source of nitrous oxide.
- NO_2^- oxidation: The second step of the nitrification process producing NO_3^-. Nitrification expresses both diel and depth variability. Rates may also be substantially higher in upwelled waters and diminish as upwelled water parcels 'mature'.

The combination of these experiments should provide a useful insight into N-dynamics within this upwelling region.

CTD's sampled: All pre-dawn monster casts.
4, 11, 16, 18, 20, 24, 29, 33, 35, 43, 48, 52, 54, 58, 64, 66, 68, 73, 77, 82, 86, 92, 97

Samples taken for:

1. N-assimilation kinetics at 55% sPAR. Using ^{15}N-tecniques, the theoretical maximum rate of NO_3^- and NH_4^+ assimilation (V_{max}) and half saturation constant (K_s) will be determined.
2. NH_4^+ regeneration at 55% sPAR. Using isotope dilution techniques the rate of NH_4^+ regeneration will be measured and used to correct NH_4^+ assimilation rate data.
3. NH_4^+ oxidation at 55% sPAR. Using isotope dilution techniques the rate of NH_4^+ oxidation will be measured.
4. NO_2^- oxidation at 55%, 1% and (1%-50m). Using isotope dilution techniques the rate of NO_2^- oxidation will be measured.

Delivery of results:

Results should be available within 6 months of receiving frozen samples.

Plankton community structure

Glen Tarran and Claire Widdicombe

Plymouth Marine Laboratory, West Hoe, Plymouth, UK

Aims and Objectives

To study temporal and spatial variations in planktonic communities in and out of upwelled water off the coast of Mauritania in the Eastern subtropical Atlantic Ocean using predawn and noon CTD profiles, the pumped trace metal-free fish and various plankton nets.

Methods and initial findings

Water from the CTD Niskin bottles was collected for a variety of measurements:

a) quantification of nano- and picophytoplankton and bacteria by flow cytometry.

b) phytoplankton and microzooplankton community composition and abundance from microscopic analysis of samples preserved with Lugol's iodine .

c) phytoplankton pigment composition and concentrations using high performance liquid chromatography (HPLC).

Table 1 summarises the CTD casts sampled for plankton community structure during the cruise.

Table 1: CTD casts sampled for plankton commumity structure

Date	Julian day	CTD cast #	Time on deck GMT	Latitude N	Longitude W	Water column (m)	Depth range sampled
16-Apr	106	1	17:17	23.04	17.50	1212	2-80
18-Apr	108	3	06:32	22.19	19.14	3434	2-250
19-Apr	109	5	08:40	21.48	19.11	????	2-250
20-Apr	110	12	04:42	21.20	18.46	2594	2-275
21-Apr	111	17	04:25	21.50	17.24	65	2-52

22-Apr	112	19	04:30	21.43	17.26	63	2-50
23-Apr	113	21	04:50	21.20	17.37	77	2-65
23-Apr	113	23	13:21	21.13	17.40	83	2-65
24-Apr	114	25	04:52	21.01	17.47	90	2-82
24-Apr	114	27	13:21	20.94	17.49	87	2-77
24-Apr	114	28	19:47	20.90	17.55	100	2-90
25-Apr	115	30	05:12	20.86	17.63	107	2-90
25-Apr	115	32	14:04	20.82	17.69	502	5-240
26-Apr	116	34	05:20	20.69	17.80	506	2-200
26-Apr	116	36	13:34	20.68	17.84	563	5-300
27-Apr	117	38	05:09	20.66	17.91	666	2-160
27-Apr	117	40	13:37	20.62	17.96	699	5-400
28-Apr	118	41	10:39	20.72	18.26	1510	2-200
28-Apr	118	42	14:07	20.71	18.30	1509	2-300
29-Apr	119	44	05:03	20.65	18.47	1566	2-200
29-Apr	119	46	14:24	20.63	18.55	2027	2-249
29-Apr	119	47	19:45	20.65	18.61	2301	5-50
30-Apr	120	49	05:10	20.63	18.68	2569	2-200
08-May	128	53	05:37	21.42	17.93	1108	2-200
09-May	129	55	05:35	21.52	17.99	1323	2-200

Table 1 continued

Date	Julian day	CTD cast #	Time on deck GMT	Latitude N	Longitude W	Water column (m)	Depth range sampled
09-May	129	57	13:51	21.56	18.04	1514	2-180
10-May	130	59	05:39	21.62	18.03	1451	2-200
12-May	132	62	19:05	19.21	19.72	3230	2-70
13-May	133	63	15:49	19.67	18.45	2548	5-70

14-May	134	65	06:05	19.87	18.16	2082	2-150
15-May	135	66	09:36	19.43	17.93	2232	2-200
15-May	135	67	14:03	19.44	17.96	2253	5-70
16-May	136	69	05:26	19.51	18.10	2397	2-200
16-May	136	71	13:04	19.54	18.15	2355	2-100
16-May	136	72	20:39	19.58	18.22	2366	2-30
17-May	137	74	05:30	19.59	18.29	2448	2-120
17-May	137	76	12:57	19.61	18.33	2457	5-40
18-May	138	78	05:24	19.68	18.46	2565	2-120
18-May	138	81	14:52	19.72	18.44	2546	5-100
19-May	139	83	05:24	19.74	18.63	2734	2-120
20-May	140	87	05:29	19.69	18.78	2813	2-120
20-May	140	88	09:06	19.68	18.81	2832	2-75
20-May	140	89	13:07	19.67	18.84	2857	2-30
20-May	140	90	17:10	19.68	18.87	2804	2-40
20-May	140	91	21:05	19.69	18.88	2893	2-50
21-May	141	93	05:31	19.64	18.91	2905	2-110
22-May	142	97	05:35	19.52	18.11	3039	2-100

Flow cytometry

Fresh seawater samples were collected from CTD casts in clean 250 mL polycarbonate bottles from a Seabird CTD system containing 22 x 20 L Niskin bottles and 2 x 10L Niskin bottles. Samples were stored in a refrigerator until analysed (less than 1 hour). 2.5 mL samples were used for immediate flow cytometric analysis to characterise and enumerate *Prochlorococcus* and *Synechococcus* (both cyanobacteria), pico-eukaryotes and nanophytoplankton based on their light scattering and fluorescence properties. The flow cytometer used was a Becton Dickinson FACSort instrument. Of the 2.5 mL, approx 1.5 mL of sample was actually analysed to provide vertical profiles of phytoplankton abundance per millilitre, at the 6 depths used for incubation experiments (1, 7, 20, 33, 55 and 97% of incident light), plus additional depths. Samples from the same depths were also preserved immediately for bacterial abundance analysis after 30 min fixation with 0.5% glutaraldehyde (final concentration) at 4^{o}C and 1 hour staining at room temperature with a mixture of Sybr Green I DNA stain and potassium citrate buffer.

Underway sampling from the fish outlet located in the deck laboratory was carried out as follows: 5 mL flow cytometry tubes were rinsed twice with water from the fish and then filled to the top. 2.5 mL was then used for flow cytometric analysis as detailed in section 1a. Sampling from the fish was carried out on 3 occasions: cross-filament transect on 3 May at 30 minute intervals; cross-filament transect on 11-12 May at 20 minute intervals; diel experiments on 20-21 May at hourly intervals.

Data from CTD profiles and underway samples will be available with 12 months of cruise completion.

Sample collection for phytoplankton and microzooplankton community composition and abundance from microscopic analysis of samples preserved with Lugol's iodine .

Seawater samples were collected at the same time as samples for flow cytometry, from the same CTDs. Duplicate samples from 6 light depths (97, 55, 33, 14, 7 and 1% of incident light) were preserved in 200 mL amber glass jars containing acid lugol's iodine (2% final concentrations). One replicate was for phytoplankton analysis and the other for microzooplankton analysis. Some of the afternoon CTDs, which began at around solar noon did not sample specific light depths. In these cases, five or six sample depths were chosen within the euphotic zone. Samples will be transported back to the laboratory for microscopic analysis, which should take about 12 months to complete.

Sample filtration for phytoplankton pigment composition and concentrations using high performance liquid chromatography (HPLC).

Seawater samples were collected at the same time as samples for flow cytometry, from the same CTDs. Samples from the 6 light depths mentioned above were collected into clean 2 L polypropylene bottles and either 1 or 2 L were vacuum filtered through 25 mm diameter GF/F glass microfibre filters. Once filtration was complete the filters were folded and placed 2 mL cryovials, snap frozen in liquid nitrogen for approx. 1 minute and then stored in a -80^{o}C freezer. The filters will remain in the freezer until the RRS Discovery returns to the UK and will then be transported in a liquid nitrogen dry shipper to PML, where the pigment composition and concentrations will be determined using HPLC, which should be completed in 12 months.

Net hauls for the analysis of mesoplankton, including jellies.

Vertical net hauls were preformed for the qualitative enumeration of phytoplankton (10µm Apstein net) and zooplankton (60µm Bongo and 700µm net). The zooplankton net hauls are for Claudia Castellini's (SAHFOS) own research. Table 2 summarises the net hauls that were carried out during the cruise.

Table 2: Plankton commumity structure net hauls

Date	Time (GMT)	Latitude N	Longitude W	Number	Net	Depth (m)
23-Apr	11:30	21 07.904	17 23.684	#1	Apstein (10µm)	20
	12:15			#2	Bongo (60µm)	50
	12:45			#3	Zooplankton (700µm)	50
24-Apr	14:10	20 55.741	17 30.419	#4	Apstein (10µm)	20
	14:20			#5	Bongo (60µm)	50
	14:30			#6	Zooplankton (700µm)	50
25-Apr	15:04	20 48.292	17 43.063	#7	Apstein (10µm)	50
	15:25			#8	Bongo (60µm)	200
	15:45			#9	Zooplankton (700µm)	200
27-Apr	14:00			#10	Apstein (10µm)	50
29-Apr	15:40	20 38.033	18 35.101	#11	Apstein (10µm)	50
	16:00			#12	Bongo (60µm)	200
	16:18			#13	Zooplankton (700µm)	200
09-May	10:15	21°31.15	18°00.61	#17	Apstein (10µm)	50
10-May	10:05	21°32.25	18°00.85	#18	Apstein (10µm)	50
12-May	19:52	19°12.56	19°44.59	#19	Apstein (10µm)	50
13-May		19°40.53	18°27.25	#20	Apstein (10µm)	50
14-May	10:25			#21	Apstein (10µm)	50
16-May	10:15	19°32.71	18°08.58	#22	Apstein (10µm)	50

17-May	10:25	19°35.48	18°19.18	#23	Apstein (10µm)	50
	10:38			#24	Zooplankton (700µm)	200
	11:08			#25	Bongo (60µm)	200
18-May	15:40	19°43.53	18°27.73	#26	Apstein (10µm)	50
19-May	10:00	19°44.74	18°38.86	#27	Apstein (10µm)	50
20-May	10:15	19° 40.89	18° 49.42	#28	Apstein (10µm)	50
21-May	10:30	19° 34.9	18° 56.35	#29	Apstein (10µm)	50

Cycling of organic nutrients

Polly Hill

National Oceanography Centre, Southampton

Introduction

In providing a significant source of nutrients to surface waters, seawater upwelled from depth is hypothesised to play a key role in regulating ocean biogeochemistry with resultant climatic feedback effects.

Objectives for cruise

1. Measure ambient amino acid (methionine, leucine, tyrosine) and urea concentration and turnover time in surface seawater using radiotracer dilution bioassay incubations
2. Measure effect of UV irradiation on the bioavailability of nutrients.

Methods

Ambient concentrations and turnover rates of urea and three amino acids - leucine, methionine, tyrosine – by total bacterioplankton were measured using isotopic dilution time-series incubations. Using the same seawater sample, additions of UV irradiated deep seawater were made and the response of the bacterioplankton community measured in terms of the change in rate of amino acid uptake.

Seawater samples taken

Seawater samples were collected from 55% light depth from pre-dawn and 9am CTDs (Table 1).

Date	Station	Depth, m
16.04.09	1	6
18.04.09	3	7
19.04.09	5	10
20.04.09	12	10
21.04.09	17	5

22.04.09	19	5
23.04.09	21	5
23.04.09	22	5
24.04.09	25	5
24.04.09	26	5
25.04.09	30	5
25.04.09	31	20
26.04.09	34	5
26.04.09	35	5
27.04.09	38	5
27.04.09	39	5
28.04.09	41	11
29.04.09	44	7
29.04.09	45	7
30.04.09	49	8
30.04.09	50	7
04.05.09	51	5
08.05.09	53	5
09.05.09	55	8
09.05.09	56	8
10.05.09	59	7
10.05.09	60	7
13.05.09	63	10
14.05.09	65	4
15.05.09	66	5
16.05.09	69	3
16.05.09	70	4
17.05.09	74	5
17.05.09	75	3
18.05.09	78	5

18.05.09	80	5
19.05.09	83	5
19.05.09	84	5
20.05.09	87	5
20.05.09	88	5
20.05.09	89	5
20.05.09	90	5
20.05.09	91	5
21.05.09	93	5
21.05.09	94	5
22.05.09	97	5
22.05.09	99	5

Table 1. List of seawater samples taken. Information not yet collected from past few days

Results

Radioactive samples were counted onboard; however, data need to be checked before being made available. Data checking should be completed within the next few months.

Phosphate cycling

Simon Thomas

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Rational.

To investigate the molecular diversity, community structure and gene expression of microbes capable of the utilisation of organic phosphorus compound resulting in both the regeneration of phosphate, and the production of potentially climatically-important gases. In addition these samples will be used to determine metylotroph activity and the diversity of nitrogen fixation and methane oxidation genes

In addition, the activity of alkaline phosphatases, capable of the cleavage of the carbon to phosphorus ester linkage, has been determined throughout the duration of the lagrangiun study and during several transects through the upwelling filament.

Methods

Molecular samples were collected from 55%, 14%, !% and 1(-50m) of the chlorophyll maximum and filtered through 0.22um sterivex filters. 1.8ml of RNALater was then added to each sterivex in order to prevent mRNA degradation. The filters were then plugged at both ends and stored @ 4^{o}C overnight. The RNALater was then removed; the filters were wrapped in parafilm and stored @ -80^{o}C for later analysis.

A comprehensive list of the samples collected with relevant details is provided in the Appendices.

Community structure, genetic diversity and gene expression will be analysed at PML over the next 10 months. Samples

Alkaline phosphatase activity was measure by the fluorometric determination of the fluorescent product of the enzymatic reduction of methylumbelliferyl phosphate according to the method of Rees *et al* (2009)

To identify species specific alkaline phosphatase activity the enzyme labelled fluorescence assay (ELF) was employed according to the procedure described in Rees *et al* (2009)

Results.

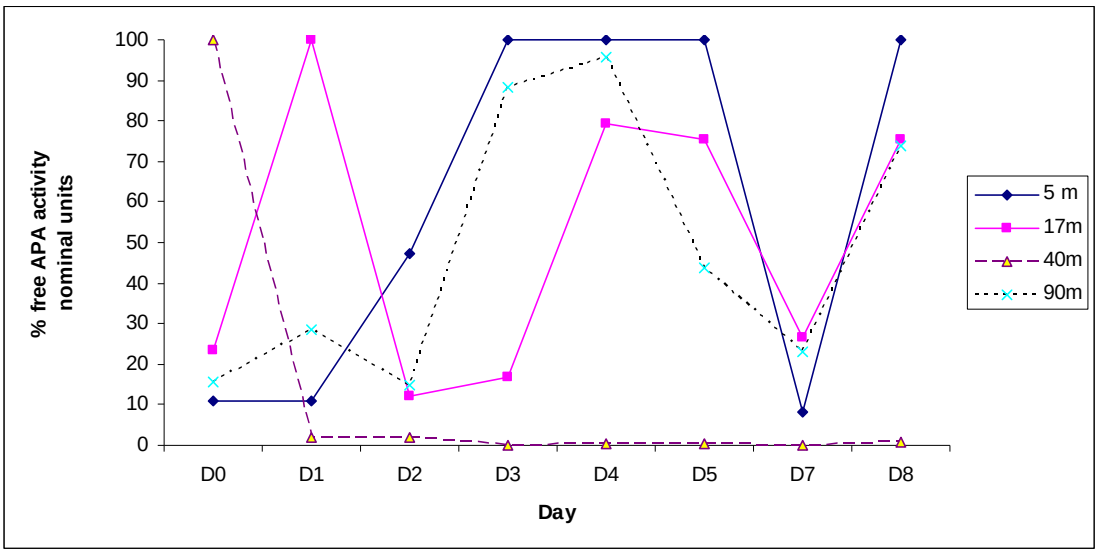

Figure 1 : Alkaline phosphatase activity in nominal units, during the first lagrangian study.

Preliminary analysis (figure 1) illustrates that alkaline phosphatases are expressed constitutively, rather than as a result of phosphate depletion during the first lagrangian study. No correlation between expression and phosphate levels was observed, but there was a weak association between alkaline phosphatase activity of nitrate levels.

The ELF assay revealed cell specific alkaline phosphatase activity by diatom, dinoflagellate and copepod species.

References

Rees et al (2009) Alkaline phosphatase activity in the western English Channel: Elevations induced by high summertime rainfall. Estuarine, Coastal and Shelf Science. 81: 569-574

Central Scientific Event and Station Log

Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
15/04/2009	0942 BST		28 28.6	016 13.8				F.A.O.P.
	0950 BST							anchor secured
	1000 BST		28 25.9	016 13.4				steering 200 oT
	1100 BST		28 14.9	016 17.9				
	1200 BST		28 03.0	016 22.5				
	1208 BST		28 01.4	016 25.1				A/C 189 oT
	1300 BST		27 52.1	016 25.1				
	1400 BST		27 41.0	016 26.8				
	1500 BST		27 30.0	016 29.0				
	1600 BST		27 19.1	016 30.8				1615 Emergency & lifeboat muster
	1735 BST		27 02.00	016 33.7				
	1800 BST		26 57.2	016 34.4				
	1900 BST		26 46.7	016 36.0				
	2000 BST		26 36.4	016 38.1				
	2100 BST		26 25.2	016 40.0				
	2200 BST		26 14.1	016 42.0				
	2300 BST		26 03.2	016 43.4				
	2400 BST		25 51.0	016 46.0				
16/04/2009	0200 BST		25 29.7	016 50.0				clocks retarded 1 hr to GMT
	0200 GMT		25 19.5	016 51.9				
	03:30		25 02.8	016 54.8				
	04:00		24 57.8	016 55.5				
	05:00		24 46.4	016 57.0				
	06:00		24 34.0	016 58.7				
	07:00		24 23.4	017 00.7				
	08:00		24 12.5	017 02.8				
	09:00		24 00.0	017 5.0				A/C to 218 T to follow 1000m contour
	10:00		23 50.0	017 12.5				
	11:00		23 41.0	017 20.5				
	11:00		23 41.0	017 20.5				Commence load test on CTD unit
	11:20		23 37.8	017 22.8				load test complete
	12:00		23 31.1	017 25.9				
	13:00		23 20.1	017 28.5				
	14:00		23 09.2	017 17.2				
	14:48		23 02.4	017 30.0				hove to on stn commence science
	15:00		23 02.3	017 30.3		Drifter 1		testing drifter buoyancy
	15:11		23 02.3	017 30.3				
	15:20		23 02.2	017 30.6				drifter inboard
	15:34		23 02.2	017 30.7				wire walker buoyancy test
	15:43		23 02.3	017 30.7				wire walker inboard
	15:47		23 02.3	017 30.7				wire walker overboard
	16:02		23 02.3	017 30.8				wire walker deployed

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	16:12		23 02.4	017 30.8		CTD 1		shakedown CTD overboard
	16:25		23 02.4	017 30.8		Fish 1		deploy starboard davit
	16:44		23 02.4	017 30.9		CTD 1		at 100m up to 150m
	16:54		23 02.4	017 30.9		OPT 1		deployed starbd quarter
	17:14		23 02.4	017 30.9		OPT 1		inboard
	17:18		23 02.4	017 30.9				CTD inboard
	18:54		23 01.3	017 30.9				drifter grappled
	19:02		23 01.3	017 30.9				drifter inboard
	19:18		23 00.9	017 31.2				proceeding to 100m contour
	21:00		22 52.6	017 19.6				
	22:00		22 46.7	017 10.3				
	22:55		22 47.6	017 09.9				hove to for MVP testing
	23:01		22 47.6	017 10.0		MVP 1		MVP deployed
	23:04		22 47.6	017 10.0				MVP in water
	23:15		22 47.6	017 10.0				MVP tow 7 knts
17/04/2009	00:00:00		22 46.8	017 11.9				hove to
	00:50		22 47.4	017 12.0				continue MVP survey
	02:00		22 40.3	017 09.6				
	02:30		22 36.8	017 10.6				completed 100m survey
	04:45		22 26.0	017 23.7				reduce speed to recover MVP
	04:58		22 25.8	017 24.0		MVP 1		MVP on deck
	06:00		22 16.3	017 27.1				
	08:00		21 56.3	017 27.1				
	08:45		21 49.3	017 28.1				Hove to on station MVP4
	09:00		21 49.3	017 28.1				
	09:12		21 49.3	017 28.1				move to deploy drifters 090T
								deployment speed 7 knts
	09:21		21 49.5	017 27.2				first drifter deployed
	09:31		21 49.5	017 26.0				second drifter deployed
	09:41		21 49.5	017 25.0				third drifter deployed
	09:47		21 49.5	017 24.1				fourth drifter deployed
	09:48		21 49.5	017 23.9				return to MVP4 position and heave to
	10:00		21 49.6	017 25.4				on course for MVP4 position
	10:24		21 49.6	017 28.2				hove to on station MVP4
	11:00		21 49.6	017 28.3				hove to on station MVP4
	12:00		21 49.7	017 28.2				hove to on station MVP4
	13;20		21 49.7	017 28.4		MVP 2		MVP deployed
	13:30		21 50.3	017 28.8				commence MVP survey
	18:00		21 52.6	018 02.9				
	20:00		21 54.0	018 18.5				MVP survey continues
	21:00		21 54.6	018 27.2				MVP survey continues
	22:00		21 55.7	018 35.0				MVP survey continues

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	23:00		21 55.9	018 42.4				MVP survey continues
	23:50		21 56.5	018 48.1				A/C to 309T, MVP survey
	00:00		21 57.0	018 49.0				MVP survey continues
18/04/2009	03:15		22 10.7	019 07.7				MVP inboard
	03:20		22 10.7	019 07.8				Hove to awaiting CTD
	04:12		22 11.0	019 08.2		CTD 2		CTD o/B down to ca. 300m
	04:28		22 11.0	019 08.2		CTD 2		CTD to 10m
	04:46		22 11.0	019 08.3		CTD 2		CTD inboard
	05:47		22 11.0	019 08.54		CTD 3		CTD overboard down to 250m
	06:03		22 11.29	019 08.60		CTD 3		CTD to 150m
	06:32		22 11.33	019 08.7		CTD 3		CTD inboard
	06:45		22 11.46	019 08.65				MVP in water
	07:14		22 11.5	019 08.6				commence MVP survey
	08:00		22 14.6	019 11.9				MVP survey towards MVP3
	09:00		22 18.3	019 17.8				MVP survey continues
	10:00		22 23.3	019 24.7				MVP survey continues
	10:37		22 26.0	019.28.2				commence turn for MVP3 to 209T to head fopr MVP4
	10:51		22 25.4	019 29.8				continue MVP survey 7 knots
	11:00		22 24.2	019 30.8				continue MVP survey
	12:00		22 18.6	019 34.5				continue MVP survey
	14:00		22 06.3	019 42.6				
	14:48		22 01.2	019 45.8				adjusted track to 183T
	18:00		21 38.7	019 47.0				
	21:00		21 21.4	019 45.5				adjusted course to 053T, continue MVP survey to MVP5
	22:00		21 25.7	019 39.6				continue MVP survey
	23:00		21 29.8	019 33.8				continue MVP survey
	00:00		21 34.5	019 27.4				continue MVP survey
19/04/2009	02:00		21 42.8	019 15.6				
	03:30		21 48.1	019 06.7				commenced track 179o to MVP6
	06:00		21 30.3	019 06.1				continue MVP survey toward MVP6
	06:05		21 29.2	019 06.1				commence recovering MVP
	06:17		21 28.6	019 06.2				MVP on deck, turn to heave to
	06:55		21 28.6	019 06.4		CTD 4		CTD overboard down to 125m
	07:23		21 28.6	019 06.4		CTD 4		CTD inboard
	08:03		21 28.8	019 06.5		CTD 5		CTD overboard down to 250m
	09:00		21 28.8	019 06.6		CTD 5		CTD inboard
	09:00		21 28.8	019 06.7				hove to on station
	10:00		21 28.6	019 06.8				MVP deployed, continue survey
								MVP6 173T at 7 knots
	11:40		21 16.6	019 05.9				commence recovery of MVP (fault)
	11:55		21 16.0	019 05.9				hove to on station

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	12:00		21 16.0	019 05.9				hove to on station
	14:00		21 16.7	019 07.3				
	14:18		21 16.8	019 07.5				PES fish inboard
	15:12		21 16.5	019 07.2				proceeding to MVP7
	18:00		21 24.5	018 46.3				proceeding to MVP7
	21:08		21 33.0	018 25.1				hove to on station
	21:10		21 33.0	018 25.1		CTD 6		CTD overboard to 350m
	21;40		21 33.1	018 25.2		CTD 6		CTD inboard
	21:43		21 33.1	018 25.2				proceed towards WP15
	22:00		21 31.4	018 25.3				
	22:15		21 30.5	018 25.6				hove to on station for CTD 7
	22:20		21 30.5	018 25.6		CTD 7		CTD overboard to 350m
	22:45		21 30.5	018 25.6		CTD 7		CTD inboard
	22:46		21 30.5	018 25.6				proceed towards WP15
	23:00		21 29.7	018 25.7				
	23:14		21 28.7	018 25.7		CTD 8		Hove to for CTD 8, CTD overboard to 350m
	23:40		21 28.8	018 25.8		CTD 8		CTD inboard
	23:41		21 28.8	018 25.8				proceed towards WP15
	00:00		21 26.5	018 25.9				
20/04/2009	00:19		21 24.9	018 28.9		CTD 9		Hove to, CTD overboard
	00:46		21 24.8	018 26.4		CTD 9		CTD inboard
	00:52		21 24.7	018 26.4				proceed rowards WP15
	01:26		21 20.2	018 26.7		CTD 10		Hove to CTD overboard
	01:49		21 20.1	018 26.9		CTD 10		CTD inboard
	03:02		21 12.0	018 27.3		CTD 11		hove to - CTD overboard
	03:30		21 12.1	018 27.6		CTD 11		CTD inboard
	04:00		21 12.2	018 27.6		CTD 12		CTD overboard to 300m
	04:44		21 12.4	018 27.8		CTD 12		CTD inboard
	05:29		21 12.5	018 27.8				proceeding towards WP 13 30 min steam
	06:14		21 08.5	018 27.7		CTD 13		Hove to CTD overboard to 300m
	06:36		21 08.6	018 27.8		CTD 13		CTD inboard proceeding 076o for 30 min
	07:15		21 09.4	018 26.2		CTD 14		CTD overboard to 350m
	07:37		21 09.0	018 26.3		CTD 14		CTD inboard
	08:20		21 10.2	018 24.2		CTD 15		CTD overboard to 350m
	08:45		21 10.2	018 24.3		CTD 15		CTD inboard
	08:50		21 10.2	018 24.3				proceed towards WP15 080oT
	12:00		21 13.3	018 02.5				
	14:00		21 14.7	017 50.5				
	15:15		21 16.0	017 45.1				track 061oT
	16:00							evaporator off
	20:56		21 29.8	017 14.7				hove to on station
	21:10		21 29.8	017 14.7				proceed on course 062 oT

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	00:00		21 28.0	017 18.3				
21/04/2009	02:00		21 31.1	017 11.6				
	02:55		21 30.0	017 14.6				hove to on station
	03:01		21 30.0	017 14.6		CTD 16		CTD overboard
	03:19		21 29.8	017 14.6		CTD 16		CTD inboard
	04:02		21 29.9	017 14.5		CTD 17		CTD overboard to 52m
	04:26		21 29.8	017 14.5		CTD 17		CTD inboard
	05:32		21 30.0	017 14.5				proceeding to WP5 B/T stopped
	06:00		21 31.4	017 15.0				
	08:30		21 37.6	017 16.1				hove to on station WP5
	08:31		21 37.6	017 16.1				proceed to depth 48 marker 070oT
	09:16		21 39.0	017 12.2				load test on CTD wire and calibrtaion of load cell
	09:50		21 40.0	017 09.4				load cell calibration complete
	10:00		21 40.2	017 08.5				continue towards 48m sounding position 070oT
	10:05		21 40.0	017 08.2				A/C to 210oT to head for WP#16
	11:00		21 34.4	017 11.2				proceeding towards WP#16 210oT
	11:50		21 30.0	017 14.5				hove to on station at WP#16
	12:00		21 30.0	017 14.5				hove to on station at WP#16
	13:20		21 29.9	017 14.6				commence testing buoy
	14:10		21 29.3	017 14.6				all gear inboard
	14:20		21 29.3	017 14.6				resume testing
	14:40		21 29.3	017 14.7				all gear inboard
	14:44		21 29.3	017 14.8				commence testing buoy
	15:02		21 29.1	017 14.9				all gear inboard
	15:52		21 18.8	017 15.0				wire walker buoy released
	16:04		21 28.5	017 15.2				deploy second buoy for buoyancy test
	16:17		21 28.5	017 15.2				second buoy released
	16:33		21 28.3	017 15.4				deploy cable on port quarter to remove residual turns in it
	16:45		21 28.3	017 15.4				wire recovered
	18:50		21 26.8	017 15.5				buoy grappled
	18:53		21 26.8	017 15.5				buoy recovered
	19:10		21 26.5	017 15.5				buoy #2 grappled
	19:22		21 26.5	017 15.5				buoy #2 recovered
	19:49		21 26.5	017 15.7				commence deploying turbulence probe
	19:57		21 26.6	017 15.7				turbulence probe deployed
	20:31		21 27.0	017 15.8				turbulence probe inboard
	20:31		21 27.0	017 15.8				proceed 020T to WP#3
	21:18		21 30.0	017 14.6				deploy buoy
	22:30		21 28.7	017 14.5				tracking buoy
22/04/2009	03:01		21 26.5	017 15.2		CTD 18		CTD overboard
	03:25		21 26.5	017 15.4		CTD 18		CTD inboard
	04:04		21 25.9	017 15.8		CTD 19		CTD overboard

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	04:28		21 25.8	017 16.0		CTD 19		CTD inboard
	11:10		21 21.5	017 16.4				recover drifter buoy, engine stopped
	12:00		21 20.1	017 16.1				thruster pushing ahead with wind on stbd shoulder
	13:10							steering tested
	13:15							testing ahead and astern
	13:39		21 18.7	017 17.0				chain
	14:48		21 14.8	017 18.5				GPS buoy inboard
	16:25		21 18.63	017 17.18		#5747		drifter buoy deployed
	16:29		21 18.7	017 17.18				commence deploying SF6 chemical hose
	16:40		21 18.7	017 17.2				SF6 hose deployed
	17:08		21 18.1	017 17.3				commence grid pattern, water sampler fish deployed
	17:44		21 17.5	017 17.5				stop grid due to hose problems
	21:00		21 15.4	017 20.3				continue following grid deploying SF6
	22:00		21 15.5	017 17.3				continue following grid deploying SF6
	23:30		21 12.5	017 19.0				hove to on station, SF6 deployment complete, begin deploying drifters
	23:42		21 12.6	017 19.0		#7547		first drifter deployed
	23:43		21 12.6	017 19.0				proceed to second drifter deployment position
23/04/2009	00:26		21 14.6	017 17.4		#2881		second drifter deployed
	01:08		21 16.1	017 20.1		#5990		third drifter deployed
	01:49		21 13.4	017 22.8		#5988		fourth drifter deployed
	02:13		21 13.1	017 20.9				hove to in vicinity of patch centre
	03:32		21 12.3	017 21.7		CTD 20		CTD overboard
	03:50		21 12.2	017 21.9		CTD 20		CTD inboard
	04:26		21 11.7	017 22.01		CTD 21		CTD overboard
	04:50		21 11.68	017 22.23		CTD 21		CTD inboard
	09:03		21 09.2	017 22.6		CTD 22		CTD overboard
	09:30		21 09.2	017 22.7		CTD 22		CTD inboard. Continue tracking drifter
	10:00		21 08.9	017 22.8				continue tracking drifter buoy
	11:00		21 08.2	017 22.7				proceed to position 21 03.0N 017 21.0W course 145T to update drifter buoy position
	11:25		21 06.7	017 22.1				drifter buoy position update, return to patch centre 325T
	11:51		21 08.1	017 23.6				hove to on station tracking drifter buoy
	12:00		21 08.1	017 23.6				hove to in vicinity of patch centre
	12:04		21 08.1	017 23.7		NET 1		nets overboard (Apstein 10 micron)
	12:11		21 08.0	017 23.7		NET 1		nets inboard
	12:13		21 08.0	017 23.7		NET 2		nets overboard (Bongo 60 micron)
	12:29		21 07.9	017 23.7		NET 2		nets inboard
						NET 3		nets overboard (700 micron)
	12:40		21 07.7	017 23.7		NET 3		nets inboard
	12:34		21 07.7	017 23.8		CTD 23		CTD overboard
	13:00		21 07.7	017 23.8		OPT 002		optics rig overboard

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	13:21		21 07.3	017 23.9		CTD 23		CTD inboard
	13:35		21 07.4	017 24.0		OPT 002		optics rig inboard
	14:48		21 06.7	017 24.4		OPT 003		optics rig overboard
	15:05		21 06.5	017 24.6		OPT 003		optics rig inboard
	15:12		21 06.4	017 24.7				turbulence probe deployed
	16:00							turbulence probe recovered
	18:00		21 04.8	017 25.4				
	18:43		21 04.8	017 25.4				deploy turbulence probe
	19:28		21 04.8	017 25.2				probe recovered, re-establish marker buoy
	19:58		21 03.7	017 25.6				commence SF6 survey
	20:45		21 01.5	017 26.0				hove to 4km from patch centre
	21:15		21 01.5	017 26.0				commence SF6 survey
24/04/2009	01:00		21 03.8	017 28.9				proceeding towards patch centre
	02;30		21 01.6	017 27.3				hove to near patch centre
	03:30		21 00.9	017 27.9		CTD 24		CTD overboard
	03:50		21 00.8	017 28.0		CTD 24		CTD inboard
	04:26		21 00.4	017 28.3		CTD 25		CTD overboard
	04:50		21 00.2	017 28.5		CTD 25		CTD inboard Instructed remain near drifter buoy
	05:56		20 59.7	017 28.6				commence SF6 survey, B/T off
	08:15		20 58.0	017 28.7				hove to on station to start CTD at 09:00 in patch centre
	09:05		20 57.9	017 28.7		CTD 26		CTD overboard
	09:33		20 57.8	017 28.7		CTD 26		CTD inboard
	09:33		20 57.8	017 28.7				hove to in vicinity of patch centre
	10:16		20 57.4	017 28.8				deploy turbulence probe speed 0.5 knts
	11:00		20 57.7	017 28.8				turbulence probe recovered
	11:20		20 56.7	017 29.1				hove to in vicinity of patch centre
	12:16		20 56.5	017 29.4				turbulence probe deployed
	12:36		20 56.5	017 29.3				turbulence probe inboard
	12:43		20 56.4	017 29.6		OPT 004		optics rig overboard
	12;55		20 56.3	017 29.7		CTD 27		CTD overboard
	13:13		20 56.2	017 29.8		OPT 004		optics rig inboard
	13:20		20 56.1	017 29.9		CTD 27		CTD inboard
	14:09		20 55.6	017 30.3		NET 4		nets overboard (Apstein 10 micron)
						NET 4		nets inboard
						NET 5		nets overboard (Bongo 60 micron)
						NET 5		nets inboard
						NET 6		nets overboard (700 micron)
	14:33		20 55.3	017 30.8		NET 6		nets inboard
	14:56		20 55.5	017 31.2				turbulence probe deployed
	15:36		20 55.7	017 31.7				turbulence probe inboard
	17:00		20 54.8	017 32.5				commence air sampling head to wind hove to until 19:00
	18:26		20 54.0	017 32.9				deploy turbulence probe

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	19:10		20 54.3	017 33.3				turbulence probe recovered
	19:15		20 54.3	017 33.3		CTD 28		CTD overboard
	19:48		20 54.1	017 33.6		CTD 28		CTD inboard, start SF6 survey
	21:00		20 55.1	017 32.1				continue SF6 survey
25/04/2009	01:50		20 51.7	017 38.8				heading towards central buoy
	02:26		20 51.1	017 36.1				hove to on station
	03:46		20 51.1	017 37.1		CTD 29		CTD overboard
	04:11		20 52.0	017 37.5		CTD 29		CTD inboard
	04:45					CTD 30		CTD overboard
	05:12		20 51.8	017 38.3		CTD 30		CTD inboard
	06:00		20 50.8	017 39.0				commence search for drifter buoy
	07:15		20 43.0	017 34.3				updated buoy position, proceeding 288
	08:30		20 42.4	017 42.6				hove to on station in vicinity of drifter buoy, fish inboard
	09:17		20 42.0	017 42.5		#7547		wire walker grappled
	09:18		20 42.0	017 42.5		#7547		wire walker inboard, proceed to centre of patch
	11:00		20 49.1	017 40.4				hove to patch centre, 0.5nm 270oT
	11:11		20 49.4	017 40.8		CTD 31		CTD overboard
	12:00		20 49.4	017 41.0		CTD 31		CTD inboard
	12:40		20 49.2	017 41.5		OPT 005		optics rig overboard
	13:09		20 49.1	017 41.6		CTD 32		CTD overboard
	13:41		20 49.2	017 41.9		OPT 005		optics rig inboard
	14:04		20 49.2	017 41.1		CTD 32		CTD inboard
	14:14		20 49.3	017 41.1				turbulence probe deployed
	15:04		20 48.2	017 42.4				turbulence probe inboard
	15:18		20 48.4	017 42.8		NET 7		commenced net deployment (Apstein 10 micron)
						NET 7		net inboard
						NET 8		nets overboard Bongo 60 micron
						NET 8		nets inbopard
						NET 9		nets overboard 700 micron
	16:07		20 48.1	017 43.4		NET 9		completed net deployment
	16:15		20 48.0	017 43.4				commenced turbulence probe deployment
	16:44		20 48.07	017 43.73				turbulence probe recovered
	17:00		20 48.0	017 43.9				atmospheric sampling commences
	18:06		20 47.5	017 44.7				turbulence probe overboard
	18:58		20 47.7	017 45.01				turbulence probe inboard, atmospheric sampling finished
	19:48		20 45.4	017 44.1		#7547		deployed wire walker, commence sf6 survey
26/04/2009	03:12		20 41.9	017 46.9				hove to on station
	03:34		20 41.9	017 47.0		CTD 33		CTD overboard
	04:04		20 41.5	017 47.2		CTD 33		CTD inboard
	04:44		20 41.5	017 47.6		CTD 34		CTD overboard
	05:25		20 41.3	017 48.1		CTD 34		CTD inboard, awaiting sampling before moving off
	06:00		20 40.74	017 48.31				start SF6 survey to NE

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	09:00		20 40.1	017 48.7		CTD 35		CTD overboard
	09:41		20 39.9	017 49.0		CTD 35		CTD inboard, hove to in vicinity of patch
	11:20		20 40.0	017 50.0				commence turbulence probe in patch centre
	12:00		20 40.2	017 50.4				
	12:15		20 40.6	017 50.4				turbulence probe inboard
	12:32		20 40.6	017 50.3		OPT 006		optics rig overboard
	12:36		20 40.7	017 50.6		CTD 36		CTD overboard
	13:13		20 40.9	017 50.7		OPT 006		optics rig inboard
	13:33		20 41.0	017 50.6		CTD 36		CTD inboard
	14:58		20 40.9	017 50.9				turbulence probe deployed
	16:38		20 41.9	017 50.8				turbulence probe recovered
	17:00		20 41.4	017 52.5				hove to for air sampling
	17:30		20 41.3	017 52.4				deploying turbulence probe
	18:30		20 41.8	017 52.5				turbulence probe inboard. Commence search for wire walker
	21:00		20 41.0	017 54.2				finish search for wire walker buoy, commence SF6 survey
27/04/2009	02:00		20 41.4	018 04.9				
	03:22		20 40.4	017 54.2				hove to on station
	03:30		20 40.4	017 54.2		CTD 37		CTD overboard
	03:53		20 40.2	017 54.4		CTD 37		CTD inboard
	04:35		20 39.7	017 54.4		CTD 38		CTD overboard
	05:09		20 39.6	017 54.8		CTD 38		CTD inboard, standing by drifter buoy measuring SF6
	09:00		20 37.4	017 56.2		CTD 39		CTD overboard
	09:38		20 37.3	017 56.3		CTD 39		CTD inboard, hove to in vicinity of patch centre
	11:24		20 36.4	017 57.1				commence turbulence probe
	12:00		20 36.8	017 57.3				
	12:12		20 37.0	017 57.3				turbulence probe inboard
	12:34		20 37.0	017 57.5		CTD 40		CTD overboard
	12:34		20 37.0	017 57.5		OPT 007		optics rig overboard
	13:27		20 37.5	017 57.9		OPT 007		optics rig inboard
	13:37		20 37.6	017 58.0		CTD 40		CTD inboard
	14:30		20 37.3	017 58.9		NET 10		net overboard (Apstein)
	14:39		20 37.3	017 59.0		NET 10		net inboard
	15:15		20 36.4	017 56.8				hove to in vicinity of buoy
	16:21		20 36.5	017 57.1		#7547		wire walker buoy grappled
	16:26		20 36.4	017 57.3		#7547		buoy recovered
	16:38		20 36.2	017 57.54				move to centre patch buoy
	17:39		20 35.9	018 00.2				commence SF6 survey
	23:00		20 36.6	017 59.7				
28/04/2009	00:00		20 39.5	018 00.1				SF6 survey continues
	02:00		20 38.7	018 05.4				

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Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	03:00		20 38.9	018 06.1				hove to on station
	03:12		20 38.8	018 06.2				commence SF6 survey
	04:24		20 43.5	018 08.3				hove to on station assessing weather for CTD ing
	04:50		20 43.8	018 08.6				Wx NNE 30 with mod/rough sea. Decision not to launch CTD taken. Pitching moderately. Hove to awaiting instructions. SF6 mapping conducted throughout
	08:25		20 44.1	018 12.1				relocate to find SF6 patch centre
	09:50		20 43.2	018 15.2				hove to in vicinity of patch centre
	09:58		20 43.2	018 15.2		#xxxx		drifter buoy deployed
	10:04		20 43.3	018 15.2		CTD 41		CTD overboard
	10:40		20 43.3	018 15.4		CTD 41		CTD inboard
	11:40		20 42.9	018 17.7				hove to in vicinity of drifter buoy
	12:00		20 42.9	018 17.9				
	12:26		20 42.9	018 18.0		CTD 42		CTD overboard
	12:36		20 42.8	018 18.1		OPT 008		optics rig overboard
	13:14		20 42.7	018 18.4		OPT 008		optics rig inboard
	14:08		20 42.9	018 18.6		CTD 42		CTD inboard
	17:00							commence atmospheric sampling
	19:12		20 40.2	018 22.8				commence SF6 patch survey
	00:00		20 41.5	018 22.5				SF6 survey continues
29/04/2009	02:00		20 37.7	018 25.8				
	03:20		20 39.1	018 27.0				hove to - getting drift direction
	03:31		20 39.1	018 27.1		CTD 43		CTD overboard. Buoy 258oT 0.9
	03:54		20 39.0	018 27.4		CTD 43		CTD inboard
	04:25		20 38.7	018 27.8		CTD 44		CTD overboard
	05:03		20 38.6	018 28.4		CTD 44		CTD inboard, sampling commences
	05:48		20 38.7	018 28.9				commence SF6 mapping
	08:58		20 37.7	018 30.9		CTD 45		CTD overboard
	09:35		20 37.6	018 31.1		CTD 45		CTD inboard, hove to in vicinity of patch centre
	10:12		20 37.2	018 31.6				commence turbulence probe
	10:40		20 36.5	018 32.2				turbulence probe overboard
	11:53		20 37.7	018 33.4				turbulence probe inboard
	12:00		20 37.8	018 33.3				
	12:25		20 37.8	018 31.9		CTD 46		CTD overboard
	12:38		20 37.8	018 33.1		OPT 009		optics rig overboard
	13:12		20 38.0	018 33.4		OPT 009		optics rig inboard
	14:24		20 38.3	018 33.9		CTD 46		CTD inboard
	14:35		20 38.3	018 34.0				turbulence probe deployed ca 1 hr
	15:48		20 38.2	018 35.1		NET 11		commence net deployment (Apstein)
						NET 11		Apstein inboard
						NET 12		Bongo overboard

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Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
						NET 12		Bongo inboard
						NET 13		700 micron overboard
	16:31		20 38.3	018 35.5		NET 13		complete net deployment
	16:57		20 37.4	018 35.6				turbulence probe deployed
	18:34		20 38.7	018 36.1				turbulence probe inboard
	19:06		20 38.8	018 36.5		CTD 47		CTD overboard
	19:43		20 38.9	018 36.8		CTD 47		CTD inboard, commence SF6 survey
	00:00		20 38.4	018 39.8				SF6 mapping continues
30/04/2009	02:00		20 36.3	018 35.8				
	02:53		20 38.3	018 39.5				hove to on station
	03:34		20 38.2	018 40.3		CTD 48		CTD overboard, buoy 145oT and 0.8
	04:00		20 38.1	018 40.5		CTD 48		CTD inboard
	04:32		20 38.0	018 40.8		CTD 49		CTD overboard
	05:08		20 37.9	018 41.2		CTD 49		CTD inboard
	08:55		20 35.9	018 42.5		CTD 50		CTD overboard
	09:26		20 35.8	018 42.6		CTD 50		CTD inboard
	10:00		20 35.6	018 43.2				proceed to pick up drifter buoy
	10:40		20 34.9	018 43.8		#2880		drifter grappled
	10:43		20 34.9	018 43.9		#2880		drifter inboard. Hove to on station awaiting drifter buoy positions
	10:45		20 34.9	018 43.9				proceed 090 T to pick up other drifter buoys
	12:00		20 35.4	018 43.0				
	14:00		20 35.1	018 44.3				continue searching for buoys
	16:00		20 32.9	018 44.8				
	17:36		20 39.5	018 42.0		#2881		buoy grappled
	17:38		20 39.5	018 42.0		#2881		buoy recovered hove to awaiting MVP deployment
	18:44		20 39.6	018 40.0		#2879		buoy grappled
	18:45		20 39.6	018 40.0		#2879		buoy recovered
	18:49		20 39.6	018 40.0				deploying MVP
	21:00		20 52.3	018 37.2				continue MVP survey
01/05/2009	00:22		21 10.1	018 17.4				track 238 T
	02:00		21 03.3	018 37.3				
	04:00		20 33.7	018 30.7				
	06:00		20 47.6	019 03.9				MVP survey continues
	08:00		20 38.7	019 08.7				
	12:00		20 43.7	018 47.9				
	14:00		20 51.7	018 32.2				
	16:00		21 00.1	018 26.2				
	16:55		21 03.9	018 21.3				MVP recovered. Hove to for BBQ
	20:00		21 04.1	018 20.3				
	20:30		21 04.3	018 20.1				begin deployment of MVP
	20:58		21 04.3	018 21.4				MVP overboard. Commence survey 215 oT

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Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
02/05/2009	02:00		20 35.6	018 41.9				
	04:00		20 24.2	018 50.6				
	04:55		20 19.7	018 53.9				MVP recovered Hove to awaiting buoy position
	04:58		20 19.7	018 53.8				commence search for buoy
	06:48		20 20.8	018 49.9		#5990		grappled
	06:49		20 20.8	018 49.8		#5990		buoy recovered
	07:00		20 20.8	018 49.7				MVP deployed BT off
	10:18		20 02.9	018 37.3				MVP recovered
	10:20		20 02.9	018 37.3				commence search for buoy
	10:54		20 02.0	018 37.1		#5988		buoy grappled
	10:55		20 02.0	018 37.1		#5988		buoy #5988 onboard
	11:10		20 02.0	018 37.0				MVP deployed - continue with survey
	14:00		20 11.3	018 34.9				
	16:00		20 34.2	018 18.1				
	20:00		20 57.3	018 15.7				
	20:25		20 59.9	018 14.2				begin recovery of MVP
	20:35		20 59.9	018 14.1				MVP inboard
	20:38		20 59.8	018 14.1				deploy MVP and continue with survey
03/05/2009	02:00		20 24.7	018 24.3				
	04:00		20 11.0	018 28.7				
	04:24		20 08.3	018 29.4				A/C to 097o 10 degrees per minute
	06:00		20 05.7	018 18.6				
	07:22		20 05.5	018 09.8				A/C to 005o 10 degrees per minute
	08:00		20 08.8	018 09.1				
	08:49		20 14.5	018 08.6				begin recovery of sampling fish
	08:50		20 14.5	018 08.6				sampling fish inboard
	09:00		20 14.7	018 08.7				deploy sampling fish, continue with MVP survey
	12:00		20 33.7	018 06.6				continue with MVP survey
	14:00		20 47.8	018 05.2				
	15:48		21 00.0	018 04.1				new track 070oT
	18:05		21 04.2	017 08.1				new track 189oT
	20:00		20 51.3	017 49.0				MVP survey continues
	00:00		20 23.6	017 54.4				MVP survey continues
04/05/2009	02:00		20 09.1	017 57.4				
	04:00		19 55.1	018 00.0				
	05:00		19 48.1	018 00.8				A/C 087 at 10 degrees per minute
	08:00		19 47.5	017 40.0				MVP survey continues
	11:00		19 48.4	017 17.4				commence recovery of MVP
	11:15		19 48.2	017 17.0				MVP at 2m hove to on station
	11:17		19 48.3	017 17.0		51	CTD	CTD overboard to 350m
	11:45		19 48.3	017 17.0		51		CTD inboard
	11:52		19 48.3	017 17.0				commence MVP vertical dip to 350m

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Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	12:19		19 48.4	017 17.2		14		Apstein net deployment
	12:33		19 48.4	017 17.3		15		Bongo net deployment
	12:50		19 48.4	017 17.5		16		700 micron net deployment
	13:07		19 48.4	017 17.6				nets inboard
	13:26		19 48.7	017 17.7				resume MVP survey
	17:00		20 04.4	017 29.2				
	19:54		20 23.7	017 34.5				A/C 022oT
	22:35		20 40.5	017 27.7				A/C 002oT
05/05/2009	02:00		21 03.7	017 26.6				
	02:36		21 07.7	017 26.9				new track 282 oT
	04:45		21 09.8	017 42.9				new track 177 oT
	06:00		21 00.7	017 42.9				
	08:00		20 46.5	017 42.0				
	12:00		20 17.1	017 39.7				MVP survey throughout
	14:36		19 58.7	017 38.8				MVP inboard
	14:44		19 58.6	017 38.9				Hove to
	15:17		19 58.8	017 39.1				complete test deployment
	15:30		19 58.8	017 39.1				deployed ADCP buoy
	15:40		19 58.9	017 39.0				wave sampler inboard
	15:57		19 58.7	017 39.4				grappled
	16:03		19 58.7	017 39.5				all gear inboard
	16:23		19 58.9	017 39.6				deployment of ADCP starts
	16:25		19 58.9	017 39.6				ADCP buoy deployed
	17:08		19 58.9	017 39.8				deploying wire walker
	17:24		19 59.0	017 39.9				deployed wave rider
	18:45		19 59.3	017 40.9				grappled
	18:59		19 59.2	017 41.0				buoy recovered
	19:14		19 59.5	017 40.9				buoy grappled
	19:20		19 59.5	017 41.0				buoy recovered
	20:00		20 00.0	017 42.7				commence ADCP survey
	00:00		20 15.0	018 01.6				ADCP survey continues
06/05/2009	02:00		20 28.9	018 01.9				
	04:00		20 41.4	018 02.6				
	07:24		21 05.7	018 03.8				A/C 090 oT ADCP survey continues
	08:00		21 06.0	017 59.4				
	08:30		21 06.0	017 53.1				A/C 180oT ADCP survey continues
	14:00		20 11.4	017 53.1				
	15:12		20 30.0	017 53.0				hove to awaiting instructions
	17:54		20 31.0	017 53.4				instructed to proceed to 21 30N 18W for survey work
	20:00		20 48.5	017 55.2				survey adjusted to new position
	21:30		21 00.5	017 59.9				A/C 326oT to begin ADCP survey
07/05/2009	02:00		21 12.8	017 54.8				

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Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	05:24		21 31.5	018 01.5				A/C 122oT
	07:44		21 22.4	017 45.0				hove to awaiting survey results
	08:00		21 22.7	017 45.0				
	08:36		21 23.2	017 45.0				MVP overboard
	09:00		21 23.2	017 45.0				commence MVP survey 286oT
	09:43		21 24.1	017 48.7				A/C to 173 oT, continue MVP survey
	11:55		21 10.8	017 46.7				A/C to 013 oT, continue MVP survey
	12:00		21 11 .4	017 46.6				
	14:00		21 25.0	017 43.3				
	17:52		21 27.3	018 08.2				A/C 143oT
	18:18		21 23.2	018 05.6				instructed to continue on this course for 1 hour
	19:08		21 16.5	018 00.9				Instructed to stop, commence recovering MVP
	19:16		21 15.9	018 00.6				MVP recovered, hove to, instructed to steer 030oT
	21:00		21 25.2	017 54.7				hove to, ADCP buoy overboard
	21:34		21 25.8	017 54.7				deploy MVP and commence ADCP survey
08/05/2009	02:00		21 25.7	017 53.6				
	03:25		21 25.3	017 36.1				hove to
	03:35		21 25.4	017 56.1				MVP inboard
	04:04		21 25.5	017 55.7			52	CTD overboard to 150m
	04:26		21 25.5	017 55.7			52	CTD inboard
	05:02		21 25.5	017 56.0			53	CTD overboard to 200m
	05:37		21 25.5	017 56.2			53	CTD inboard, commence sampling
	06:30		21 26.0	017 56.5				commence box survey ADCP
	11:15		21 28.6	017 57.4				hove to in vicinity of ADCP buoy
	11:35		21 28.8	017 57.4				proceed to position 4 km NW of ADCP buoy
	12:00		21 30.0	017 58.7				
	13:18		21 31.1	017 59.4				floatation deployed
	13:19		21 31 1	017 59.4				wire walker deployed
	13:41		21 31.3	017 59.3				SF6 hose deployed
	14:00		21 31.0	017 59.4				commence SF6 deployment
	20:12		21 31.7	018 01.4				complete SF6 deployment, recover SF6 equipment
	20:18		21 31.7	018 01.5				all SF6 deployment equipment inboard
	20:34		21 31.7	018 01.6				Carioca buoy overboard
	20:37		21 31.8	018 01.5				MVP overboard
	21:00		21 32.0	018 01.5				commence MVP survey
09/05/2009	02:00		21 32.3	017 59.7				continue MVP survey
	03:10		21 36.8	017 36.2				MVP inboard
	03:54		21 31.8	017 59.0				hove to on station
	04:00		21 31.7	017 59.0			54	CTD overboard to 120m, commence air sampling
	04:28		21 31.6	017 59.1			54	CTD inboard
	05:00		21 31.2	017 59.4			55	CTD overboard to 200m
	05:35		21 30.7	017 59.8			55	CTD inboard

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Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	06:24		21 30.3	017 59.8				commence turbulence probing
	08:33		21 30.9	017 59.4				turbulence probe inboard. Proceed to patch centre
	09:04		21 30.5	018 00.0			56	hove to CTD overboard to 200m
	09:35		21 30.7	018 00.1			56	CTD inboard
	10:11		21 31.1	018 00.6			17	Apstein net overboard
	10:25		21 31.3	018 00.7			17	Apstein net inboard
	10:27		21 31.3	018 00.7				commence turbulence probing
	11:30		21 31.8	018 02.2				turbulence probe inboard
	12:00		21 33.6	018 02.3				
	12:03		21 33.8	018 02.5				hove to on station
	12:07		21 33.8	018 02.6			57	CTD overboard
	12:35		21 34.2	018 02.7			opt 010	optics rig overboard
	13:21		21 34.5	018 01.9			opt 011	optics rig overboard
	13:40		21 34.6	018 02.8				optics rig inboard
	13:46		21 34.7	018 02.8				wire walker overbaord
	13:52		21 34.8	018 02.8			57	CTD inboard
	14:12		21 34.8	018 02.6				commence turbulence probe towards drifter buoy
	15:20		21 34.0	018 02.8				completed turbulence probe deployment
	16:00		21 52.8	018 02.9				commence turbulence probe
	17:30		21 33.0	018 02.8				turbulence probe recovered
	17:45		21 33.7	018 02.8				MVP deployed
	18:25							MVP failure
10/05/2009	02:00		21 37.7	018 04.3				
	03:47		21 39.1	018 02.2				hove to on station
	03:59		21 39.1	018 02.2			58	CTD overboard to 120m
	04:22		21 39.1	018 02.1			58	CTD inboard
	05:02		21 37.4	018 02.0			59	CTD overboard to 200m
	05:39		21 37.3	018 02.1			59	CTD inboard, commence sampling
	06:00		21 37.2	018 02.2				instructed to steer 070 at 3 knots
	06:40		21 37.5	018 00.8				hove to to deploy drifter
	06:47		21 37.5	018 00.8				drifter deployed, steer 040 at max speed to find and recover ADCP buoy
	07:41		21 40.9	017 56.3				buoy grappled
	07:52		21 40.8	017 56.4				buoy recovered
	08:52		21 36.3	018 00.7				hove to in vicinity of drifter buoy
	09:03		21 36.3	018 00.6			60	CTD overboard to 200m
	09:35		21 36.2	018 00.7			60	CTD inboard
	10:03		21 36.2	018 00.8			18	Apstein net overboard
	10:15		21 36.2	018 00.8			18	Apstein net inboard
	10:30		21 36.2	018 00.8				proceed to position for ADCP buoy deployment
	11:12		21 36.0	018 00.3				hove to for ADCP buoy deployment
	11:15		21 36.1	018 00.3				ADCP buoy overboard

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Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	11:18		21 36.1	018 00.3				proceed to position for CTD
	11:45		21 36.1	018 01.6				hove to in vicinity of patch centre
	11:47		21 36.5	018 01.6			61	CTD overboard to 1430m
	12:00		21 36.2	018 01.8				
	12:34		21 36.5	018 02.0			OPT 012	optics rig overboard
	13:23		21 36.9	018 02.3			61	CTD inboard
	13:38		21 37.0	018 02.4				optics rig inboard
	15:00		21 33.0	018 03.6				turbulence probe overboard
	19:34		21 34.9	018 04.0				turbulence probe recovered
	21:10		21 35.2	018 04.5				commence ADCP survey B/T off
11/05/2009	02:00		21 40.7	018 05.7				
	05:50		21 39.0	018 03.5				ADCP survey, standing by first buoy
	07:04		21 39.3	018 03.2				buoy grappled
	07:18		21 39.2	018 03.2				buoy recovered. Proceed to wave rider to recover
	08:03		21 36.9	018 03.8				buoy grappled
	08:07		21 36.8	018 03.9				buoy recovered
	08:07		21 36.8	018 03.9				proceed to pick up drifter buoy
	09:21		21 32.6	018 08.0				drifter grappled
	09:23		21 32.6	018 08.0				drifter inboard
	09:35		21 32.6	018 08.0				proceed to Carioca buoy position
	12:00		21 17.4	018 20.9				
	12:33		21 14.2	018 24.8				buoy grappled
	12:38		21 14.2	018 24.8				all gear inboard
	13:00		21 14	018 25				set course 194 (T)
	16:00		20 41.9	018 33.4				
	18:00		20 19.4	018 39.3				
	20:00		19 56.2	018 45.3				
12/05/2009	01:30		18 54.0	019 01.3				new track 172o(T)
	02:12		18 46.0	019 00.4				new track 335o (T)
	06:00		19 17.0	019 16.0				
	08:00		19 31.9	019 23.4				
	10:00		19 40.8	019 31.6				
	14:06		18 56.3	019 50.1				new track 342o(T)
	15:26		19 06.8	019 55.7				hove to. MVP test weight deployed
	16:10		19 08.0	19 54.5				MVP test wt recovered
	16:25		19 08.6	019 54.9				instructed to 19 12 8N 019 42.7 W BT off
	18:20		19 12.8	019 43.1				v/l hove to preparing for CTD BT on
	18:31		19 12.8	019 43.2			62	CTD overboard to 200m
	19:05		19 12.8	019 43.8			62	CTD inboard
	19:54		19 12.5	019 44.5			Net 18	Apstein net overboard
	20:05		19 12.5	019 44.5			Net 18	Apstein net inboard
	21:15		19 12.5	019 44.5				commence ADCP survey BT off

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
13/05/2009	02:00		19 10.0	019 07.2				
	04:00		19 22.3	019 01.0				
	06:30		19 20.4	018 45.5				v/l head to wind to allow clearing of galley due to backed up scuppers due to heel wind NNE x 30 knts
	09:00		19 26.1	018 46.2				proceed back to track to continue ADCP survey
	10:00		19 18.6	018 40.0				continue ADCP survey
	10:30		19 17.2	018 36.6				hove to for MVP testing
	10:47		19 17.2	018 36.7				MVP overboard. Proceed 030 o(T) at 7 knts
	11:30		19 21.5	018 34.4				testing of MVP complete, continue with ADCP / MVP survey
	12:00		19 25.0	018 33.0				
	14:00		19 37.2	018 28.1				
	14:34		19 39.6	018 27.0				MVP inboard
	15:18		19 40.4	018 26.8			63	CTD overboard
	15:49		19 40.5	018 27.1			63	CTD inboard
	16:00		19 40.5	018 27.3			Net 20	Apstein net overboard
	16:14		19 40.5	018 27.4			Net 20	Apstein net inboard
	16:15							reposition v/l for MVP launch
	17:00		19 36.9	018 28.1				hove to preparing to deploy MVP
	17:03		19 37.0	018 28.1				MVP deployed
	19:36		19 51.9	018 21.7				A/C 090o(T)
	21:34		19 52.6	018 08.5				hove to, to deploy drifter buoy
	21:36		19 52.6	018 08.5				drifter buoy overboard
	21:43		19 52.6	018 08.5				commence ADCP MVP survey
14/05/2009	02:00		19 54.5	018 10.7				
	03:25		19 51.7	018 08.3				MVP inboard
	03:34		19 52.9	018 09.7				Hove to
	04:47		19 52.2	018 09.0			64	CTD overboard and down to 150m
	05:09		19 52.1	018 09.3			64	CTD inboard
	05:36		19 52.2	018 09.8			65	CTD overboard and down to 150m
	06:06		19 52.2	018 10.2			65	CTD inboard
	07:36		19 53.0	018 10.8				buoy grappled
	07:42		19 53.0	018 10.8				buoy recovered
	08:25		19 52.4	018 11.2				MVP overboard. Commence ADCP survey. BT off
								051 o(T) at 7.0 knts
	10:30		20 00.0	018 00.0				A/C to 282 o(T)
	12:00		20 02.5	018 10.5				
	13:46		20 02.9	018 11.1				MVP inboard
	18:40		19 20.6	017 58.4				A/C 066 T new patch location
	20:00		19 24.3	017 50.0				v/l hove to preparing to deploy wire walker
	20:10		19 24.4	017 49.9				wire walker buoy overboard
	20:18		19 24.6	017 49.9				MVP overboard Commence ADCP survey
	22:19		19 24.5	017 51.8				MVP inboard Proceed to patch centre

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	22:38		19 24.5	017 51.4				start to deploy SF6 hoses
	23:10		19 24.8	017 51.1				hove to on station Preparing to deploy SF6
	23:40		19 24.8	017 51.3				start SF6 deployment
15/05/2009	02:00		19 25.6	017 51.9				
	05:19		19 25.7	017 52.8				head to wind recovering SF6 hose
	05:30		19 25.8	017 52.9				SF6 hose recovered
	05:42		19 26.0	017 53.1				Carioca buoy deployed (unlit)
	06:52		19 24.9	017 55.1				ADCP buoy deployed
	07:19		19 25	017 54.0				drifter buoy 1 deployed
	07:56		19 26.1	017 55.6				drifter buoy 2 deployed
	08:40		19 25.6	017 55.7				hove to on station in patch centre
	09:05		19 25.6	017 55.7			66	CTD overboard down to 200m
	09:08		19 25.6	017 55.7			OPT 013	optics rig overboard
	09:40		19 25.7	017 55.9			66	CTD inboard
	09:51		19 25.7	017 55.9			OPT 013	optics rig inboard
	10:23		19 25.9	017 56.4			NET 21	Apstein net overboard
	10:35		19 25.9	017 56.4			NET 21	Apstein net inboard
	10:50		19 25.9	017 56.4				turbulence probe overboard
	11:43		19 26.0	017 57.1				turbulence probe inboard
	11:50		19 26.0	017 57.3				hove to for CTD in patch centre
	11:54		19 26.0	017 57.3			67	CTD overboard down to 2240m
	noon		19 26.2	017 57.4				
	12:31		19 26.3	017 57.6			OPT 014	optics rig overboard
	12:50		19 26.4	017 57.7			67	CTD at 2240m on way up
	13:10		19 26.3	017 57.8			OPT 014	optics rig inboard
	14:04		19 26.7	017 57.9			67	CTD inboard
	14:22		19 26.4	017 58.1				commence turbulence probe
	15:30		19 22.7	017 58.9				completed turbulence probe
	15:43		19 27.7	017 59.0			OPT 015	optics rig overboard
	16:24							optics rig inboard waiting for shipping to clear to allow launch of MVP
	17:06		19 28.7	017 59.3				MVP deployed
16/05/2009	01:04		19 29.8	018 01.7				MVP inboard
	02:00		19 22.4	018 04.4				
	03:40		19 30.2	018 05.5				hove to on station
	04:00		19 30.4	018 05.7			68	CTD overboard to 150m
	04:24		19 30.6	018 05.8			68	CTD inboard
	04:54		19 30.8	018 06.1			69	CTD overboard to 200m
	05:28		19 31.0	018 06.5			69	CTD inboard, commence sampling
	06:04		19 31.2	018 06.7				sampling completed, proceeding to recover drifter
	06:51		19 28.6	018 07.1				buoy grappled
	06:52		19 28.6	018 07.1				buoy recovered

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	07:30		19 30.6	018 07.3				turbulence probe deployed
	08:30		19 31.1	018 07.5				turbulence probe inboard
	08:30		19 31.1	018 07.5				proceed to patch centre for CTD
	09:03		19 32.5	018 08.3			70	CTD overboard to 200m
	09:10		19 32.5	018 08.3			OPT 016	optice rig overboard
	09:42		19 32.6	018 08.5			70	CTD inboard
	09:50		19 32.6	018 08.5			OPT 016	optics rig inboard
	10:11		19 32.7	018 08.5			NET 22	Apstein net overboard
	10:25		19 32.7	018 08.5			NET 22	Apstein net inboard
	10:35		19 32.7	018 08.5				turbulence probe overboard
	11:25		19 33.3	018 08.8				turbulence probe inboard
	11:40		19 32.2	018 09.1				hove to in patch centre
	noon		19 32.5	018 09.1				
	12:07		19 32.3	018 09.2			71	CTD overboard
	12:32		19 32.6	018 09.3			OPT 017	optics rig overboard
	13:04		19 32.6	018 09.7			71	CTD inboard
	13:09		19 32.6	018 09.3			OPT 017	optics rig inboard
	13:30		19 32.6	018 09.7				commence turbulence probe
	16:37		19 35.0	018 10.9				turbulence probe recovered trying to steam 0.5 knts x 180o
	16:58		19 34.5	018 10.9				steering difficult, decision to steam to patch, re-establish and hove to for turbulence probe
	17:15		19 33.3	018 11,4				on location, probe deployed
	18:58		19 35.0	018 12.4				probe recovered
	19:37		19 34.5	018 12.9				drifter buoy deployed
	20:07		19 35.0	018 12.9			72	CTD overboard to 150m
	20:43		19 35.2	018 13.0			72	CTD inboard
	21:40		19 35.2	018 13.0				start ADCP mapping
17/05/2009	02:00		19 34.9	019 14.0				ADCP survey continues
	04:00		19 35.2	018 17.1				hove to on station
	04:03		19 35.1	018 17.1			73	CTD overboard to 120m. Commence atmospheric sampling
	04:28		19 35.2	018 17.3			73	CTD inboard (monster)
	05:00		19 35.5	018 17.6			74	CTD overboard to 120m
	05:31		19 35.5	018 17.8			74	CTD inboard, commence sampling
	05:50		19 35.4	018 17.9				atmospheric sampling finished
	06:44		19 35.3	018 18.1				turbulence probe deployed
	08:25		19 36.4	018 18.0				turbulence probe inboard, hove to on station
	09:08		19 36.5	018 18.5			OPT 018	optics rig overboard
	09:10		19 36.5	018 18.5			75	CTD overboard down to 200m
	09:48		19 36.5	018 18.7			75	CTD inboard
	09:48		19 36.5	018 18.7			OPT 018	optics rig inboard

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	10:24		19 36.4	018 19.0			NET 23	Apstein net overboard
	10:37		19 36.4	018 19.0			NET 23	Apstein net inboard
	10:38		19 36.4	018 19.0			NET 24	net overboard
	11:05		19 36.5	018 19.3			NET 24	net inboard
	11:07		19 36.5	018 19.3			NET 25	net overboard
	11:25		19 36,6	018 19.4			NET 25	net inboard
	12:00		19 36.6	018 21.0				hove to in patch centre
	12:05		19 36.7	018 21.2			76	CTD overboard
	12:34		19 36.8	018 21.5			OPT 019	optics rig overboard
	12:46		19 36.8	018 21.6			OPT 019	optics rig inboard
	12:57		19 36.9	018 21.6			76	CTD inboard
	13:03		19 36.96	018 21.7				drifter deployed
	13:14		19 37.2	018 21.8				turbulence probe deployed
	14:38		19 38.7	018 22.5				turbulence probe inboard
	15:15		19 36.8	018 22.9				turbulence probe deployed
	17:15		19 35.2	018 20.3				16:15 turbulence probe recovered, buoy grappled
	17:18		19 35.2	018 20.3				buoy recovered
	18:12		19 35.8	018 20.7				buoy grappled
	18:20		19 35.8	018 20.8				buoy recovered
	19:50		19 37.2	018 27.0				wire walker deployed
	20:20		19 38.7	018 27.2				ADCP buoy deployed
	20:50		19 38.7	018 27.2				commence ADCP survey
18/05/2009	02:00		19 42.41	018 28.0				
	03:45		19 40.5	018 27.5				hove to
	04:00		19 40.6	018 27.5			77	CTD overboard to 120m Atmospheric sampling starts
	04:25		19 40.6	018 27.6			77	CTD inboard (monster)
	04:48							buoy (unlit) 7456 spotted and missed
	04:58		19 40.5	018 27.8			78	CTD overbboard and down to 120m
	05:25		19 40.5	018 28.0			78	CTD inboard, commence sampling
	06:00		19 40.4	018 28.4				Atmospheric sampling ends. Proceed to recover drifter buoy
	07:00		19 35.7	018 29.5				buoy grappled
	07:01		19 35.7	018 29.5				buoy recovered Proceeding back to locate SF6
	07:42		19 38.7	018 29.4				hove to preparing for CTD
	07:44		19 38.7	018 29.4			79	CTD overboard and down to 70m
	08:17		19 38.8	018 29.5			79	CTD inboard
	08:20		19 38.8	018 29.5				proceed north to patch centre
	10:06		19 43.1	018 26.0			80	hove to on station, CTD overboard to 120m
	10:40		19 43.1	018 26.2			80	CTD inboard
	10:42		19 43.1	018 26.2				drifter buoy overboard
	11:00		19 43.1	018 26.2				commence ADCP survey
	noon		19 45.9	018 24.0				

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	12:32		19 45.3	018 26.5				hove to on station
	12:37		19 45.3	018 26.5			81	CTD overboard
	12:50		19 43.3	018 26.7			OPT 020	optics rig overboard
	13:27		19 43.3	018 26.8			OPT 020	optics rig inboard
	14:52		19 43.5	018 17.3			81	CTD inboard
	15:38		19 43.5	018 27.9			NET 26	net overboard
	15:47		19 43.5	018 28.0			NET 26	net inboard
								turbulence probing 14:00 till 16:00. Relocated at 16:00
	16:31		19 41.0	018 30.2				hove to - deploying turbulence probe
	18:52		19 42.0	018 31.4				probe recovered, commence wire walker search
	20:10		19 37.6	018 37.0				buoy grappled
	20:20		19 37.6	018 37.0				buoy inboard and secure. Proceed to ADCP survey start &
	21:15		19 43.0	018 23.9				commence ADCP survey
19/05/2009	02:00		19 45.8	018 43.1				
	03:50		19 44.4	018 37.3				hove to on station
	03:58		19 44.4	018 37.4			82	CTD overboard to 120m Atmospheric sampling
	04:22		19 44.4	018 37.5			82	CTD inboard
	04:56		19 44.4	018 37.6			83	CTD overboard to 120m
	05:24		19 44.4	018 37.7			83	CTD inboard
	06:00		19 44.5	018 37.9				Atmospheric sampling completed
	06:15		19 44.5	018 37.9				wire walker deployed
	08:55		19 44.5	018 38.8			84	CTD overboard to 120m
	09:30		19 44.6	018 38.8			84	CTD inboard
	10:00		19 44.7	018 38.8			27	Apstein net overboard
	10:15		19 44.8	018 38.9			27	Apstein net inboard
	noon		19 45.0	018 39.3				
	12:05		19 45.0	018 39.3			85	CTD overboard
	12:30		19 45.0	018 39.6			OPT 021	optics rig overboard
	13:03		19 45.0	018 39.4			85	CTD + optics rig inboard
	15:00							grappled ADCP
	15:07		19 19.7	018 43.0				ADCP drifter inboard
	16:03		19 33.7	018 41.9				B/T on, buoy sighted
	16:20		19 33.8	018 41.6				grappled
	16:21		19 33.8	018 41.6				recovered, proceeding to patch
	18:15		19 45.4	018 39.3				hove to
	19:22		19 43.6	018 42.5				in position for buoy launch (ADCP)
	19:26		19 43.6	018 42.5				buoy deployed
	19:32		19 43.8	018 42.5				MVP deployed
	00:00		19	18				MVP survey throughout
20/05/2009	02:00		19 41.7	018 48.1				
	02:29		19 39.3	018 49.8				MVP inboard

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Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	04:00		19 41.6	018 46.0			86	CTD overboard to 120m
	04:23		19 41.4	018 46.2			86	CTD inboard
	05:00		19 41.2	018 46.7			87	CTD overboard to 120m
	05:26		19 41.1	018 47.1			87	CTD inboard
	05:40		19 41.2	018 47.2				commence deploying drifter buoy 2880
	06:36		19 41.3	018 47.2				turbulence probe in water
	07:01		19 41.5	018 47.8				probe recovered
	08:07		19 41.1	018 48.8				grappled
	08:12		19 41.1	018 48.8				recovered
	08:30		19 40.9	018 48.6			88	CTD overboard to 110m
	08:30		19 40.9	018 48.6			OPT 022	optics cast overboard
	08:50		19 40.9	018 48.7			OPT 022	optics rig inboard
	09:03		19 41.0	018 48.8			88	CTD inboard
	09:30		19 40.7	018 49.2				turbulence probe overboard
	09:58		19 40.8	018 49.3				turbulence probe inboard
	10:14		19 40.8	018 49.4			NET 28	Apstein net overboard
	10:23		19 40.8	018 49.4			NET 28	Apstein net inboard
	10:42		19 40.2	018 49.7				turbulence probe overboard
	11:30		19 40.7	018 49.9				turbulence probe inboard
	11:50							turbulence probe overboard
	noon		19 40.1	018 30.3				
	12:28		19 40.4	018 50.3				turbulence probe inboard
							OPT 023	optics rig overboard
	13:07		19 40.4	018 30.3			89	CTD inboard
	13:13		19 40.4	018 50.5			OPT 023	optics rig inboard
	13:26		19 40.6	018 50.8				turbulence probe overboard
	14:14		19 41.1	018 50.3				turbulence probe inboard
	14:40		19 40.4	018 51.3				turbulence probe overboard
	16:16		19 41.5	018 51.8				probe recovered
	16:36		19 41.0	018 52.0			90	CTD overboard to 120m
	16:40		19 41.0	018 52.0			OPT 024	optics rig overboard
	17:02		19 41.0	018 52.3			90	CTD inboard
	17:05		19 41.0	018 52.3			OPT 024	optics rig inboard
	17:16		19 41.0	018 52.4				turbulence probe overboard
	17:56		19 41.4	018 52.6				turbulence probe inboard - repositioning
	18:19		19 40.8	018 52.9				hove to
	18:50		19 41.0	018 52.8				turbulence probe deployed
	19:30		19 41.6	018 52.7				probe inboard
	19:48		19 41.0	018 52.8				turbulence probe in water
	20:16		19 41.2	018 53.0				turbulence probe inboard
	20:30		19 41.1	018 53.0			91	CTD overboard to 120m
	20:30		19 41.1	018 53.0			OPT 025	optics rig overboard

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Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	20:56		19 41.2	018 52.9			OPT 025	optics rig inboard
	21:05		19 41.2	018 52.9			91	CTD inboard
	21:30		19 41.3	018 52.9				turbulence probe overboard
	22:30		19 41.5	018 53.1				turbulence probe inboard
	23:30		19 40.2	018 52.8				turbulence probe overboard
21/05/2009	00:20		19 40.3	018 52.7				turbulence probe inboard
	02:00		19 40.7	018 53.2				
	03:58		19 38.3	018 54.0			92	CTD overboard, air sampling commences
	04:21		19 38.2	018 54.0			92	CTD inboard
	04:59		19 38.1	018 54.2			93	CTD overboard to 110m
	05:32		19 57.9	018 54.5			93	CTD inboard, sampling commences
	06:02		19 37.4	018 54.8				air sampling completed, commence buoy searching
	07:04		19 33.2	018 55.5				buoy grappled
	07:16		19 33.1	018 55.6				buoy recovered
	08:00		19 36.3	018 55.3				hove to, SF6 survey
	09:25		19 35.0	018 56.0			94	CTD overboard to 100m
	09:54		19 35.0	018 56.1			94	CTD inboard
	10:30		19 34.8	018 56.3			NET 29	Apstein net overboard
	10:42		19 34.8	018 56.4			NET 29	Apstein net inboard
	11:45		19 35.0	018 58.0				hove to for CTD
	noon		19 35.0	018 58.2				
	12:03		19 34.9	018 58.2			95	CTD overboard
	12:36		19 34.7	018 58.3			OPT 026	optics rig overboard
	13:01		19 34.7	018 58.4			95	CTD at 2930m on way up
	13:18		19 34.7	018 58.4			OPT 026	optics rig inboard
	14:23		19 34.3	018 58.8			95	CTD inboard
	15:14		19 34.0	018 59.3			2879	buoy wire walker deployed
	15:23		19 34.1	018 59.4				commence turbulence probe
	16:24		19 34.1	018 59.4				turbulence rpobe recovered
	16:51		19 34.0	018 59.4				MVP deployed Bow thruster off
	22:03		19 30.5	019 08.4				MVP inboard
	22:41		19 30.8	019 08.8				commence SF6 survey
22/05/2009	02:00		19 30.3	019 07.6				
	04:09		19 31.4	019 06.2			96	CTD overboard to 100m
	04:30		19 31.3	019 06.4			96	CTD inboard
	05:09		19 31.1	019 06.7			97	CTD overboard to 100m
	05:36		19 30.8	019 06.9			97	CTD inboard
	06:17		19 30.4	019 07.4			98	CTD overboard to 100m
	06:44		19 30.1	019 07.6			98	CTD inboard
	07:35		19 29.6	019 08.4			99	CTD overboard to 500m
	08:34		19 29.3	019 08.7			99	CTD inboard
	08:40		19 29.3	019 08.7				proceed to pick up ADCP buoy

Central Scientific Event and Station Log

Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	09:45		19 26.5	019 05.8				ADCP buoy grappled
	09:56		19 26.5	019 05.8				ADCP buoy onboard, proceed to pick up drifter
	noon		19 17.9	019 12.4				
	12:31		19 17.2	019 13.6				drifter inboard
	14:03		19 26.3	019 09.2			OPT 027	hove to on station
	14:08		19 26.3	019 09.2			OPT 027	optics rig overboard
	14:49		19 26.2	019 09.4			OPT 027	optics rig inboard
	15:06		19 26.3	19 09.3				wire walker inboard
	15:28		19 26.0	019 09.9				MVP deployed
	15:38		19 25.6	019 09.7				commenced MVP survey at 10 knots
	20:00		18 56.8	018 36.3				continue MVP survey
	22:00		19 03.5	018 33.9				continue MVP survey
	00:00		19 10.2	018 23.2				continue MVP survey
23/05/2009	02:00		19 16.8	018 10.2				
	04:00		19 28.3	018 12.6				
	06:06		19 42.6	018 19.5				MVP survey continues
	08:00		19 54.6	018 25.6				MVP survey continues
	09:48		20 01.3	018 36.0				reduce speed to recover MVP
	09:56		20 01.3	018 36.3				MVP inboard, hove to on station
	10:16		20 01.6	018 36.4				proceed 180oT to recover Carioca buoy
	12:00		19 45.0	018 36.5				
	14:00		19 22.3	018 36.6				
	16:00		19 00.7	018 36.6				
	18:29		18 52.0	018 46.5				buoy grappled
	18:30		18 52.0	018 46.5				buoy recovered
	19:16		18 52.1	018 46.7			100	CTD overboard to 500m
	19:45		18 52.3	018 46.7			100	CTD inboard. Commence 3 hr steam 015oT
	22:40		19 14.4	018 40.2				hove to on station for CTD
	22:48		19 14.4	018 40.2			101	CTD overboard to 500m
	23:25		19 14.5	018 40.1			101	CTD inboard. Commence 3 hr steam 015oT
24/05/2009	02:00		19 35.3	018 34.3				
	02:32		19 38.8	018 33.4			102	hove to on station
	02:36		19 38.8	018 33.4			102	CTD overboard
	03:08		19 38.9	018 33.4			102	CTD inboard
	03:12		19 38.9	018 33.4				3 hr steam on 015oT
	05:54		19 58.9	018 27.5				06:15 CTD cancelled - end of science due to current wx/spd req/ETA Tenerife
	10:00		20 27.4	018 19.1				on passage to Tenerife 015oT
	12:00		20 41.5	018 15.8				A/C 013 oT
	14:00		20 37.2	018 11.7				
	16:00		21 12.7	018 07.9				
	18:00		21 29.1	018 04.0				

Central Scientific Event and Station Log

Cruise: **UK SOLAS Discovery 338 ICON cruise**

Start date	Start time GMT	Cast Event ID	Latitude oN	Longitude oW	Water depth (m)	Activity/ Gear	Site/ Station name	Comments/Notes
	20:00		21 45.2	018 00.0				average speed 8.125 knts
	22:00		22 02.4	017 55.8				
	00:00		21 18.1	017 52.1				
25/05/2009	01:00	GMT	22 26.0	17 50.2				clock advances 1 hr to GMT+1
	02:10	GMT+1						reduced to 140 rpm due to high propulsion motor temp
	03:00		22 33.6	017 48.3				increased to 145 rpm
	04:00		22 40.8	017 46.6				average speed 7.8 knts
	06:00		22 55.2	017 43.0				
	08:00		23 09.9	017 39.4				average speed last 4 hrs 7.47 knots

Appendix 2 Turbulence probe stations during D338. Depth corresponds to total water column depth and not the maximum depth of the profiles.

	Jday	Date	Time	Cast N	Lat	North	Lon	West	Depth	Observations
1	113	23/04/09	15:15	1	21	6.42000	17	24.62000	83	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:18	2	21	6.44900	17	24.67300	83	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:21	3	21	6.47800	17	24.72600	83	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:24	4	21	6.50000	17	24.75900	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:27	5	21	6.52400	17	24.79200	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:31	6	21	6.54950	17	24.82165	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:34	7	21	6.57558	17	24.85021	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:38	8	21	6.60167	17	24.87877	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:41	9	21	6.62775	17	24.90733	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:45	10	21	6.65383	17	24.93588	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:48	11	21	6.67992	17	24.96444	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:52	12	21	6.70600	17	24.99300	84	NEXT TO CENTRAL DRIFTER
1	113	23/04/09	15:57	13	21	6.73300	17	25.03600	84	NEXT TO CENTRAL DRIFTER
2	113	23/04/09	18:46	14	21	4.89300	17	25.36300	84	1KM FROM CENTRAL BUOY
2	113	23/04/09	18:52	15	21	4.90650	17	25.34685	84	1KM FROM CENTRAL BUOY
2	113	23/04/09	18:58	16	21	4.92000	17	25.33070	84	1KM FROM CENTRAL BUOY
2	113	23/04/09	19:01	17	21	4.93330	17	25.32150	84	1KM FROM CENTRAL BUOY
2	113	23/04/09	19:05	18	21	4.93320	17	25.30720	84	1KM FROM CENTRAL BUOY
2	113	23/04/09	19:08	19	21	4.92350	17	25.29110	84	1KM FROM CENTRAL BUOY
2	113	23/04/09	19:13	20	21	4.90870	17	25.28195	84	1KM FROM CENTRAL BUOY
2	113	23/04/09	19:18	21	21	4.89390	17	25.27280	84	1.5KM FROM CENTRAL BUOY
2	113	23/04/09	19:22	22	21	4.87330	17	25.26600	84	1.5KM FROM CENTRAL BUOY
2	113	23/04/09	19:26	23	21	4.85270	17	25.25920	84	1.5KM FROM CENTRAL BUOY. low winds but still 1.5 2 m waves
3	114	24/04/08	10:20	24	20	57.47087	17	28.87247	86	bad down at the beginning
3	114	24/04/09	10:23	25	20	57.48442	17	28.86889	86	
3	114	24/04/09	10:28	26	20	57.49943	17	28.86219	86	

3	114	24/04/09	10:32	27	20	57.54664	17	28.85799	87	
3	114	24/04/09	10:35	28	20	57.58069	17	28.85021	86	
3	114	24/04/09	10:40	29	20	57.60880	17	28.83860	86	
3	114	24/04/09	10:44	30	20	57.63296	17	28.83430	86	
3	114	24/04/09	10:47	31	20	57.65241	17	28.83316	87	
3	114	24/04/09	10:51	32	20	57.67571	17	28.83079	87	
3	114	24/04/09	10:55	33	20	57.69929	17	28.82835	86	
4	114	24/04/09	12:16	34	20	56.51470	17	29.42970	86	Only 5 profiles because 12:30 it's CTD.PROBLEM!!
4	114	24/04/09	12:23	35	20	56.52270	17	29.44950	85	Sensors cap on !!
4	114	24/04/09	12:26	36	20	56.51550	17	29.46610	86	very depth!!! I think.
4	114	24/04/09	12:30	37	20	56.49102	17	29.48780	85	
4	114	24/04/09	12:33	38	20	56.48417	17	29.49611	86	
5	114	24/04/09	14:58	39	20	55.48880	17	31.22820	96	
5	114	24/04/09	15:02	40	20	55.51550	17	31.25210	95	
5	114	24/04/09	15:06	41	20	55.54090	17	31.28830	96	
5	114	24/04/09	15:10	42	20	55.55970	17	31.33530	96	
5	114	24/04/09	15:14	43	20	55.57330	17	31.37920	97	
5	114	24/04/09	15:18	44	20	55.58990	17	31.42840	96	
5	114	24/04/09	15:22	45	20	55.60930	17	31.47510	97	
5	114	24/04/09	15:26	46	20	55.62980	17	31.52850	97	
5	114	24/04/09	15:32	47	20	55.64510	17	31.57870	97	
5	114	24/04/09	15:34	48	20	55.65280	17	31.62370	97	
6	114	24/04/09	18:30	49	20	54.06350	17	32.97406	100	
6	114	24/04/09	18:34	50	20	54.12106	17	33.00294	100	
6	114	24/04/09	18:37	51	20	54.15741	17	33.03016	100	
6	114	24/04/09	18:42	52	20	54.18861	17	33.07678	100	
6	114	24/04/09	18:47	53	20	54.19719	17	33.12177	100	
6	114	24/04/09	18:51	54	20	54.20256	17	33.16267	101	

6	114	24/04/09	18:55	55	20	54.20476	17	33.19970	101	
6	114	24/04/09	18:59	56	20	54.20788	17	33.23516	101	
6	114	24/04/09	19:03	57	20	54.22639	17	33.26665	101	
6	114	24/04/09	19:07	58	20	54.25347	17	33.29802	101	
7	115	25/04/09	14:18	59	20	49.26856	17	42.18604	568	Adjusted probe buoyancy
7	115	25/04/09	14:25	60	20	49.21879	17	42.13328	567	
7	115	25/04/09	14:32	61	20	49.83275	17	42.07285	577	
7	115	25/04/09	14:39	62	20	48.86607	17	42.08248	627	
7	115	25/04/09	14:48	63	20	48.57445	17	42.23758	613	
7	115	25/04/09	15:00	64	20	48.37641	17	42.33756	595	
8	115	25/04/09	16:09	65	20	48.06119	17	43.49399	627	
8	115	25/04/09	16:27	66	20	48.07681	17	43.57089	634	
8	115	25/04/09	16:33	67	20	48.07926	17	43.64057	640	
8	115	25/04/09	16:41	68	20	48.07340	17	43.71371	646	
9	115	25/04/09	18:08	69	20	47.54700	17	44.70800	722	
9	115	25/04/09	18:14	70	20	47.50000	17	44.77500	728	
9	115	25/04/09	18:42	71	20	47.54499	17	44.96917	736	
9	115	25/04/09	18:50	72	20	47.62898	17	45.03267	744	
10	116	26/04/09	11:26	73	20	40.10324	17	50.07583	529	!!!! Ship velocity 2-2.5Knots
10	116	26/04/09	11:35	74	20	40.34669	17	49.90905	531	
10	116	26/04/09	11:58	75	20	40.14483	17	50.42961	540	
10	116	26/04/09	12:08	76	20	40.38100	17	50.41843	547	
11	116	26/04/09	15:04	77	20	41.02485	17	50.88464	587	
11	116	26/04/09	15:14	78	20	41.12897	17	51.04240	597	
11	116	26/04/09	15:24	79	20	41.19441	17	51.20079	605	
11	116	26/04/09	15:34	80	20	41.29207	17	51.18459	608	
11	116	26/04/09	15:43	81	20	41.38372	17	51.15681	611	
11	116	26/04/09	15:53	82	20	41.38551	17	51.14243	611	
11	116	26/04/09	16:02	83	20	41.39313	17	51.11724	611	
11	116	26/04/09	16:11	84	20	41.52144	17	51.05926	613	

11	116	26/04/09	16:21	85	20	41.68209	17	50.97584	617	
11	116	26/04/09	16:30	86	20	41.79867	17	50.89900	620	
12	116	26/04/09	17:37	87	20	41.39312	17	52.48422	657	
12	116	26/04/09	17:47	88	20	41.53051	17	52.52595	664	
12	116	26/04/09	17:57	89	20	41.64386	17	52.55299	670	
12	116	26/04/09	18:06	90	20	41.73278	17	52.56428	673	
12	116	26/04/09	18:14	91	20	41.79079	17	52.54157	675	
12	116	26/04/09	18:23	92	20	41.82071	17	52.50025	675	
13	117	27/04/09	11:31	93	20	36.55332	17	57.15273	682	
13	117	27/04/09	11:41	94	20	36.62041	17	57.25536	687	
13	117	27/04/09	11:53	95	20	36.73574	17	57.29346	690	
13	117	27/04/09	12:00	96	20	36.79725	17	57.30797	690	
13	117	27/04/09	12:08	97	20	36.91836	17	57.31015	691	
14	118	29/04/2009	10:43	98	20	36.61985	18	32.32499	1860	
14	118	29/04/2009	10:53	99	20	36.73400	18	32.50900	1892	
14	118	29/04/2009	11:03	100	20	36.89202	18	32.70090	1929	
14	118	29/04/2009	11:14	101	20	37.06666	18	32.89101	1955	
14	118	29/04/2009	11:26	102	20	37.23168	18	33.07246	1957	
14	118	29/04/2009	11:34	103	20	37.39541	18	33.13738	1977	
15	118	29/04/2009	14:37	104	20	38.2617	18	34.0115	2119	
15	118	29/04/2009	14:43	105	20	38.40072	18	34.10235	2124	
15	118	29/04/2009	14:54	106	20	38.67875	18	34.28410	2134	
15	118	29/04/2009	15:05	107	20	38.85903	18	34.47730	2144	
15	118	29/04/2009	15:25	108	20	38.60000	18	34.98107	NaN	
16	118	29/04/2009	17:04	109	20	37.56127	18	35.58526	NaN	
16	118	29/04/2009	17:14	110	20	37.69505	18	35.66377	1182	
16	118	29/04/2009	17:25	111	20	37.82737	18	35.74070	NaN	
16	118	29/04/2009	17:35	112	20	37.95312	18	35.80962	2332	
16	118	29/04/2009	17:45	113	20	38.07515	18	35.87575	2322	
16	118	29/04/2009	17:55	114	20	38.22847	18	35.93787	2334	

16	118	29/04/2009	18:07	115	20	38.39999	18	36.00724	2345	
16	118	29/04/2009	18:17	116	20	38.53280	18	36.05755	2349	
16	118	29/04/2009	18:25	117	20	38.65982	18	36.11509	2354	
17	129	09/05/2009	06:41	118	21	30.32104	17	59.98000	1357	SE drift with wind beam to NW, drifting with wind to starboard side. Probe away from ship to port side several meters so maybe we can use upper part of profile
17	129	09/05/2009	06:53	119	21	30.31192	17	59.88907	1355	
17	129	09/05/2009	07:02	120	21	30.31078	17	59.81370	1348	
17	129	09/05/2009	07:14	121	21	30.35558	17	59.76492	1345	
17	129	09/05/2009	07:25	122	21	30.39315	17	59.71296	1334	
17	129	09/05/2009	07:36	123	21	30.44968	17	59.66030	1339	
17	129	09/05/2009	07:47	124	21	30.55750	17	59.57631	1333	
17	129	09/05/2009	07:57	125	21	30.65457	17	59.50915	1329	
17	129	09/05/2009	08:15	126	21	30.76855	17	59.47781	1327	
18	129	09/05/2009	10:37	127	21	31.43190	18	0.74503	1405	
18	129	09/05/2009	10:47	128	21	31.54977	18	1.09206	1428	
18	129	09/05/2009	10:57	129	21	31.57984	18	1.37344	1443	
18	129	09/05/2009	11:07	130	21	31.66402	18	1.69045	1464	
18	129	09/05/2009	11:17	131	21	31.74105	18	2.00443	1484	
18	129	09/05/2009	11:28	132	21	31.87349	18	2.26899	1500	
19	129	09/05/2009	14:18	133	21	34.75300	18	2.63800	1516	
19	129	09/05/2009	14:27	134	21	34.61700	18	2.65000	1513	
19	129	09/05/2009	14:39	135	21	34.46000	18	2.66900	1515	
19	129	09/05/2009	14:48	136	21	34.35500	18	2.68100	1517	
19	129	09/05/2009	14:55	137	21	34.27400	18	2.68700	1518	
19	129	09/05/2009	15:03	138	21	34.16491	18	2.69973	1518	
19	129	09/05/2009	15:12	139	21	34.04642	18	2.72335	1522	

19	129	09/05/2009	16:09	140	21	32.90910	18	2.88528	1538	
19	129	09/05/2009	16:18	141	21	33.01117	18	2.88301	1538	
19	129	09/05/2009	16:28	142	21	33.05469	18	2.87919	1536	
19	129	09/05/2009	16:38	143	21	33.1548	18	2.8788	1536	No file
19	129	09/05/2009	16:48	144	21	33.25495	18	2.87839	1535	
19	129	09/05/2009	16:57	145	21	33.34607	18	2.85903	1534	
19	129	09/05/2009	17:07	146	21	33.45403	18	2.84413	1532	
19	129	09/05/2009	17:18	147	21	33.56136	18	2.83183	1531	Changed backscatter calibration to highest gain
19	129	09/05/2009	17:27	148	21	33.63799	18	2.81490	1530	
20	130	10/05/2009	15:08	149	21	33.09178	18	3.64261	1586	
20	130	10/05/2009	15:18	150	21	33.17465	18	3.68971	1588	
20	130	10/05/2009	15:28	151	21	33.23856	18	3.73417	1591	
20	130	10/05/2009	15:37	152	21	33.29288	18	3.79385	1595	
20	130	10/05/2009	15:47	153	21	33.35812	18	3.84756	1597	
20	130	10/05/2009	15:57	154	21	33.42933	18	3.89461	1600	
20	130	10/05/2009	16:08	155	21	33.50084	18	3.94960	1604	
20	130	10/05/2009	16:19	156	21	33.58500	18	4.01090	1607	
20	130	10/05/2009	16:28	157	21	33.66042	18	4.05749	1611	
20	130	10/05/2009	16:38	158	21	34.76656	18	4.11322	1613	
20	130	10/05/2009	16:49	159	21	33.83289	18	4.17401	1617	
20	130	10/05/2009	16:59	160	21	33.89987	18	4.22945	1620	
20	130	10/05/2009	17:11	161	21	33.99824	18	4.29141	1622	
20	130	10/05/2009	17:20	162	21	34.08586	18	4.32937	1625	
20	130	10/05/2009	17:30	163	21	34.16553	18	4.35306	1626	
20	130	10/05/2009	17:40	164	21	34.24689	18	4.38023	1627	
20	130	10/05/2009	17:49	165	21	34.36196	18	4.39449	1628	
20	130	10/05/2009	18:01	166	21	34.48634	18	4.42357	1628	
20	130	10/05/2009	18:12	167	21	34.56939	18	4.43564	1628	
20	130	10/05/2009	18:22	168	21	34.63281	18	4.44478	1628	
20	130	10/05/2009	18:33	169	21	34.67909	18	4.46312	1630	

20	130	10/05/2009	18:42	170	21	34.71414	18	4.45557	1628	
20	130	10/05/2009	18:51	171	21	34.39238	18	4.39116	1624	
20	130	10/05/2009	19:01	172	21	34.77803	18	4.31597	1619	
20	130	10/05/2009	19:10	173	21	34.81257	18	4.23936	1614	
20	130	10/05/2009	19:20	174	21	34.86873	18	4.15143	1607	
20	130	10/05/2009	19:30	175	21	34.90334	18	4.07559	1603	profile data starts at 60 m
21	135	15/05/2009	10:53	176	19	26.17600	17	56.68300	2241	
21	135	15/05/2009	11:03	177	19	26.35705	17	56.67045	2237	
21	135	15/05/2009	11:13	178	19	26.51292	17	56.60015	2235	
21	135	15/05/2009	11:23	179	19	26.43151	17	56.47180	2233	
21	135	15/05/2009	11:34	180	19	26.13035	17	56.87454	2244	
22	135	15/05/2009	14:27	181	19	26.50190	17	58.18835	2271	
22	135	15/05/2009	14:36	182	19	26.75999	17	58.31608	2272	
22	135	15/05/2009	14:46	183	19	26.94275	17	58.47753	2276	
22	135	15/05/2009	14:55	184	19	27.10462	17	58.60896	2280	
22	135	15/05/2009	15:04	185	19	27.30563	17	58.74805	2284	
22	135	15/05/2009	15:14	186	19	27.50738	17	58.88047	2288	
22	135	15/05/2009	15:25	187	19	27.68104	17	58.91882	2288	
23	136	16/05/2009	07:37	188	19	30.69163	18	7.34276	2402	
23	136	16/05/2009	07:47	189	19	30.77239	18	7.38902	2400	
23	136	16/05/2009	07:56	190	19	30.88582	18	7.45366	2397	
23	136	16/05/2009	08:06	191	19	30.98377	18	7.64129	2395	
23	136	16/05/2009	08:16	192	19	31.08397	18	7.53989	2393	
23	136	16/05/2009	08:25	193	19	31.18748	18	7.52250	2389	
24	136	16/05/2009	10:42	194	19	32.88077	18	8.60485	2342	
24	136	16/05/2009	10:51	195	19	33.01198	18	8.63989	2336	
24	136	16/05/2009	11:01	196	19	33.04784	18	8.70117	2337	
24	136	16/05/2009	11:11	197	19	33.16785	18	8.76469	2334	
24	136	16/05/2009	11:19	198	19	33.30184	18	8.80105	2332	
25	136	16/05/2009	13:38	199	19	32.75992	18	9.73424	2352	

25	136	16/05/2009	13:47	200	19	32.96522	18	9.77887	2348	
25	136	16/05/2009	13:56	201	19	33.12158	18	9.84375	2344	
25	136	16/05/2009	14:05	202	19	33.26055	18	9.91389	2342	
25	136	16/05/2009	14:14	203	19	33.42006	18	9.98027	2340	
25	136	16/05/2009	14:23	204	19	33.54475	18	10.04323	2337	
25	136	16/05/2009	14:33	205	19	33.66702	18	10.10007	2335	
25	136	16/05/2009	14:42	206	19	33.7956	18	10.1757	2332	
25	136	16/05/2009	14:51	207	19	33.93177	18	10.22661	2330	
25	136	16/05/2009	15:01	208	19	34.04997	18	10.28811	2329	
25	136	16/05/2009	15:11	209	19	34.13798	18	10.34392	2329	
25	136	16/05/2009	15:20	210	19	34.24013	18	10.41757	2330	
25	136	16/05/2009	15:30	211	19	34.34220	18	10.49975	2334	
25	136	16/05/2009	15:39	212	19	34.45828	18	10.56976	2334	
25	136	16/05/2009	15:48	213	19	34.56655	18	10.63925	2335	
25	136	16/05/2009	15:58	214	19	34.65625	18	10.69920	2338	
25	136	16/05/2009	16:09	215	19	34.79261	18	10.78759	2339	
25	136	16/05/2009	16:19	216	19	34.89500	18	10.86740	2339	
25	136	16/05/2009	16:29	217	19	34.98518	18	10.91740	2340	
26	136	16/05/2009	16:54	218	19	34.65150	18	10.91276	2339	Turn to patch centre
27	136	16/05/2009	17:23	219	19	33.43768	18	11.51467	2354	
27	136	16/05/2009	17:33	220	19	33.53590	18	11.66188	2353	
27	136	16/05/2009	17:42	221	19	33.67560	18	11.77723	2354	
27	136	16/05/2009	17:51	222	19	33.86610	18	11.89796	2355	
27	136	16/05/2009	18:02	223	19	34.02670	18	11.98182	2356	
27	136	16/05/2009	18:12	224	19	34.19500	18	12.06400	2358	
27	136	16/05/2009	18:22	225	19	34.32900	18	12.12380	2361	
27	136	16/05/2009	18:31	226	19	34.47880	18	12.18780	2361	
27	136	16/05/2009	18:41	227	19	34.65238	18	12.27800	2362	
27	136	16/05/2009	18:51	228	19	34.85873	18	12.39279	2361	
28	137	17/05/2009	06:50	229	19	35.31680	18	18.17250	2466	
28	137	17/05/2009	07:00	230	19	35.45400	18	18.14000	2478	

28	137	17/05/2009	07:10	231	19	35.58800	18	18.08800	2469	
28	137	17/05/2009	07:20	232	19	35.70300	18	18.02280	2458	
28	137	17/05/2009	07:30	233	19	35.79150	18	17.97500	2456	
28	137	17/05/2009	07:40	234	19	35.88300	18	17.97800	2451	
28	137	17/05/2009	07:50	235	19	35.99000	18	17.97200	2450	
28	137	17/05/2009	07:59	236	19	36.18200	18	17.97800	2441	
28	137	17/05/2009	08:08	237	19	36.33100	18	18.00600	2423	
28	137	17/05/2009	08:20	238	19	36.47744	18	18.05882	2423	
29	137	17/05/2009	13:19	239	19	37.25271	18	21.84657	2463	
29	137	17/05/2009	13:28	240	19	37.45245	18	21.90781	2463	
29	137	17/05/2009	13:38	241	19	37.65337	18	21.97377	2459	
29	137	17/05/2009	13:48	242	19	37.84578	18	22.04587	2462	
29	137	17/05/2009	14:01	243	19	38.03389	18	22.17214	2464	
29	137	17/05/2009	14:10	244	19	38.20573	18	22.26142	2467	
29	137	17/05/2009	14:20	245	19	38.38643	18	22.35693	2468	
29	137	17/05/2009	14:30	246	19	38.56316	18	22.45684	2469	
30	137	17/05/2009	15:21	247	19	36.89800	18	22.89766	2473	
30	137	17/05/2009	15:30	248	19	37.09054	18	22.93193	2473	
30	137	17/05/2009	15:40	249	19	37.29820	18	22.90975	2470	
30	137	17/05/2009	15:50	250	19	37.50214	18	22.89400	2470	
30	137	17/05/2009	16:03	251	19	37.70948	18	22.96056	2473	
31	138	18/05/2009	16:41	252	19	41.12186	18	30.41497	2607	
31	138	18/05/2009	16:51	253	19	41.20018	18	30.55065	2610	
31	138	18/05/2009	17:01	254	19	41.28570	18	30.65633	2610	
31	138	18/05/2009	17:11	255	19	41.33283	18	30.73732	2611	
31	138	18/05/2009	17:22	256	19	41.43659	18	30.83420	2615	
31	138	18/05/2009	17:33	257	19	41.54751	18	30.90539	2616	
31	138	18/05/2009	17:43	258	19	41.55390	18	30.98564	2616	
31	138	18/05/2009	17:54	259	19	41.64049	18	31.09833	2618	
31	138	18/05/2009	18:05	260	19	41.71974	18	31.18231	2620	
31	138	18/05/2009	18:14	261	19	41.78378	18	31.23433	2619	

31	138	18/05/2009	18:24	262	19	41.91267	18	31.29621	2622	
31	138	18/05/2009	18:34	263	19	41.98214	18	31.35324	2623	
31	138	18/05/2009	18:44	264	19	42.04625	18	31.39471	2619	
32	140	20/05/2009	06:45	265	19	41.30000	18	47.70000	2824	
32	140	20/05/2009	06:53	266	19	41.41200	18	47.81000	2826	
33	140	20/05/2009	09:37	267	19	40.60402	18	49.29768	2842	
33	140	20/05/2009	09:45	268	19	40.62000	18	49.28828	2841	
33	140	20/05/2009	09:55	269	19	40.79547	18	49.33113	2842	
34	140	20/05/2009	10:48	270	19	40.32104	18	49.77733	2847	
34	140	20/05/2009	10:58	271	19	40.38847	18	49.79690	2848	
34	140	20/05/2009	11:07	272	19	40.52885	18	49.83420	2850	
34	140	20/05/2009	11:16	273	19	40.65974	18	49.86527	2851	
34	140	20/05/2009	11:25	274	19	40.73334	18	49.86706	2851	
35	140	20/05/2009	11:54	275	19	40.02253	18	50.28159	2851	
35	140	20/05/2009	11:59	276	19	40.06885	18	50.28897	2852	
35	140	20/05/2009	12:06	277	19	40.10552	18	50.29574	2853	
35	140	20/05/2009	12:11	278	19	40.20622	18	50.29287	2854	
35	140	20/05/2009	12:17	279	19	40.28999	18	50.29483	2855	
35	140	20/05/2009	12:23	280	19	40.34765	18	50.30300	2856	
36	140	20/05/2009	13:32	281	19	40.63025	18	50.84874	2871	
36	140	20/05/2009	13:41	282	19	40.74288	18	50.87192	2871	
36	140	20/05/2009	13:49	283	19	40.85424	18	50.97376	2873	
36	140	20/05/2009	13:59	284	19	40.92475	18	51.12505	2874	
36	140	20/05/2009	14:08	285	19	41.00650	18	51.24130	2875	
37	140	20/05/2009	14:43	286	19	40.36611	18	51.49994	2877	
37	140	20/05/2009	14:51	287	19	40.45846	18	51.54333	2877	
37	140	20/05/2009	14:59	288	19	40.52277	18	51.58473	2878	
37	140	20/05/2009	15:10	289	19	40.58986	18	51.67662	2879	
37	140	20/05/2009	15:20	290	19	40.77007	18	51.74043	2880	
37	140	20/05/2009	15:33	291	19	40.99690	18	51.76959	2880	
37	140	20/05/2009	15:44	292	19	41.10093	18	51.76249	2879	

37	140	20/05/2009	15:56	293	19	41.30460	18	51.76716	2879	
37	140	20/05/2009	16:07	294	19	41.48185	18	51.79428	2880	
37	140	20/05/2009	17:21	295	19	41.11164	18	52.47929	2886	
37	140	20/05/2009	17:28	296	19	41.23292	18	52.51521	2887	
37	140	20/05/2009	17:34	297	19	41.29996	18	52.54938	2887	
37	140	20/05/2009	17:40	298	19	41.36460	18	52.57900	2888	
37	140	20/05/2009	17:46	299	19	41.43182	18	52.61437	2888	
37	140	20/05/2009	17:52	300	19	41.46820	18	52.64063	2889	
38	140	20/05/2009	18:55	301	19	41.09472	18	52.88009	2892	
38	140	20/05/2009	19:00	302	19	41.17041	18	52.86779	2892	
38	140	20/05/2009	19:05	303	19	41.22224	18	52.84521	2892	
38	140	20/05/2009	19:10	304	19	41.32045	18	52.81016	2891	
38	140	20/05/2009	19:16	305	19	41.43044	18	52.78476	2890	
38	140	20/05/2009	19:22	306	19	41.53502	18	52.76958	2889	
38	140	20/05/2009	19:26	307	19	41.59883	18	52.76054	2890	
38	140	20/05/2009	19:52	308	19	41.04204	18	52.86133	2892	
38	140	20/05/2009	19:57	309	19	41.10466	18	52.88920	2893	
38	140	20/05/2009	20:02	310	19	41.14151	18	52.90111	2892	
38	140	20/05/2009	20:07	311	19	41.19007	18	52.91652	2892	
38	140	20/05/2009	20:13	312	19	41.21492	18	52.98873	2892	
39	140	20/05/2009	21:33	313	19	41.34599	18	52.95866	2892	
39	140	20/05/2009	21:39	314	19	41.37733	18	52.94367	2893	
39	140	20/05/2009	21:44	315	19	41.41716	18	52.92952	2892	
39	140	20/05/2009	21:49	316	19	41.43510	18	52.91125	2892	
39	140	20/05/2009	21:55	317	19	41.44945	18	52.88482	2891	
39	140	20/05/2009	22:00	318	19	41.48619	18	52.88677	2891	
39	140	20/05/2009	23:34	319	19	40.24360	18	52.84674	2892	
39	140	20/05/2009	23:39	320	19	40.23351	18	52.84174	2891	
39	140	20/05/2009	23:44	321	19	40.22332	18	52.82395	2891	
39	140	20/05/2009	23:49	322	19	40.20838	18	52.80533	2891	
39	140	20/05/2009	23:54	323	19	40.19624	18	52.78480	2890	

39	141	21/05/2009	00:00	324	19	40.18580	18	52.76192	2889	
39	141	21/05/2009	00:05	325	19	40.20478	18	52.73245	2889	
39	141	21/05/2009	00:10	326	19	40.23445	18	52.71155	2889	
40	141	21/05/2009	15:28	327	19	34.08553	18	59.43744	2957	
40	141	21/05/2009	15:32	328	19	34.09476	18	59.47114	2956	
40	141	21/05/2009	15:36	329	19	34.09207	18	59.49504	2957	
40	141	21/05/2009	15:41	330	19	34.08372	18	59.51735	2957	
40	141	21/05/2009	15:46	331	19	34.09777	18	59.54029	2957	
40	141	21/05/2009	15:52	332	19	34.12065	18	59.55262	2957	
40	141	21/05/2009	15:58	333	19	34.15123	18	59.55909	2957	
40	141	21/05/2009	16:03	334	19	34.17030	18	59.55515	2957	
40	141	21/05/2009	16:07	335	19	34.17039	18	59.54002	2957	
40	141	21/05/2009	16:13	336	19	34.16477	18	59.54000	2957	
40	141	21/05/2009	16:18	337	19	34.16733	18	59.54086	2956	

Underway Water Sampling Log - UK SOLAS cruises

Water bottle annex TSG sampling - salinity and chlorophyll

Cruise: Discovery D338 ICON

Date	Time GMT	Latitude	Longitude	TSG temp	TSG salinity	TSG fluor	Sample e.g. salinity or chl	volume filtered	Sample ID	Scientist
106	08:19	24 08.25	17 03.43				sal		901/1	Martin
106	until 15:47						clean fluorometer			Martin
107	08:33	21 55.04	17 27.37				sal		901/2	Martin
107	15:00	21 50.81	17 39.67				chl x 3	250 ml		Claire
107	17:00	21 53.32	18 11.24				chl x 3	250 ml		Claire
107	23:07	21 55.98	18 42.89				chl x3	250 ml		Thomas & Bea
108	03:14	22 10.72	19 07.69				chl x3	250 ml		Claire
108	06:52	22 11.44	19 08.72	20	36.72	0.17	chl x3	250 ml		Claire
108	11:02	22 23.51	18 31.29	19.7	36.67	0.14	chl x3	250 ml		Simon
108	14:58	20 00.54	19 45.73	20.1	36.43	0.24	chl x3	250 ml		Simon
108	17:21	21 43.38	19 46.82				sal		901/3	Martin
108	18:58	21 32.45	19 47.56	20.8	36.8	0.13	chl x3	250 ml		Simon
108	23:00	21 30.21	19 33.36				chl x 3			Thomas & Bea
109	02:00	21 42.76	19 15.65	19.6	36.64	0.26	chl x3	250 ml		John
109	07:29	21 28.69	19 06.43	19.4	36.62	0.31	chl x3	250 ml		Claire
109	11:01	21 22.83	19 06.19	18.4	36.21	0.39	chl x3	250 ml		Simon
109	14:58	21 16.94	18 07.83	19	36.26	0.65	chl x3	250 ml		Simon
109	16:35	21 20.58	18 56.61				sal		901/4	Martin
109	19:16	21 28.41	18 35.97	19.6	36.66	0.29	chl x3	250 ml		Claire
109	23:05	21 28.80	18 25.77	19.6	36.67	0.23	chl x3	250 ml		Ricardo
110	03:00	21 12.02	18 23.51	18.4	36.39	0.39	chl x3	250 ml		Susan
110	10:01	21 11.5	18 16.01				sal		901/5	Martin
110	12:18	21 13.33	18 00.28	18.43	36.36	0.25	chl x3	250 ml		Claire
110	15:21	21 16.10	17 42.75	18.8	36.51	0.27	chl x3	250 ml		Claire
110	18:45	21 24.55	17 25.65	17.7	36.25	1.2	chl x3	250 ml		Claire
110	22:25	21 31.49	17 10.88				chl x3	250 ml		Bea

Underway Water Sampling Log - UK SOLAS cruises

Water bottle annex TSG sampling - salinity and chlorophyll

Cruise: Discovery D338 ICON

Date	Time GMT	Latitude	Longitude	TSG temp	TSG salinity	TSG fluor	Sample e.g. salinity or chl	volume filtered	Sample ID	Scientist
111	03:40	21 29.95	17 14.57	17	36.18	0.9	chl x3	250 ml		Susan
111	06:52	21 34.12	17 15.94	16.8	36.18	1.05	chl x3	250 ml		Claire
111	11:07	21 32.91	17 12.14	16.6	36.14	0.58	chl x3	100 ml		Simon
111	15:00	21 29.15	17 14.84				chl x3	100 ml		Claire
111	16:40	21 23.5	17 15.4				sal		901/6	Martin
111	19:08	21 26.4	17 15.5	16.8	36.14	1.07	chl x3	100 ml		Frankie
111	22:52	21 28.60	17 14.5				chl x3	100 ml		Bea
112	03:04	21 26.52	17 15.15	16.8	36.16	0.73	chl x3	100 ml		Simon
112	07:04	21 24.14	17 16.16	16.7	36.15	0.8	chl x3	100 ml		Claire
112	11:09	21 21.48	17 16.41	16.8	36.16	0.44	chl x3	100 ml		Claire
112	11:17	21 21.1	17 16.4				sal		901/7	Martin
112	15:10	21 13.78	17 18.65	16.5	36.1	0.54	chl x3	100 ml		Simon
112	17:32	21 16.22	17 19.24	16.9	36.15	1	chl x3	50 ml		Claire
113	03:22	21 12.34	17 21.61	16.9	36.15	0.54	chl x3	50 ml		Simon
113	07:27	21 10.32	17 22.19	16.8	36.15	0.74	chl x3	20 ml		Claire
113	10:56	21 08.69	17 23.05				sal		901/8	Martin
113	11:05	21 07.85	17 22.37	16.9	36.15	0.48	chl x3	50 ml		Frankie
114	10:09	20 57.46	17 28.88				sal		901/9	Martin
	until 10:17						clean fluorometer and transmissometer			Martin
116	11:24	20 40.07	17 50.09				sal		901/10	Martin
117	13:28	20 37.53	17 57.87				sal		901/11	Martin
119	19:44	20 38.92	18 36.92				sal		901/12	Martin
120	10:56	20 34.90	18 44.05				sal		901/13	Martin
120	11:00						clean fluorometer and transmissometer			Martin
121	09:30	20 33.65	19 01.23				sal		901/14	Martin
122	10:45	20 02.08	18 37.25				sal		901/15	Martin

Underway Water Sampling Log - UK SOLAS cruises

Water bottle annex TSG sampling - salinity and chlorophyll

Cruise: Discovery D338 ICON

Date	Time GMT	Latitude	Longitude	TSG temp	TSG salinity	TSG fluor	Sample e.g. salinity or chl	volume filtered	Sample ID	Scientist
123	12:02	20 34.46	18 06.59	17.7	35.99	0.31	chl x1	100 ml		Claire
123	18:12	21 03.41	17 48.12	17.1	36.03	0.95	chl x1	100 ml		Claire
124	09:55	19 48.09	17 25.51	17.1	35.75	0.58	chl x1	100 ml		Claire
124	14:04	19 50.3	17 14.6				sal		901/16	Martin
124	14:41	19 52.81	17 17.85	17.5	35.94	0.99	chl x1	100 ml		Claire
124	16:58	20 04.31	17 29.19	17.3	36.02	1.7	chl x1	100 ml		Claire
124	18:31	20 14.39	17 33.21	17	36.04	1.24	chl x1	100 ml		Claire
125	10:54	20 24.80	17 40.5	16.8	36.03	0.79	chl x1	100 ml		Claire
125	15:44	19 58.46	17 39.09				chl x1	100 ml		Claire
125	16:26	19 58.9	17 39.68				sal		901/17	Martin
	until 16:32						clean fluorometer and transmissometer			Martin
126	10:33	20 50.23	17 53.19	16.8	35.97	0.58	chl x1	100 ml		Claire
126	13:27	20 22.9	17 52.9				sal		901/18	Martin
129	13:42	21 34.4	18 2.6				sal		901/19	Martin
130	11:10	21 36.0	18 00.3				sal		901/20	Martin
131	09:18	21 32.57	18 08.1			1.69	chl	50 ml		Claire
131	10:11	21 29.1	18 11.3				sal		901/21	Martin
	until 10:16						clean fluorometer and transmissometer			Martin
132	10:20	19 36.07	19 33.73				sal		901/22	Martin
134	10:47	20 00.8	18 01.7				sal		901/23	Martin
135	13:13	19 26.45	17 57.78	18.4	35.62	0.34	chl x 1	100 ml		Claire
135	18:27									
	until 18:32						clean fluorometer and transmissometer			Martin
135	18:34	19 25.7	17 58.5				sal		901/24	Martin CT lab
136	14:12	19 33.4	18 9.9				sal		901/25	Martin
136	15:48	19 34.56	18 10.64	18.5	35.64	0.34	chl x 1	100 ml		Claire

Underway Water Sampling Log - UK SOLAS cruises

Water bottle annex TSG sampling - salinity and chlorophyll

Cruise: Discovery D338 ICON

Date	Time GMT	Latitude	Longitude	TSG temp	TSG salinity	TSG fluor	Sample e.g. salinity or chl	volume filtered	Sample ID	Scientist
136	20:39	19 35.27	18 13.05				clean fluorometer and transmissometer			Martin
137	11:12	19 36.5	18 19.4				sal		901/26	Martin
137	19:14	19 37.3	18 25.13	18.6	35.67	0.67	chl x 1	100 ml		Claire
138	10:51	19 43.2	18 26.3				sal		901/27	Martin
139	10:29	19 44.9	18 38.9				sal		901/28	Martin
139	15:07	19 39.68	18 42.99	18.8	35.7	1.1 or 0.7	chl x 1	100 ml		Claire
139	16:05	19 33.73	18 41.86	18.8	35.76	0.9	chl x1	100 ml		Claire
140	15:23	19 40.8	18 51.9				sal		901/29	Martin
	until 15:27						clean fluorometer and transmissometer			Martin
141	13:49	19 34.6	18 58.5				sal		901/30	Martin
141	18:53	19 24.7	18 52.65	19.5	35.78	0.6	chl x 1	100 ml		Claire
141	19:38	19 29.19	18 55.00	19.3	35.76	1.27	chl x 1	100 ml		Claire
142	10:34	19 22.9	19 3.5				sal		901/31	Martin
142	13:18	19 30.45	18 36.78	18.8	35.64	0.3	chl x 1	100 ml		Claire
143	15:36	19 04.8	18 36.2				sal		901/32	Martin
145	09:23	23 29.6	17 34.6				sal		901/33	Martin CT lab

Underway Water Sampling Log - UK SOLAS cruises D338

Chem lab outlet from pCO2 machine

Cruise: Discovery D338 ICON

Date	Time GMT	Latitude N	Longitude W	TSG temp	TSG salinity	TSG fluor	Time Winkler oxygen GMT	Sample ID (e.g. oxygen bottle number)	Winkler Oxygen umol / L at in situ T	Optode Oxygen umol / L at optode T
23/04/2009	04:52	21 11.718	017 22.184	16.7	36.16	0.65	04:53:06	288	209.95	222.24
23/04/2009	09:40	21 09.279	017 22.733	16.6	36.16	0.75	09:41:07	288	209	221.57
23/04/2009	13:31	21 07.328	017 23.965	16.8	36.14	0.75		288	lost	
24/04/2009	05:18	21 03.11	017 28.415	16.8	36.17	0.83	05:18:04	175	222.14 ?	235.72
24/04/2009	09:30	20 57.815	017 28.787	16.9	36.19	0.82	09:30:03	175	221.54	235.69
24/04/2009	19:41	20 54.208	017 33.569	17	36.15	1.12	19:42:02	173	247.23	259.95
25/04/2009	04:05	20 52.02	017 37.309	17	36.18	0.86	04:06:03	176	232.52	246.16
25/04/2009	04:59	20 51.793	017 38.104	16.9	36.16	0.89	05:00:05	177	233.82	248.27
25/04/2009	12:11	20 49.324	017 41.068	17.1	36.16	0.87	12:12:04	176	247.16	262.48
26/04/2009	05:17	20 41.306	017 48.024	17.1	36.22	0.57	05:17:05	177	226.84	240.67
27/04/2009	05:05	20 39.665	017 54.728	17.2	36.23	0.39	05:05:07	288	230.14	243.52
27/04/2009	09:34	20 37.328	017 56.408	17.1	36.22	0.37	09:35:06	176	224.85	237.63
27/04/2009	13:45	20 37.598	017 58.118	17.3	36.23	0.4	13:45:09	175	231.78	245.67
28/04/2009	14:09	20 42.904	018 18.590	17.3	36.21	0.34	14:09:10	199	233.59	245.77
29/04/2009	14:15	20 38.267	018 33.809	17.6	36.25	0.2	lost	187		
29/04/2009	19:37	20 38.908	018 36.867	17.6	36.25	0.33	lost	191		
30/04/2009	05:04	20 37.961	018 41.129	17.6	36.26	0.24	05:05:04	197	234.83	251.11
03/05/2009	08:50	20 14.468	018 08.654	18.7	36.27	0.39	lost	200		
03/05/2009	09:45	20 19.165	018 08.312	18.5	36.23	0.31	lost	201		
03/05/2009	10:37	20 24.693	018 07.651	17.7	36.04	0.37	lost	202		
03/05/2009	13:18	20 42.915	018 05.635	18.3	36.21	0.36	lost	203		
03/05/2009	14:46	20 52.925	018 04.927	17.3	36.02	0.27	lost	204		
03/05/2009	20:32	20 47.422	017 49.582	17.1	35.96	1.04	lost	205		

Underway Water Sampling Log - UK SOLAS cruises D338

Chem lab outlet from pCO2 machine

Cruise: Discovery D338 ICON

Date	Time GMT	Latitude N	Longitude W	TSG temp	TSG salinity	TSG fluor	Time Winkler oxygen GMT	Sample ID (e.g. oxygen bottle number)	Winkler Oxygen umol / L at in situ T	Optode Oxygen umol / L at optode T
06/05/2009	08:55	21 03.93	017 53.15	16.8	35.88	0.64	08:58:02	206	219.86	229.02
06/05/2009	09:45	20 56.72	017 53.11	16.7	35.93	0.43	09:52:04	207	211.75	224.28
06/05/2009	11:04	20 45.41	017 53.09	17.1	35.84	0.45	11:04:01	208	208.23	223.09
06/05/2009	12:35	20 31.42	017 53.00	16.5	35.91	0.81	12:35:04	209	225.92	228.14
06/05/2009	14:02	20 21.35	017 53.09	17.7	35.81	0.69	14:04:05	211	235.88	249.37
06/05/2009	16:43	20 30.40	017 53.13	16.7	35.91	1.54	16:46:03	212	233.16	244.57
06/05/2009	18:12	20 33.77	017 53.69	16.6	35.9	1.32	18:16:05	213	212.43	225.58
07/05/2009	09:01	21 23.54	017 45.10	17.5	36.02	0.26	08:59:03	214	234.04	250.28
07/05/2009	14:07	21 25.55	017 43.39	17.5	36.04	0.16	14:10:01	216	222.15	234.7
08/05/2009	05:30	21 25.48	017 56.19	17.7	36.04	0.3	05:24:03	218	237.09	255
09/05/2009	04:18	21 31.59	017 59.19	17.6	36.03	0.27	04:15:13	288	242.8	256.7
09/05/2009	05:31	21 30.79	017 59.77	17.8	36.02	0.24	05:27:12	169	240.36	257.05
09/05/2009	09:29	21 30.54	018 00.07	17.9	36.03	0.47	09:21:13	199	need bottle volume	257.5
09/05/2009	13:46	21 34.7	018 02.8	17.7	36.03	0.36	13:52:01	159	??	245.41
10/05/2009	09:29	21 36.3	018 00.74	18	36.04	0.78	09:32:04	293	need bottle volume	255.7
10/05/2009	12.21	21 36.89	018 02.23	18.4	36.05	0.66	12:20:12	219	239.87	256.88
14/05/2009	06:01	19 52.19	018 10.17	18.4	35.8	0.66	06:00:06	195	234.56	253.16
15/05/2009	14:00	19 26.63	017 57.87	18.2	35.6	0.37	13:58:09	274	231.55	249.3
16/05/2009	05:17	19 30.9	018 06.42	18	35.64	0.41	05:14:07	220	227.63	245.39
16/05/2009	09:35	19 32.5	018 8.4	18.04	35.64	0.34	09:24:11	197	227.24	246.76
16/05/2009	12:57	19 32.5	018 9.4	18.18	35.64	0.27	12:57:01	222	231.97	251.01
pCO2 machine not working at time of CTD casts										
19/05/2009	05:05	oxygen chamber cleaned - brown biofilm and sediment								
19/05/2009	09:25	19 44.55	018 38.84	18.3	35.65	0.37		229		249 bubbles in flow
19/05/2009		19 45.03	018 39.23	18.38	35.65	0.31		222	213.66	258
19/05/2009	17:28	increased non-toxic flow rate								

Underway Water Sampling Log - UK SOLAS cruises D338

Chem lab outlet from pCO2 machine

Cruise: Discovery D338 ICON

Date	Time GMT	Latitude N	Longitude W	TSG temp	TSG salinity	TSG fluor	Time Winkler oxygen GMT	Sample ID (e.g. oxygen bottle number)	Winkler Oxygen umol / L at in situ T	Optode Oxygen umol / L at optode T
20/05/2009	04:20	19 41.62	018 46.02	18.4	35.66	0.53	04:17:14	978	238.86	258.73
20/05/2009	05:20	19 41.17	018 47.03	18.4	35.66	0.53	05:13:17	976	241.18	257.89
20/05/2009	08:56	19 40.91	018 48.6	18.4	35.66	0.5	08:56:15	232	??	257.35
20/05/2009	13:00	19 40.46	018 50.31	18.6	35.66	0.42	12:58:00	257	242.92	261.52
20/05/2009	16:59	19 40.95	018 52.00	18.9	35.66	0.35	16:55:00	235	245.94	262.54
20/05/2009	21:00	19 41.18	018 53.04	18.7	35.66	0.58	20:53:05	982	247.2	262.67
21/05/2009	04:14	19 38.32	018 53.95	18.6	35.66	0.56	04:13:21	227	246.24	260.44
21/05/2009	05:28	19 38.16	018 54.26	18.6	35.66	0.56	05:26:01	228	245.36	259.73
21/05/2009	09:50	19 35.05	018 56.08	18.6	35.66	0.43		168	??	259
21/05/2009	14:19	19 35.02	018 58.13	18.7	35.66	0.44		164	250.33	264
22/05/2009	04:26	19 31.38	019 06.20	18.8	35.67	0.64		226	250.46	263
22/05/2009	05:33	19 31.12	019 06.70	18.8	35.67	0.64		227	??	261
22/05/2009	06:41	19 30.39	019 07.43	18.8	35.71	0.6		228	??	261
22/05/2009	08:27	19 29.70	019 08.34	18.8	35.69	0.62		987	224.64	259

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
17/04/2009	13:37	Fish	21 50.190 N	017 29.59 W	nutrients	U1	Malcolm W.
17/04/2009	14:09	Fish	21 50.308 N	017 33.85 W	nutrients	U2	Malcolm W.
17/04/2009	14:37	Fish	21 50.582 N	017 37.21 W	nutrients	U3	Malcolm W.
17/04/2009	15:10	Fish	21 50.974 N	017 41.29 W	N2O / CH4	N2O 1	Andy
17/04/2009	15:14	Fish	21 51.018 N	017 41.76 W	nutrients	U4	Malcolm W.
17/04/2009	16:09	Fish	"	"	N2O / CH4	N2O 2	Andy
17/04/2009	17:04	Fish	21 52.034 N	017 56.04 W	nutrients	U6	Malcolm W.
17/04/2009	18:07	Fish	21 54.709 N	018 04.16 W	nutrients	U7	Malcolm W.
17/04/2009	19:08	Fish	21 53.419 N	018 12.11 W	nutrients	U8	Malcolm W.
17/04/2009	19:08	Fish	"	"	N2O / CH4	N2O 3	Andy
17/04/2009	20:14	Fish	21 54.138 N	018 20.964 W	N2O / CH4	N2O 4	Ian
17/04/2009	21:17	Fish	21 54.836 N	018 29.035 W	nutrients	U9	Andy
18/04/2009	02:36	Fish	22 08.56 N	019 04.725 W	nutrients	U10	Malcolm W.
19/04/2009	16:00	Fish	21 58.997 N	019 00.671 W	N2O / CH4	N2O 5	Ian
19/04/2009	19:04	Fish	21 27.8254 N	018 37.410 W	N2O / CH4	N2O 6	Ian
20/04/2009	06:01	Fish	21 08.66 N	018 27.99 W	nutrients	U11	Malcolm W.
20/04/2009	08:01	Fish	21 09.99 N	018 24.615 W	nutrients	A1	Malcolm W.
20/04/2009	08:59	Fish	21 10.46 N	018 23.20 W	nutrients	A2	Malcolm W.
20/04/2009	10:00	Fish	21 11.53 N	018 16.04 W	nutrients	A3	Glen
20/04/2009	11:00	Fish	21 12.55 N	018 9.24 W	nutrients	A4	Glen
20/04/2009	12:06	Fish	21 13.32 N	018 01.57 W	nutrients	A5	Malcolm W.
20/04/2009	13:10	Fish	21 13.88 N	017 55.21 W	nutrients	A6	Malcolm W.
20/04/2009	14:09	Fish	21 15.65 N	017 44.69 W	nutrients	A7	Malcolm W.
20/04/2009	16:03	Fish	21 17.89 N	017 39.18 W	nutrients	A8	Malcolm W.

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
20/04/2009	18:15	Fish	21 23.18 N	017 28.37 W	nutrients	A9	Malcolm W.
20/04/2009	19:35	Fish	21 26.55 N	017 21.44 W	nutrients	A10	Malcolm W.
20/04/2009	21:35	Fish	21 30.77654 N	017 12.25410 W	nutrients	A11	Ian
21/04/2009	06:58	Fish	21 34.37 N	017 16.02 W	nutrients	A13	Malcolm W.
21/04/2009	08:46	Fish	21 38.09 N	017 15.20 W	nutrients	Q	Carol
21/04/2009	09:24	Fish	21 39.25 N	017 11.72 W	nutrients	U9	Carol
21/04/2009	10:02	Fish	21 40.36 N	017 08.08 W	nutrients	U8	Carol
21/04/2009	10:28	Fish	21 37.49 N	017 09.46 W	nutrients	U7	Carol
21/04/2009	10:46	Fish	21 35.76 N	017 10.51 W	nutrients	U18	Carol
21/04/2009	11:00	Fish	21 34.32 N	017 11.32 W	nutrients	U17	Carol
21/04/2009	11:10	Fish	21 33.29 N	017 11.92 W	nutrients	U18	Carol
21/04/2009	11:25	Fish	21 31.78 N	017 12.89 W	nutrients	yellow S	Carol
21/04/2009	11:40	Fish	21 30.3 N	017 14.10 W	nutrients	yellow T	Carol
03/05/2009	07:00	Fish	20 05.07	018 12.00	DMS		John
03/05/2009	07:20	Fish	20 05.35	018 10.02	DMS		John
03/05/2009	07:40	Fish	20 07.11	018 09.36	DMS		John
03/05/2009	08:00	Fish	20 09.18	018 09.16	DMS		John
03/05/2009	08:20	Fish	20 11.32	018 08.94	DMS		John
03/05/2009	08:42	Non toxic	20 09.97	018 09.356	molecular	6042492	Simon
03/05/2009	08:51	Fish	20 14.55	018 08.68	nutrients	A1	Malcolm W.
03/05/2009	08:51	Fish	20 14.55	018 08.68	AFC	1	Glen
03/05/2009	09:20	Fish	20 16.33	018 08.68	DMS		John
03/05/2009	09:30	Fish	20 17.56	018 08.51	AFC	2	Glen
03/05/2009	09:30	Fish	20 17.56	018 08.51	nutrients	A2	Glen

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
03/05/2009	09:40	Fish	20 18.43	018 08.41	DMS		John
03/05/2009	10:00	Fish	20 20.54	018 08.15	DMS		John
03/05/2009	10:02	Fish	20 20.77	018 08.11	nutrients	A3	Malcolm W.
03/05/2009	10:20	Fish	20 22.76	018 07.87	DMS		John
03/05/2009	10:30	Fish	20 23.97	018 07.72	nutrients	A4	Glen
03/05/2009	10:30	Fish	20 23.97	018 07.72	AFC	4	Glen
03/05/2009	10:40	Fish	20 24.98	018 07.63	DMS		John
03/05/2009	11:00	Fish	20 27.23	018 07.39	DMS		John
03/05/2009	11:00	Fish	20 27.23	018 07.39	AFC	5	Malcolm W.
03/05/2009	11:00	Fish	20 27.23	018 07.39	nutrients	A5	Malcolm W.
03/05/2009	11:05	Non toxic	20 27.77	018 07.32	molecular	6042492	Simon
03/05/2009	11:20	Fish	20 29.43	018 07.12	DMS		John
03/05/2009	11:30	Fish	20 30.54	018 07.00	AFC	6	Glen
03/05/2009	11:30	Fish	20 30.54	018 07.00	nutrients	A6	Glen
03/05/2009	11:40	Fish	20 31.60	018 06.89	DMS		Frankie
03/05/2009	12:00	Fish	20 33.62	018 06.67	nutrients	A7	Malcolm W.
03/05/2009	12:00	Fish	20 33.62	018 06.67	AFC	7	Malcolm W.
03/05/2009	12:00	Fish	20 33.64	018 06.67	DMS		Frankie
03/05/2009	12:30	Fish	20 37.22	018 06.38	nutrients	A8	Glen
03/05/2009	12:30	Fish	20 37.22	018 06.38	AFC	8	Glen
03/05/2009	12:40	Fish	20 38.30	018 06.31	DMS		Frankie
03/05/2009	13:00	Fish	20 40.75	018 06.01	nutrients	A9	Glen
03/05/2009	13:00	Fish	20 40.75	018 06.01	AFC	9	Glen
03/05/2009	13:00	Fish	20 40.75	018 06.01	DMS		Frankie

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
03/05/2009	13:20	Fish	20 42.79	018 05.66	DMS		Frankie
03/05/2009	13:30	Fish	20 43.98	18 05.52	nutrients	A10	Malcolm W.
03/05/2009	13:30	Fish	20 43.98	18 05.52	AFC	10	Malcolm W.
03/05/2009	13:40	Fish	20 45.12	18 05.43	DMS		Frankie
03/05/2009	14:00	Fish	20 47.51	18 05.26	DMS		Frankie
03/05/2009	14:00	Fish	20 47.51	18 05.26	nutrients	A11	Glen
03/05/2009	14:00	Fish	20 47.51	18 05.26	AFC	11	Glen
03/05/2009	14:20	Fish	20 49.89	018 05.14	DMS		Frankie
03/05/2009	14:30	Fish	20 51.02	018 05.06	AFC	12	Malcolm W.
03/05/2009	14:30	Fish	20 51.02	018 05.06	nutrients	A12	Malcolm W.
03/05/2009	14:40	Fish	20 52.15	018 04.98	DMS		Frankie
03/05/2009	14:42	Non toxic	20 52.34	018 04.97	molecular	6042493	Simon
03/05/2009	15:00	Fish	20 54.41	018 04.83	DMS		John
03/05/2009	15:00	Fish	20 54.41	018 04.83	nutrients	A13	Glen
03/05/2009	15:00	Fish	20 54.41	018 04.83	AFC	13	Glen
03/05/2009	15:20	Fish	20 56.90	018 04.63	DMS		John
03/05/2009	15:30	Fish	20 58.21	018 04.46	nutrients	A14	Malcolm W.
03/05/2009	15:30	Fish	20 58.21	018 04.46	AFC	14	Malcolm W.
03/05/2009	15:40	Fish	20 59.17	018 04.31	DMS		John
03/05/2009	16:00	Fish	21 00.64	018 02.68	nutrients	U15	Glen
03/05/2009	16:00	Fish	21 00.64	018 02.68	AFC	15	Glen
03/05/2009	16:00	Fish	21 00.64	018 02.68	DMS		John
03/05/2009	16:20	Fish	21 01.59	018 00.40	DMS		John
03/05/2009	16:30	Fish	21 02.08	017 59.14	nutrients	U16	Malcolm W.

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
03/05/2009	16:30	Fish	21 02.08	017 59.14	AFC	16	Malcolm W.
08/05/2009	06:58	Non toxic	21 26.58	017 59.26	nutrients	A1	Carol
08/05/2009	07:14	Non toxic	21 28.26	017 59.18	nutrients	A2	Carol
08/05/2009	08:10	Non toxic	21 23.72	017 57.35	nutrients	A3	Carol
11/05/2009	18:55	Fish	20 08.10	018 42.26	nutrients	A1	Carol
11/05/2009	19:30	Fish	20 01.65	018 43.97	AFC	1930	Glen
11/05/2009	19:30	Fish	20 01.65	018 43.97	DMS		John
11/05/2009	19:40	Fish	19 59.65	018 44.49	AFC	1940	Glen
11/05/2009	19:40	Fish	19 59.65	018 44.49	DMS		John
11/05/2009	19:50	Fish	19 57.82	018 44.97	AFC	1950	Glen
11/05/2009	20:00	Fish	19 55.96	018 45.46	AFC	2000	Glen
11/05/2009	20:00	Fish	19 55.96	018 45.46	DMS		John
11/05/2009	19:50	Non toxic	19 58.3	018 44.83	molecular	6042504	Simon
11/05/2009	19:50	Fish	19 58.29	018 44.83	nutrients	A2	Simon
11/05/2009	20:00	Fish	19 55.45	018 45.60	nutrients	A3	Carol
11/05/2009	20:10	Fish	19 54.08	018 45.97	AFC	2010	Glen
11/05/2009	20:12	Fish	19 53.68	018 46.07	nutrients	A4	Carol
11/05/2009	20:20	Fish	19 52.19	018 46.47	AFC	2020	Glen
11/05/2009	20:20	Fish	19 52.19	018 46.47	nutrients	A5	Simon
11/05/2009	20:20	Fish	19 52.19	018 46.47	DMS		John
11/05/2009	20:30	Fish	19 50.28	018 46.95	AFC	2030	Glen
11/05/2009	20:30	Fish	19 50.28	018 46.95	nutrients	A6	Simon
11/05/2009	20:40	Fish	19 48.41	018 47.34	AFC	2040	Glen
11/05/2009	20:40	Fish	19 48.41	018 47.34	nutrients	A7	Simon

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
11/05/2009	20:40	Fish	19 48.41	018 47.34	DMS		John
11/05/2009	20:50	Fish	19 46.53	018 47.93	AFC	2050	Glen
11/05/2009	20:50	Fish	19 46.53	018 47.93	nutrients	A8	Simon
11/05/2009	21:00	Fish	19 44.73	018 48.39	AFC	2100	Glen
11/05/2009	21:00	Fish	19 44.73	018 48.39	nutrients	A9	Simon
11/05/2009	21:00	Fish	19 44.73	018 48.39	DMS		John
11/05/2009	21:10	Fish	19 42.75	018 48.93	AFC	2110	Glen
11/05/2009	21:10	Fish	19 42.75	018 48.93	nutrients	A10	Simon
11/05/2009	21:20	Fish	19 40.86	018 49.44	AFC	2120	Glen
11/05/2009	21:20	Fish	19 40.86	018 49.44	nutrients	A11	Simon
11/05/2009	21:20	Fish	19 40.86	018 49.44	DMS		John
11/05/2009	21:30	Fish	19 38.00	018 49.93	AFC	2130	Glen
11/05/2009	21:30	Fish	19 38.00	018 49.93	nutrients	U12	Simon
11/05/2009	21:21	Fish	19 40	018 49	ovoc		Rachael
11/05/2009	21:40	Fish	19 37.02	018 50.43	AFC	2140	Glen
11/05/2009	21:40	Fish	19 37.02	018 50.43	nutrients	A13	Simon
11/05/2009	21:40	Fish	19 37.02	018 50.43	DMS		John
11/05/2009	21:40	Non toxic	19 37.02	018 50.43	molecular	6042505	Simon
11/05/2009	21:50	Fish	19 35.05	018 50.95	AFC	2150	Glen
11/05/2009	21:50	Fish	19 35.05	018 50.95	nutrients	U14	Simon
11/05/2009	22:00	Fish	19 33.30	018 51.42	AFC	2200	Glen
11/05/2009	22:00	Fish	19 33.30	018 51.42	nutrients	U15	Simon
11/05/2009	22:00	Fish	19 33.30	018 51.42	DMS		John
11/05/2009	22:10	Fish	19 31.34	018 51.93	AFC	2210	Glen

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
11/05/2009	22:10	Fish	19 31.34	018 51.93	nutrients	U16	Simon
11/05/2009	22:20	Fish	19 29.34	018 52.46	AFC	2220	Glen
11/05/2009	22:20	Fish	19 29.34	018 52.46	nutrients	U17	Simon
11/05/2009	22:20	Fish	19 29.34	018 52.46	DMS		Frankie
11/05/2009	22:30	Fish	19 27.52	018 52.93	AFC	2230	Glen
11/05/2009	22:30	Fish	19 27.52	018 52.93	nutrients	U18	Simon
11/05/2009	22:40	Fish	19 25.44	018 53.45	AFC	2240	Glen
11/05/2009	22:40	Fish	19 25.44	018 53.45	nutrients	U19	Simon
11/05/2009	22:40	Fish	19 25.44	018 53.45	DMS		
11/05/2009	22:40	Non toxic	19 25.44	018 53.45	molecular	6042506	Simon
11/05/2009	22:50	Fish	19 53.58	018 53.97	AFC	2250	Glen
11/05/2009	22:50	Fish	19 53.58	018 53.97	nutrients	U20	Simon
11/05/2009	23:00	Fish	19 21.61	018 54.49	AFC	2300	Glen
11/05/2009	23:00	Fish	19 21.61	018 54.49	nutrients	U21	Simon
11/05/2009	23:00	Fish	19 21.61	018 54.49	DMS		Frankie
11/05/2009	23:10	Fish	19 19.59	018 55.01	AFC	2310	Glen
11/05/2009	23:10	Fish	19 19.59	018 55.01	nutrients	22	Simon
11/05/2009	23:20	Fish	19 17.47	018 55.56	AFC	2320	Glen
11/05/2009	23:20	Fish	19 17.47	018 55.56	nutrients	23	Simon
11/05/2009	23:20	Fish	19 17.47	018 55.56	DMS		Frankie
11/05/2009	23:30	Fish	19 15.53	018 56.08	AFC	2330	Glen
11/05/2009	23:30	Fish	19 15.53	018 56.08	nutrients	24	Simon
11/05/2009	23:40	Fish	19 13.77	018 56.53	AFC	2340	Glen
11/05/2009	23:40	Fish	19 13.77	018 56.53	nutrients	25	Simon

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Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
11/05/2009	23:40	Fish	19 13.77	018 56.53	DMS		Frankie
11/05/2009	23:40	Non toxic	19 13.77	018 56.53	molecular	6042507	Simon
11/05/2009	23:50	Fish	19 11.86	018 57.02	AFC	2350	Glen
11/05/2009	23:50	Fish	19 11.86	018 57.02	nutrients	26	Simon
12/05/2009	00:00	Fish	19 10.01	018 57.53	AFC	00:00	Glen
12/05/2009	00:00	Fish	19 10.01	018 57.53	nutrients	27	Simon
12/05/2009	00:00	Fish	19 10.01	018 57.53	DMS		Frankie
12/05/2009	00:10	Fish	19 08.15	018 50.02	AFC	00:10	Glen
12/05/2009	00:10	Fish	19 08.15	018 50.02	nutrients	28	Simon
12/05/2009	00:20	Fish	19 06.23	018 58.52	DMS		Frankie
12/05/2009	00:20	Fish	19 06.16	018 58.54	AFC	00:20	Glen
12/05/2009	00:20	Fish	19 06.16	018 58.54	nutrients	29	Simon
12/05/2009	00:30	Fish	19 04.33	018 59.00	AFC	00:30	Glen
12/05/2009	00:30	Fish	19 04.33	018 59.00	nutrients	30	Simon
12/05/2009	00:40	Fish	19 02.50	018 59.41	AFC	00:40	Glen
12/05/2009	00:40	Fish	19 02.50	018 59.41	nutrients	31	Simon
12/05/2009	00:40	Fish	19 02.50	018 59.41	DMS		Frankie
12/05/2009	00:50	Fish	19 00.58	018 59.82	AFC	00:50	Glen
12/05/2009	00:50	Fish	19 00.58	018 59.82	nutrients	32	Simon
12/05/2009	00:50	Non toxic	19 00.58	018 59.82	molecular	6042508	Simon
12/05/2009	01:00	Fish	18 58.75	019 00.23	AFC	01:00	Glen
12/05/2009	01:00	Fish	18 58.75	019 00.23	nutrients	33	Simon
12/05/2009	01:00	Fish	18 58.75	019 00.23	DMS		Frankie
12/05/2009	01:10	Fish	18 56.72	019 00.68	AFC	01:10	Glen

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
12/05/2009	01:10	Fish	18 56.72	019 00.68	nutrients	A	Simon
12/05/2009	01:20	Fish	18 54.95	019 01.11	AFC	01:20	Glen
12/05/2009	01:20	Fish	18 54.95	019 01.11	nutrients	B	Simon
12/05/2009	01:20	Fish	18 54.95	019 01.11	DMS		Frankie
12/05/2009	01:30	Fish	18 53.07	019 01.19	AFC	01:30	Glen
12/05/2009	01:30	Fish	18 53.07	019 01.19	nutrients	C	Simon
12/05/2009	01:40	Fish	18 51.18	019 00.91	AFC	01:40	Glen
12/05/2009	01:40	Fish	18 51.18	019 00.91	nutrients	D	Simon
12/05/2009	01:40	Fish	18 51.18	019 00.91	DMS		Frankie
12/05/2009	01:50	Fish	18 49.35	019 00.63	AFC	01:50	Glen
12/05/2009	01:50	Fish	18 49.35	019 00.63	nutrients	E	Simon
12/05/2009	02:00	Fish	18 47.33	019 00.33	AFC	02:00	Glen
12/05/2009	02:00	Fish	18 47.33	019 00.33	nutrients	F	Simon
12/05/2009	02:00	Fish	18 47.33	019 00.33	DMS		Frankie
12/05/2009	11:37	Fish	19 22.06	019 39.3	nutrients	A10	Malcolm W.
12/05/2009	11:54	Fish	19 18.95	019 40.59	nutrients	A10, U21	Carol
12/05/2009	12:03	Fish	19 17.31	019 41.25	nutrients	A10	Carol
12/05/2009	12:11	Fish	19 15.76	019 41.86	nutrients	A10	Carol
12/05/2009	12:21	Fish	19 13.97	019 42.56	nutrients	A10	Carol
12/05/2009	12:31	Fish	19 12.08	019 43.29	nutrients	A10	Carol
12/05/2009	12:41	Fish	19 10.29	019 43.99	nutrients	A10	Carol
12/05/2009	12:51	Fish	19 08.34	019 44.74	nutrients	A10	Carol
12/05/2009	13:08	Fish	19 05.56	019 45.75	nutrients	A10	Carol
12/05/2009	13:22	Fish	19 03.06	019 46.68	nutrients	A10	Carol

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Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
12/05/2009	13:36	Fish	19 00.42	019 47.71	nutrients	A10	Carol
12/05/2009	13:52	Fish	18 57.69	019 48.77	nutrients	A10	Carol
12/05/2009	19:07	Fish	19 12.82	019 43.89	nutrients	A10	Andy
13/05/2009	12:14	Fish	19 26.3	018 32.53	nutrients	A1	Carol
13/05/2009	13:48	Fish	19 35.88	018 28.63	nutrients	A2	Carol
13/05/2009	14:00	Fish	19 37.03	018 28.14	nutrients	A4	Carol
13/05/2009	14:35	Fish	19 39.64	018 27.00	nutrients	A3	Carol
13/05/2009	17:02	Fish	19 37.00	018 28.13	nutrients	U16	John
13/05/2009	17:12	Fish	19 37.57	018 27.97	nutrients	A	John
13/05/2009	17:22	Fish	19 38.59	018 27.50	nutrients	B	John
13/05/2009	17:32	Fish	19 39.48	018 27.11	nutrients	C	John
13/05/2009	17:42	Fish	19 40.48	018 26.68	nutrients	D	John
13/05/2009	17:52	Fish	19 41.43	018 26.26	nutrients	E	Andy
13/05/2009	18:02	Fish	19 42.48	018 25.81	nutrients	F	Andy
13/05/2009	18:12	Fish	19 43.38	018 25.44	nutrients	G	Jo
13/05/2009	18:22	Fish	19 44.37	018 25.02	nutrients	H	Jo
13/05/2009	18:32	Fish	19 45.29	018 24.62	nutrients	I	Jo
13/05/2009	18:42	Fish	19 46.23	018 24.23	nutrients	J	Jo
13/05/2009	18:52	Fish	19 47.22	018 23.83	nutrients	K	Jo
13/05/2009	19:02	Fish	19 48.21	018 23.41	nutrients	L	Jo
13/05/2009	19:13	Fish	19 49.36	018 22.92	nutrients	M	Jo
13/05/2009	19:22	Fish	19 50.21	018 22.57	nutrients	N	Jo
13/05/2009	19:32	Fish	19 51.21	018 22.16	nutrients	O	Jo
20/05/2009	04:00	Fish	19 41.622	018 46.031	AFC	04:00	Glen

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
20/05/2009	04:00	Fish	19 41.622	018 46.031	SF6, N2O, CH4	04:00	Ian
20/05/2009	04:00	Fish	19 41.622	018 46.031	DMS/P	04:00	John
20/05/2009	05:00	Fish	19 41.269	018 46.767	AFC	05:00	Glen
20/05/2009	05:00	Fish	19 41.269	018 46.767	SF6	05:00	Phil
20/05/2009	05:00	Fish	19 41.269	018 46.767	oVOCs	05:00	Rachael
20/05/2009	05:00	Fish	19 41.269	018 46.767	DMS/P	05:00	John
20/05/2009	05:00	Fish	19 41.269	018 46.767	N2O/CH4	05:00	Ian
20/05/2009	05:00	Fish	19 41.269	018 46.767	chlorophyll	05:00	Frankie
20/05/2009	06:00	Fish	19 41.534	018 47.356	N2O/CH4	06:00	Ian
20/05/2009	06:00	Fish	19 41.534	018 47.356	oVOCs	06:00	Rachael
20/05/2009	06:00	Fish	19 41.534	018 47.356	DMS	06:00	John
20/05/2009	06:00	Fish	19 41.534	018 47.356	SF6	06:00	Phil
20/05/2009	06:00	Fish	19 41.534	018 47.356	AFC	06:00	Glen
20/05/2009	06:00	Fish	19 41.534	018 47.356	chlorophyll	06:00	Frankie
20/05/2009	07:20	Fish	19 41.217	018 48.174	N2O/CH4	07:20	Ian
20/05/2009	07:20	Fish	19 41.217	018 48.174	oVOCs	07:20	Rachael
20/05/2009	07:20	Fish	19 41.217	018 48.174	DMS	07:20	John
20/05/2009	07:20	Fish	19 41.217	018 48.174	SF6	07:20	Phil
20/05/2009	07:20	Fish	19 41.217	018 48.174	AFC	07:20	Glen
20/05/2009	07:20	Fish	19 41.217	018 48.174	chlorophyll	07:20	Frankie
20/05/2009	08:25	Fish	19 40.909	018 48.606	N2O/CH4	08:30	Ian
20/05/2009	08:25	Fish	19 40.909	018 48.606	oVOCs	08:30	Rachael
20/05/2009	08:25	Fish	19 40.909	018 48.606	DMS	08:30	John
20/05/2009	08:25	Fish	19 40.909	018 48.606	SF6	08:30	Phil

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Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
20/05/2009	08:25	Fish	19 40.909	018 48.606	AFC	08:30	Glen
20/05/2009	08:25	Fish	19 40.909	018 48.606	chlorophyll	08:30	Frankie
20/05/2009	09:00	Fish	19 41.007	018 48.851	AFC	09:00	Glen
20/05/2009	09:00	Fish	19 41.007	018 48.851	N2O/CH4	09:00	Andy
20/05/2009	09:00	Fish	19 41.007	018 48.851	DMS	09:00	John
20/05/2009	09:00	Fish	19 41.007	018 48.851	SF6	09:00	Ian
20/05/2009	09:00	Fish	19 41.007	018 48.851	chlorophyll	09:00	Frankie
20/05/2009	09:00	Fish	19 41.007	018 48.851	oVOCs	09:00	Rachael
20/05/2009	10:00	Non toxic	19 40.88	018 49.42	molecular	10:00	Simon
20/05/2009	10:20	Fish	19 40.878	018 49.423	AFC	10:20	Susan
20/05/2009	10:20	Fish	19 40.878	018 49.423	DMS	10:20	Frankie
20/05/2009	10:20	Fish	19 40.878	018 49.423	chlorophyll	10:20	Frankie
20/05/2009	10:20	Fish	19 40.878	018 49.423	oVOCs	10:20	Rachael
20/05/2009	10:20	Fish	19 40.878	018 49.423	SF6	10:20	Malcolm L
20/05/2009	10:20	Fish	19 40.878	018 49.423	N2O/CH4	10:20	Andy
20/05/2009	11:10	Fish	19 40.596	018 49.875	oVOCs	11:10	Rachael
20/05/2009	11:10	Fish	19 40.596	018 49.875	DMS	11:10	Frankie
20/05/2009	11:10	Fish	19 40.596	018 49.875	AFC	11:10	Susan
20/05/2009	11:10	Fish	19 40.596	018 49.875	N2O/CH4	11:15	Andy
20/05/2009	11:10	Fish	19 40.596	018 49.875	chlorophyll	11:15	Claire
20/05/2009	11:10	Fish	19 40.596	018 49.875	SF6	11:15	Phil
20/05/2009	12:20	Fish	19 40.329	018 50.302	chlorophyll	12:20	Claire
20/05/2009	12:20	Fish	19 40.329	018 50.302	oVOCs	12:20	Rachael
20/05/2009	12:20	Fish	19 40.329	018 50.302	AFC	12:20	Susan

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Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
20/05/2009	12:20	Fish	19 40.329	018 50.302	SF6	12:20	Phil
20/05/2009	12:20	Fish	19 40.329	018 50.302	DMS	12:20	Frankie
20/05/2009	12:20	Fish	19 40.329	018 50.302	N2O/CH4	12:25	Andy
20/05/2009	12:20	Fish	19 40.329	018 50.302	oVOCs	12:25	Jo
20/05/2009	13:00	Fish	19 40.416	018 50.44	chlorophyll	13:00	Claire
20/05/2009	13:00	Fish	19 40.416	018 50.44	oVOCs	13:00	Rachael
20/05/2009	13:00	Fish	19 40.416	018 50.44	DMS	13:00	Frankie
20/05/2009	13:00	Fish	19 40.416	018 50.44	N2O/CH4	13:08	Andy
20/05/2009	13:00	Fish	19 40.416	018 50.44	SF6	13:08	Phil
20/05/2009	13:00	Fish	19 40.416	018 50.44	AFC	13:08	Susan
20/05/2009	14:17	Fish	19 41.13	018 51.42	oVOCs	14:17	Rachael
20/05/2009	14:17	Fish	19 41.13	018 51.42	DMS	14:17	John
20/05/2009	14:17	Fish	19 41.13	018 51.42	N2O/CH4	14:24	Andy
20/05/2009	14:17	Fish	19 41.13	018 51.42	SF6	14:24	Phil
20/05/2009	14:17	Fish	19 41.13	018 51.42	AFC	14:24	Susan
20/05/2009	14:17	Fish	19 41.13	018 51.42	chlorophyll	14:24	Claire
20/05/2009	15:20	Fish	19 40.7	018 51.7	DMS/P	15:20	John
20/05/2009	15:20	Fish	19 40.7	018 51.7	oVOCs	15:20	Rachael
20/05/2009	15:20	Fish	19 40.7	018 51.7	AFC	15:20	Glen
20/05/2009	15:20	Fish	19 40.7	018 51.7	SF6	15:20	Malcolm L
20/05/2009	15:20	Fish	19 40.7	018 51.7	oVOCs	15:20	Jo
20/05/2009	15:20	Fish	19 40.7	018 51.7	CH4	15:25	Andy
20/05/2009	15:20	Fish	19 40.7	018 51.7	chlorophyll	15:25	Claire
20/05/2009	16:04	Non toxic	19 41.44	018 51.8	molecular	16:00	Simon

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Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
20/05/2009	16:30	Fish	19 41.31	018 51.8	AFC	16:30	Susan
20/05/2009	16:30	Fish	19 41.31	018 51.8	oVOCs	16:30	Rachael
20/05/2009	16:30	Fish	19 41.31	018 51.8	DMS/P	16:30	John
20/05/2009	16:30	Fish	19 41.31	018 51.8	CH4	16:30	Andy
20/05/2009	16:30	Fish	19 41.31	018 51.8	SF6	16:30	Malcolm L
20/05/2009	16:30	Fish	19 41.31	018 51.8	chlorophyll	16:30	Claire
20/05/2009	17:10	Fish	19 41.01	018 52.41	AFC	17:10	Susan
20/05/2009	17:10	Fish	19 41.01	018 52.41	oVOCs	17:10	Rachael
20/05/2009	17:10	Fish	19 41.01	018 52.41	DMS/P	17:10	John
20/05/2009	17:10	Fish	19 41.01	018 52.41	CH4	17:15	Andy
20/05/2009	17:10	Fish	19 41.01	018 52.41	SF6	17:15	Malcolm L
20/05/2009	17:10	Fish	19 41.01	018 52.41	chlorophyll	17:15	Claire
20/05/2009	18:34	Fish	19 40.96	018 52.89	oVOC oxidation	18:40	Jo
20/05/2009	18:34	Fish	19 40.96	018 52.89	CH4	18:40	Andy
20/05/2009	18:34	Fish	19 40.96	018 52.89	SF6	18:40	Phil
20/05/2009	18:34	Fish	19 40.96	018 52.89	oVOCs	18:40	Rachael
20/05/2009	18:34	Fish	19 40.96	018 52.89	DMS/P	18:40	John
20/05/2009	18:34	Fish	19 40.96	018 52.89	AFC	18:40	Glen
20/05/2009	18:34	Fish	19 40.96	018 52.89	chlorophyll	18:40	Claire
20/05/2009	19:10	Fish	19 41.325	018 52.809	AFC	19:10	Glen
20/05/2009	19:10	Fish	19 41.325	018 52.809	oVOCs	19:10	Rachael
20/05/2009	19:10	Fish	19 41.325	018 52.809	chlorophyll	19:10	Claire
20/05/2009	19:10	Fish	19 41.325	018 52.809	CH4	19:10	Andy
20/05/2009	19:10	Fish	19 41.325	018 52.809	SF6	19:10	Phil

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Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
20/05/2009	19:10	Fish	19 41.325	018 52.809	DMS/P	19:10	John
20/05/2009	20:13	Fish	19 41.218	018 52.997	AFC	20:13	Glen
20/05/2009	20:13	Fish	19 41.218	018 52.997	oVOCs	20:13	Rachael
20/05/2009	20:13	Fish	19 41.218	018 52.997	chlorophyll	20:13	Claire
20/05/2009	20:13	Fish	19 41.218	018 52.997	CH4	20:13	Andy
20/05/2009	20:13	Fish	19 41.218	018 52.997	SF6	20:13	Phil
20/05/2009	20:13	Fish	19 41.218	018 52.997	DMS/P	20:13	Frankie
20/05/2009	21:00	Fish	19 41.250	018 52.975	AFC	21:00	Glen
20/05/2009	21:00	Fish	19 41.250	018 52.975	DMS	21:00	Frankie
20/05/2009	21:00	Fish	19 41.250	018 52.975	chlorophyll	21:00	Claire
20/05/2009	21:00	Fish	19 41.250	018 52.975	SF6	21:00	Phil
20/05/2009	21:00	Fish	19 41.250	018 52.975	CH4	21:05	Andy
20/05/2009	21:00	Fish	19 41.250	018 52.975	oVOCs	21:05	Rachael
20/05/2009	22:00	Fish	19 41.48	018 52.89	AFC	22:00	Glen
20/05/2009	22:00	Fish	19 41.48	018 52.89	chlorophyll	22:00	Frankie
20/05/2009	22:00	Fish	19 41.48	018 52.89	DMS/P	22:00	Frankie
20/05/2009	22:00	Fish	19 41.48	018 52.89	oVOCs	22:00	Rachael
20/05/2009	22:00	Fish	19 41.48	018 52.89	SF6	22:00	Phil
20/05/2009	22:00	Fish	19 41.48	018 52.89	CH4	22:05	Andy
20/05/2009	22:00	nontoxic	19 41.48	018 52.89	molecular	22:05	Simon
20/05/2009	23:00	Fish	19 40.755	018 52.828	oVOCs	23:00	Rachael
20/05/2009	23:00	Fish	19 40.755	018 52.828	AFC	23:00	Glen
20/05/2009	23:00	Fish	19 40.755	018 52.828	N2O/CH4	23:00	Ian
20/05/2009	23:00	Fish	19 40.755	018 52.828	DMS/P	23:00	Frankie

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
20/05/2009	23:00	Fish	19 40.755	018 52.828	chlorophyll	23:00	Frankie
20/05/2009	23:00	Fish	19 40.755	018 52.828	SF6	23:00	Phil
21/05/2009	00:00	Fish	19 40.189	018 52.753	AFC	00:00	Glen
21/05/2009	00:00	Fish	19 40.189	018 52.753	oVOCs	00:00	Rachael
21/05/2009	00:00	Fish	19 40.189	018 52.753	SF6	00:00	Phil
21/05/2009	00:00	Fish	19 40.189	018 52.753	DMS/P	00:00	Frankie
21/05/2009	00:00	Fish	19 40.189	018 52.753	chlorophyll	00:00	Frankie
21/05/2009	01:00	Fish	19 40.675	018 52.704	AFC	01:00	Glen
21/05/2009	01:00	Fish	19 40.675	018 52.704	DMS/P	01:00	Frankie
21/05/2009	01:00	Fish	19 40.675	018 52.704	chlorophyll	01:00	Frankie
21/05/2009	01:00	Fish	19 40.675	018 52.704	SF6	01:00	Phil
21/05/2009	01:00	Fish	19 40.675	018 52.704	oVOCs	01:00	Phil
21/05/2009	02:00	Fish	19 40.713	018 53.222	AFC	02:00	Glen
21/05/2009	02:00	Fish	19 40.713	018 53.222	oVOCs	02:00	Glen
21/05/2009	02:00	Fish	19 40.713	018 53.222	DMS/P	02:00	Frankie
21/05/2009	02:00	Fish	19 40.713	018 53.222	chlorophyll	02:00	Frankie
21/05/2009	02:00	Fish	19 40.713	018 53.222	SF6	02:00	Ian
21/05/2009	03:00	Fish	19 40.249	018 53.833	AFC	03:00	Susan
21/05/2009	03:00	Fish	19 40.249	018 53.833	SF6	03:00	Ian
21/05/2009	03:00	Fish	19 40.249	018 53.833	oVOCs	03:00	Phil
21/05/2009	03:00	Fish	19 40.249	018 53.833	DMS/P	03:00	Frankie
21/05/2009	03:00	Fish	19 40.249	018 53.833	chlorophyll	03:00	Frankie
21/05/2009	04:00	Fish	19 38.311	018 53.919	AFC	04:00	Susan
21/05/2009	04:00	Fish	19 38.311	018 53.919	DMS/P	04:00	Frankie

Underway Water Sampling Log - UK SOLAS cruises

Deck lab non toxic and fish

Cruise: Discovery D338 ICON

Date	Time GMT	Non toxic or fish	Latitude	Longitude	Parameter	Sample identifier	Scientist
21/05/2009	04:00	Fish	19 38.311	018 53.919	chlorophyll	04:00	Frankie
21/05/2009	04:00	Fish	19 38.311	018 53.919	SF6	04:00	Ian
21/05/2009	04:00	Fish	19 38.311	018 53.919	oVOCs	04:00	Phil
21/05/2009	05:00	Fish	19 38.169	018 54.273	SF6	05:00	Ian
21/05/2009	05:00	Fish	19 38.169	018 54.273	oVOCs	05:00	Frankie
21/05/2009	05:00	Fish	19 38.169	018 54.273	AFC	05:00	Susan
21/05/2009	23:40	Fish	19 33.878	019 02.541	DMS	23:40	Frankie
22/05/2009	00:00	Fish	19 32.930	019 04.470	DMS	00:00	Frankie
22/05/2009	00:20	Fish	19 30.743	019 03.937	DMS	00:20	Frankie
22/05/2009	00:40	Fish	19 32.115	019 05.395	DMS	00:40	Frankie
22/05/2009	01:00	Fish	19 34.655	019 06.464	DMS	01:00	Frankie
22/05/2009	01:20	Fish	19 34.251	019 07.003	DMS	01:20	Frankie
22/05/2009	01:40	Fish	19 30.910	019 06.982	DMS	01:40	Frankie
22/05/2009	02:00	Fish	19 30.526	019 07.605	DMS	02:00	Frankie
22/05/2009	02:20	Fish	19 31.449	019 09.000	DMS	02:20	Frankie
22/05/2009	02:40	Fish	19 29.932	019 07.404	DMS	02:40	Frankie
22/05/2009	03:00	Fish	19 30.895	019 04.723	DMS	03:00	Frankie
22/05/2009	03:20	Fish	19 31.885	019 02.019	DMS	03:20	Frankie
22/05/2009	03:40	Fish	19 32.608	019 03.243	DMS	03:40	Frankie
22/05/2009	04:00	Fish	19 31.345	019 06.052	DMS	04:00	Frankie

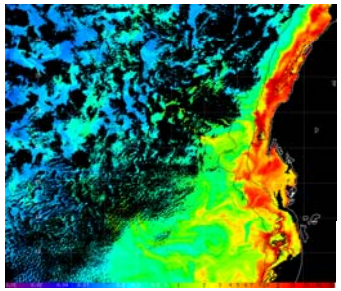
>water_sample: owner simoma on Thu Apr 2 09:39:48 2009													
barcode	**storage location**	**creation date**	*storage date*	*volume filt*	**site latitude**	**site longitude**	**depth in**	**filter type**	**filter nu**	*post filtering treatment*	*time of day*	*comments*	*bottle number*
	***text(128)**	***date(yyyy-mm-**	*date(yyyy-mm-dd*	*real(4)*	***real(8)**	***real(8)**	***real(4)**	***text(128)**	***intege**	*text(128)*	*text(5)*	*text(unlimited)*	
06-042460	chest freezer in hold	2009-04-22	2009-04-22	3	21o 26.167	17o 15.626	0	sterivex 0.22um	2	ON + RNA later	predawn	Day 0	
06-042461	chest freezer in hold	2009-04-22	2009-04-22	3	21o 26.167	17o 15.626	15	sterivex 0.22um	2	ON + RNA later	predawn	Day 0	
06-042462	chest freezer in hold	2009-04-22	2009-04-22	3	21o 26.167	17o 15.626	35	sterivex 0.22um	2	ON + RNA later	predawn	Day 0	4
06-042463	chest freezer in hold	2009-04-23	2009-04-23	10	21o 11.787	17o 22.07	5	sterivex 0.22um	2	ON + RNA later	predawn	Day1	9
06-042464	chest freezer in hold	2009-04-23	2009-04-23	10	21o 11.787	17o 22.07	15	sterivex 0.22um	2	ON + RNA later	predawn	Day1	7&8
06-042465	chest freezer in hold	2009-04-23	2009-04-23	10	21o 11.787	17o 22.07	37	sterivex 0.22um	2	ON + RNA later	predawn	Day1	4
06-042466	chest freezer in hold	2009-04-23	2009-04-23	10	21o 11.787	17o 22.07	65	sterivex 0.22um	2	ON + RNA later	predawn	Day1	3
06-042467	chest freezer in hold	2009-04-24	2009-04-24	10	21o 00.879	17o 27.93	5	sterivex 0.22um	2	ON + RNA later	predawn	Day 2	11
06-042468	chest freezer in hold	2009-04-24	2009-04-24	10	21o 00.879	17o 27.93	15	sterivex 0.22um	2	ON + RNA later	predawn	Day 2	7
06-042469	chest freezer in hold	2009-04-24	2009-04-24	10	21o 00.879	17o 27.93	34	sterivex 0.22um	2	ON + RNA later	predawn	Day 2	4
06-042470	chest freezer in hold	2009-04-24	2009-04-24	10	21o 00.879	17o 27.93	80	sterivex 0.22um	2	ON + RNA later	predawn	Day 2	2
06-042471	chest freezer in hold	2009-04-25	2009-04-25	10	22o 52.081	17o 37.14	5	sterivex 0.22um	2	ON + RNA later	predawn	Day 3	14
06-042472	chest freezer in hold	2009-04-25	2009-04-25	10	22o 52.081	17o 37.14	15	sterivex 0.22um	2	ON + RNA later	predawn	Day 3	7
06-042473	chest freezer in hold	2009-04-25	2009-04-25	10	22o 52.081	17o 37.14	34	sterivex 0.22um	2	ON + RNA later	predawn	Day 3	6
06-042474	chest freezer in hold	2009-04-25	2009-04-25	10	22o 52.081	17o 37.14	80	sterivex 0.22um	2	ON + RNA later	predawn	Day 3	2 & 3
06-042475	chest freezer in hold	2009-04-26	2009-04-26	10	22o 41.827	17o 49.09	5	sterivex 0.22um	2	ON + RNA later	predawn	Day4	11
06-042476	chest freezer in hold	2009-04-26	2009-04-26	10	22o 41.827	17o 49.09	15	sterivex 0.22um	2	ON + RNA later	predawn	Day4	
06-042477	chest freezer in hold	2009-04-26	2009-04-26	10	22o 41.827	17o 49.09	34	sterivex 0.22um	2	ON + RNA later	predawn	Day4	
06-042478	chest freezer in hold	2009-04-26	2009-04-26	10	22o 41.827	17o 49.09	80	sterivex 0.22um	2	ON + RNA later	predawn	Day4	
06-042479	chest freezer in hold	2009-04-27	2009-04-27	10	20 40.351	17 54.210	5	sterivex 0.22um	2	ON + RNA later	predawn	Day5	9
06-042480	chest freezer in hold	2009-04-27	2009-04-27	10	20 40.351	17 54.210	15	sterivex 0.22um	2	ON + RNA later	predawn	Day5	7
06-042481	chest freezer in hold	2009-04-27	2009-04-27	10	20 40.351	17 54.210	34	sterivex 0.22um	2	ON + RNA later	predawn	Day5	4
06-042482	chest freezer in hold	2009-04-27	2009-04-27	10	20 40.351	17 54.210	80	sterivex 0.22um	2	ON + RNA later	predawn	Day5	3
06-042483	chest freezer in hold	2009-04-29	2009-04-29	10	20 37.72	18 31.80	7	sterivex 0.22um	2	ON + RNA later	predawn	Day7	10
06-042484	chest freezer in hold	2009-04-29	2009-04-29	10	20 37.72	18 31.80	22	sterivex 0.22um	2	ON + RNA later	predawn	Day7	4
06-042485	chest freezer in hold	2009-04-29	2009-04-29	10	20 37.72	18 31.80	50	sterivex 0.22um	2	ON + RNA later	predawn	Day7	6
06-042486	chest freezer in hold	2009-04-29	2009-04-29	10	20 37.72	18 31.80	100	sterivex 0.22um	2	ON + RNA later	predawn	Day7	1
06-042487	chest freezer in hold	2009-04-30	2009-04-30	10	20 40.351	17 54.210	7	sterivex 0.22um	2	ON + RNA later	predawn	Day8	9
06-042488	chest freezer in hold	2009-04-30	2009-04-30	10	20 40.351	17 54.210	22	sterivex 0.22um	2	ON + RNA later	predawn	Day8	8
06-042489	chest freezer in hold	2009-04-30	2009-04-30	10	20 40.351	17 54.210	50	sterivex 0.22um	2	ON + RNA later	predawn	Day8	4
06-042490	chest freezer in hold	2009-04-30	2009-04-30	10	20 40.351	17 54.210	100	sterivex 0.22um	2	ON + RNA later	predawn	Day8	3
06-042491													
06-042492	chest freezer in hold	2009-05-03	2009-05-03	10	20 09.197	18 09.356	0	sterivex 0.22um	2	ON + RNA later	7.44am	out of filament	Non toxic
06-042493	chest freezer in hold	2009-05-03	2009-05-03	10	20 27.77	18 07.320	0	sterivex 0.22um	2	ON + RNA later	11.00am	in flament	Non toxic
06-042494	chest freezer in hold	2009-05-03	2009-05-03	10	20 52.34	18 04.990	0	sterivex 0.22um	2	ON + RNA later	15.00	In filament	Non toxic
06-042495	chest freezer in hold	2009-05-08	2009-05-08	10	21 31.990	17 54.660	8	sterivex 0.22um	2	ON + RNA later	predawn	Day 0 P2	10 and 11
06-042496	chest freezer in hold	2009-05-09	2009-05-09	10	21 31.742	17 59.067	8	sterivex 0.22um	2	ON + RNA later	predawn	Day1 p2	10
06-042497	chest freezer in hold	2009-05-09	2009-05-09	10	21 31.742	17 59.067	8	sterivex 0.22um	2	ON + RNA later	predawn	Day1 p2	11
06-042498	chest freezer in hold	2009-05-09	2009-05-09	10	21 31.742	17 59.067	60	sterivex 0.22um	2	ON + RNA later	predawn	Day1 p2	4
06-042499	chest freezer in hold	2009-05-09	2009-05-09	10	21 31.742	17 59.067	60	sterivex 0.22um	2	ON + RNA later	predawn	Day1 p2	5
06-042500	chest freezer in hold	2009-05-10	2009-05-10	10	21 39.089	18 02.226	7	sterivex 0.22um	2	ON + RNA later	predawn	Day2 p2	7
06-042501	chest freezer in hold	2009-05-10	2009-05-10	10	21 39.089	18 02.226	7	sterivex 0.22um	2	ON + RNA later	predawn	Day2 p2	8
06-042502	chest freezer in hold	2009-05-10	2009-05-10	10	21 39.089	18 02.226	50	sterivex 0.22um	2	ON + RNA later	predawn	Day2 p2	4
06-042503	chest freezer in hold	2009-05-10	2009-05-10	10	21 39.089	18 02.226	50	sterivex 0.22um	2	ON + RNA later	predawn	Day2 p2	3

06-042504	chest freezer in hold	2009-05-11	2009-05-11	10	19 58.3	18.44.85	0	sterivex 0.22um	2	ON + RNA later	transect	Transect	NA
06-042505	chest freezer in hold	2009-05-11	2009-05-11	10	19 37.04	18 50.453	0	sterivex 0.22um	2	ON + RNA later	transect	Transect	NA
06-042506	chest freezer in hold	2009-05-11	2009-05-11	10	19 25.447	18 53.452	0	sterivex 0.22um	2	ON + RNA later	transect	Transect	NA
06-042507	chest freezer in hold	2009-05-11	2009-05-11	10	19 13.76	18 56.56	0	sterivex 0.22um	2	ON + RNA later	transect	Transect	NA
06-042508	chest freezer in hold	2009-05-11	2009-05-11	10	19 00.3	18 59.82	0	sterivex 0.22um	2	ON + RNA later	transect	Transect	NA
06-042509	chest freezer in hold	2009-05-11	2009-05-11	10	18 52.07	19 01.179	0	sterivex 0.22um	2	ON + RNA later	transect	Transect	NA
06-042510	chest freezer in hold	2009-05-14	2009-05-14	10	19 50.3	18 08.8	30	sterivex 0.22um	2	ON + RNA later	predawn	P3 D0	4
06-042511	chest freezer in hold	2009-05-14	2009-05-14	10	19 50.3	18 08.8	30	sterivex 0.22um	2	ON + RNA later	predawn	P3 D0	5
06-042512	chest freezer in hold	2009-05-14	2009-05-14	10	19 50.3	18 08.8	5	sterivex 0.22um	2	ON + RNA later	predawn	P3 D0	9
06-042513	chest freezer in hold	2009-05-14	2009-05-14	10	19 50.3	18 08.8	5	sterivex 0.22um	2	ON + RNA later	predawn	P3 D0	10
06-042514	chest freezer in hold	2009-05-11	2009-05-16	10	19 30.37	18 05.072	3	sterivex 0.22um	2	ON + RNA later	predawn	P3 D2	7
06-042515	chest freezer in hold	2009-05-11	2009-05-16	10	19 30.37	18 05.072	3	sterivex 0.22um	2	ON + RNA later	predawn	P3 D2	8
06-042516	chest freezer in hold	2009-05-11	2009-05-16	10	19 30.37	18 05.072	25	sterivex 0.22um	2	ON + RNA later	predawn	P3 D2	3
06-042517	chest freezer in hold	2009-05-11	2009-05-16	10	19 30.37	18 05.072	25	sterivex 0.22um	2	ON + RNA later	predawn	P3 D2	4
06-042518	chest freezer in hold	2009-05-11	2009-05-17	10	19 35.18	18 17.16	0	sterivex 0.22um	2	ON + RNA later	predawn	P3 D3	10
06-042519	chest freezer in hold	2009-05-11	2009-05-17	10	19 35.18	18 17.16	0	sterivex 0.22um	2	ON + RNA later	predawn	P3 D3	4
06-042520	chest freezer in hold	2009-05-18	2009-05-18	10	19 40.60	19 40.60	5	sterivex 0.22um	2	ON + RNA later	predawn	P3 D4	9
06-042521	chest freezer in hold	2009-05-18	2009-05-18	10	19 40.60	19 40.60	55	sterivex 0.22um	2	ON + RNA later	predawn	P3 D4	4
06-042522	chest freezer in hold	2009-05-19	2009-05-19	10	19 44.43	18 37.36	55	sterivex 0.22um	2	ON + RNA later	predawn	p3 D5	9 and 10
06-042523	chest freezer in hold	2009-05-19	2009-05-19	10	19 44.43	18 37.36	5	sterivex 0.22um	2	ON + RNA later	predawn	P3 D5	4
06-042524	chest freezer in hold	2009-05-20	2009-05-20	10	19 41.62	18 46.03	5	sterivex 0.22um	2	ON + RNA later	predawn	P3 D6	9
06-042525	chest freezer in hold	2009-05-20	2009-05-20	10	19 41.62	18 46.03	55	sterivex 0.22um	2	ON + RNA later	predawn	P3 D6	4
06-042526	chest freezer in hold	2009-05-20	2009-05-20	10	19 40.88	18 49.42	0	sterivex 0.22um	2	ON + RNA later	10.00	dial	4
06-042527	chest freezer in hold	2009-05-20	2009-05-20	10	19 41.44	18 52.41	0	sterivex 0.22um	2	ON + RNA later	16.00	dial	4
06-042528	chest freezer in hold	2009-05-20	2009-05-20	10	19.41.48	18 52.89	0	sterivex 0.22um	2	ON + RNA later	22.00	dial	4
06-042529	chest freezer in hold	2009-05-22	2009-05-22	10	19 31.41	19 06.18	5	sterivex 0.22um	2	ON + RNA later	predawn	p3 D8	5
06-042530	chest freezer in hold	2009-05-22	2009-05-22	10	19 30.52	19 07.26	5	sterivex 0.22um	2	ON + RNA later	7.00	P3 D8	21

>water_sample: owner jod on Tue Jan 20 12:59:00 2009													
barcode	**storage locati**	**creation date**	*storage date*	*volume filter*	**site latitude**	**site longitud**	**depth in**	**filter type**	**filter nun**	*post filtering*	*time of day*	*comments*	*bottle no*
	***text(128)**	***date(yyyy-mm**	*date(yyyy-mm-*	*real(4)*	***real(8)**	***real(8)**	***real(4)**	***text(128)**	***integer(**	*text(128)*	*text(5)*	*text(unlimited)*	
06-040150	-80 freezer	2009-04-23	2009-04-23	10	21o 9.241	17o 22.819	0	Sterivex 0.22um	2	RNA later	9.00am	Day1	22
06-040151	-80 freezer	2009-04-23	2009-04-23	10	21o 9.241	17o 22.819	35	Sterivex 0.22um	2	RNA later	9.00am	Day1	
06-040152	-80 freezer	2009-04-23	2009-04-23	10	21o 9.241	17o 22.819	65	Sterivex 0.22um	2	RNA later	9.00am	Day1	
06-040153	-80 freezer	2009-04-24	2009-04-24	10	20o 57.929	17o 28.776	0	Sterivex 0.22um	2	RNA later	9.00am	Day2	22
06-040154	-80 freezer	2009-04-24	2009-04-24	10	20o 57.929	17o 28.777	35	Sterivex 0.22um	2	RNA later	9.00am	Day2	21
06-040155	-80 freezer	2009-04-24	2009-04-24	10	20o 57.929	17o 28.776	65	Sterivex 0.22um	2	RNA later	9.00am	Day2	3
06-040156	-80 freezer	2009-04-25	2009-04-25	10	20o 49.526	17 40 390	0	Sterivex 0.22um	2	RNA later	12.00am	Day3	24
06-040157	-80 freezer	2009-04-25	2009-04-25	10	20o 49.526	17 40 390	40	Sterivex 0.22um	2	RNA later	12.00am	Day3	17
06-040158	-80 freezer	2009-04-25	2009-04-25	10	20o 49.526	17 40 390	360	Sterivex 0.22um	2	RNA later	12.00am	Day3	3
06-040159	-80 freezer	2009-04-26	2009-04-26	10	20o 40.146	17 48.757	0	Sterivex 0.22um	2	RNA later	12.00am	Day4	22
06-040160	-80 freezer	2009-04-26	2009-04-26	10	20o 40.146	17 48.757	40	Sterivex 0.22um	2	RNA later	12.00am	Day4	11
06-040161	-80 freezer	2009-04-26	2009-04-26	10	20o 40.146	17 48.757	400	Sterivex 0.22um	2	RNA later	12.00am	Day4	3
06-040162	-80 freezer	2009-04-27	2009-04-27	10	20 37.406	17 36.344	0	Sterivex 0.22um	2	RNA later	12.00am	Day5	22
06-040163	-80 freezer	2009-04-27	2009-04-27	10	20 37.406	17 36.344	40	Sterivex 0.22um	2	RNA later	12.00am	Day5	11
06-040164	-80 freezer	2009-04-27	2009-04-27	10	20 37.406	17 36.344	400	Sterivex 0.22um	2	RNA later	12.00am	Day5	1
06-040165	-80 freezer	2009-04-28	2009-04-28	10	20 43.314	18 15.395	0	Sterivex 0.22um	2	RNA later	9.30am	Day6	22
06-040166	-80 freezer	2009-04-28	2009-04-28	10	20 43.314	18 15.395	40	Sterivex 0.22um	2	RNA later	9.30am	Day6	12
06-040167	-80 freezer	2009-04-28	2009-04-28	10	20 43.314	18 15.395	400	Sterivex 0.22um	2	RNA later	9.30am	Day6	1
06-040168	-80 freezer	2009-04-29	2009-04-29	10	20 57.721	18 31.080	0	Sterivex 0.22um	2	RNA later	9.30am	day7	24
06-040169	-80 freezer	2009-04-29	2009-04-29	10	20 57.721	18 31.080	80	Sterivex 0.22um	2	RNA later	9.30am	day7	10
06-040170	-80 freezer	2009-04-29	2009-04-29	10	20 57.721	18 31.080	200	Sterivex 0.22um	2	RNA later	9.30am	day7	1
06-040171	-80 freezer	2009-04-30	2009-04-30	10	20 38.780	18 14.200	0	Sterivex 0.22um	2	RNA later	9.30am	day8	12
06-040172	-80 freezer	2009-04-30	2009-04-30	10	20 38.780	18 14.200	80	Sterivex 0.22um	2	RNA later	9.30am	day8	10
06-040173	-80 freezer	2009-04-30	2009-04-30	10	20 38.780	18 14.200	200	Sterivex 0.22um	2	RNA later	9.30am	day8	1
06-040174	-80 freezer	2009-05-09	2009-05-09	10	21 30.487	18 00.014	5	Sterivex 0.22um	2	RNA later	9.30am	d1 P2	21
06-040175	-80 freezer	2009-05-09	2009-05-09	10	21 30.487	18 00.014	60	Sterivex 0.22um	2	RNA later	9.30am	d1 P2	10
06-040176	-80 freezer	2009-05-09	2009-05-09	10	21 30.487	18 00.014	200	Sterivex 0.22um	2	RNA later	9.30am	d1 P2	1
06-040177	-80 freezer	2009-05-10	2009-05-10	10	21 36.37	18 00.70	5	Sterivex 0.22um	2	RNA later	9.30am	D2 P2	21
06-040178	-80 freezer	2009-05-10	2009-05-10	10	21 36.37	18 00.70	60	Sterivex 0.22um	2	RNA later	9.30am	D2 P2	10
06-040179	-80 freezer	2009-05-10	2009-05-10	10	21 36.37	18 00.70	200	Sterivex 0.22um	1	RNA later	9.30am	D2 P2	1
06-040180	-80 freezer	2009-05-15	2009-05-15	10	19 25.61	17 55.65	3	Sterivex 0.22um	1	RNA later	9.30am	P3 D1	21
06-040181	-80 freezer	2009-05-15	2009-05-15	10	19 25.61	17 55.65	30	Sterivex 0.22um	1	RNA later	9.30am	P3 D1	8
06-040182	-80 freezer	2009-05-15	2009-05-15	10	19 25.61	17 55.65	200	Sterivex 0.22um	1	RNA later	9.30am	P3 D1	1
06-040183	-80 freezer	2009-05-16	2009-05-16	10	19 32.5	18 8.3	3	Sterivex 0.22um	1	RNA later	9.30am	P3 D2	21
06-040184	-80 freezer	2009-05-16	2009-05-16	10	19 32.5	18 8.3	30	Sterivex 0.22um	1	RNA later	9.30am	P3 D2	8
06-040185	-80 freezer	2009-05-16	2009-05-16	10	19 32.5	18 8.3	200	Sterivex 0.22um	1	RNA later	9.30am	P3 D2	1
06-040186	-80 freezer	2009-05-17	2009-05-17	10	19 36.54	18 17.16	3	Sterivex 0.22um	1	RNA later	9.30am	P3 D3	21
06-040187	-80 freezer	2009-05-17	2009-05-17	10	19 36.54	18 17.16	30	Sterivex 0.22um	1	RNA later	9.30am	P3 D3	9
06-040188	-80 freezer	2009-05-17	2009-05-17	10	19 36.54	18 17.16	200	Sterivex 0.22um	1	RNA later	9.30am	P3 D3	1

06-040189	-80 freezer	2009-05-18	2009-05-18	10	19 43.09	18 26.03	0	Sterivex 0.22um	1	RNA later	9.30am	P3 D4	21
06-040190	-80 freezer	2009-05-18	2009-05-18	10	19 43.09	18 26.03	35	Sterivex 0.22um	1	RNA later	9.30am	P3 D4	8
06-040191	-80 freezer	2009-05-18	2009-05-18	10	19 43.09	18 26.03	120	Sterivex 0.22um	1	RNA later	9.30am	P3 D4	1
06-040192	-80 freezer	2009-05-19	2009-05-19	10	19 44.64	18 38.76	0	Sterivex 0.22um	1	RNA later	9.30am	P3 D5	21
06-040193	-80 freezer	2009-05-19	2009-05-19	10	19 44.64	18 38.76	35	Sterivex 0.22um	1	RNA later	9.30am	P3 D5	9
06-040194	-80 freezer	2009-05-19	2009-05-19	10	19 44.64	18 38.76	120	Sterivex 0.22um	1	RNA later	9.30am	P3 D5	1
06-040195	-80 freezer	2009-05-21	2009-05-21	10	19 35.05	18 56.08	0	Sterivex 0.22um	1	RNA later	9.30am	P3 D7	21
06-040196	-80 freezer	2009-05-21	2009-05-21	10	19 35.05	18 56.08	35	Sterivex 0.22um	1	RNA later	9.30am	P3 D7	9
06-040197	-80 freezer	2009-05-21	2009-05-21	10	19 35.05	18 56.08	120	Sterivex 0.22um	1	RNA later	9.30am	P3 D7	1

Appendix 8 : Satellite images : modis chlorophyll



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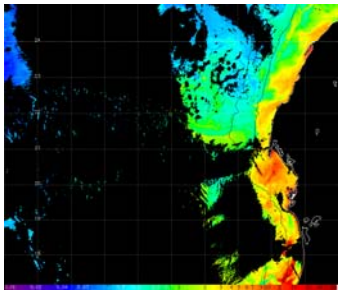

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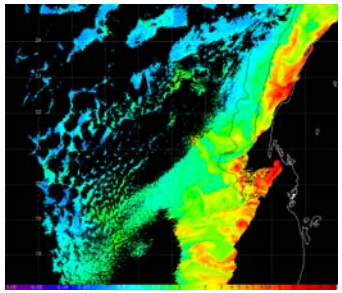

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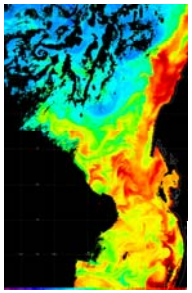

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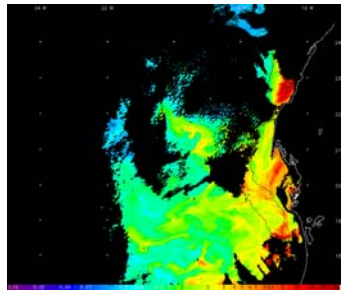

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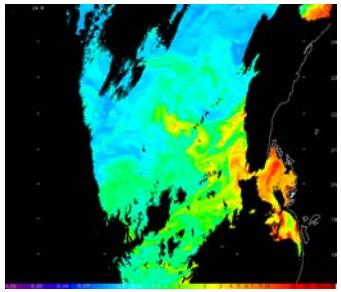

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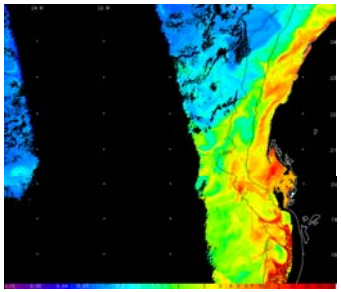

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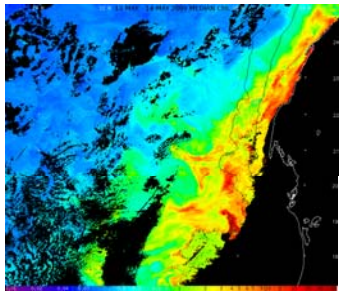

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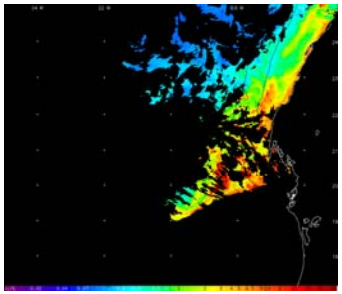

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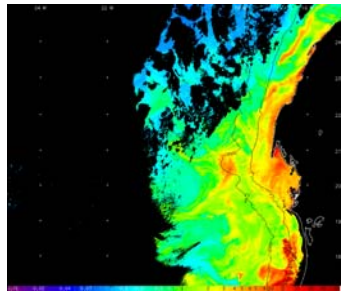

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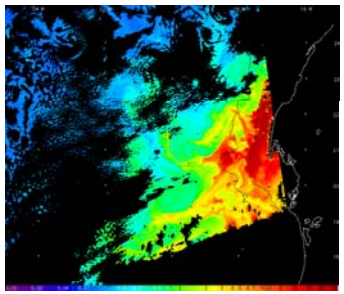

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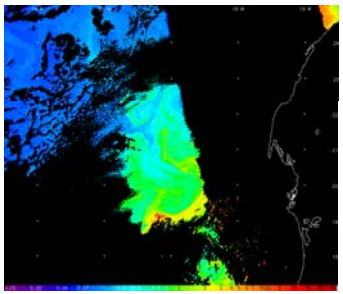

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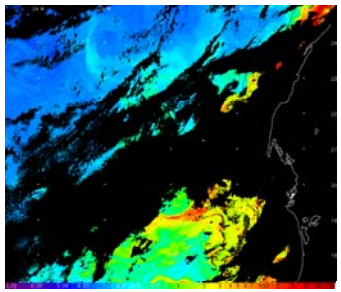
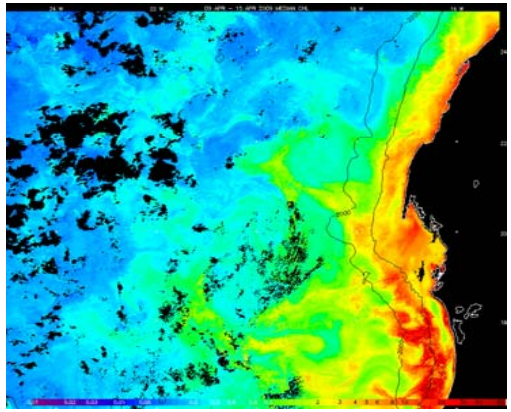
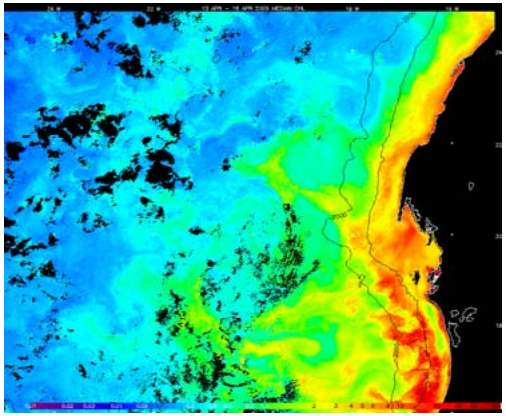


modis_chl_2009-05-21_1505

Appendix 8 : Satellite images : modis chlorophyll 7 day composites



modis_aqua_chl_2009-04-15 _7_day_composite



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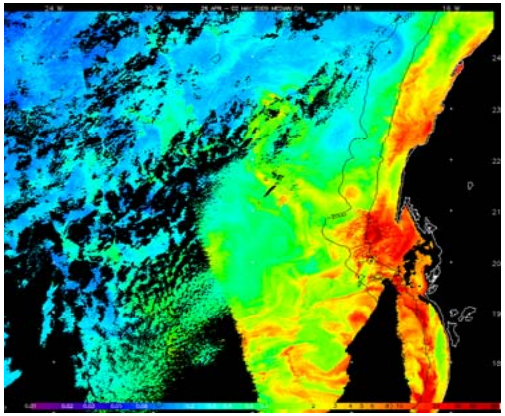
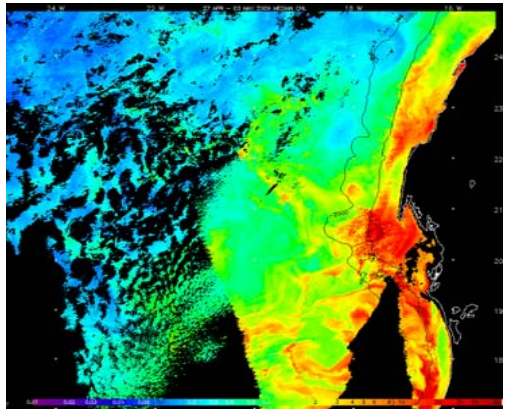
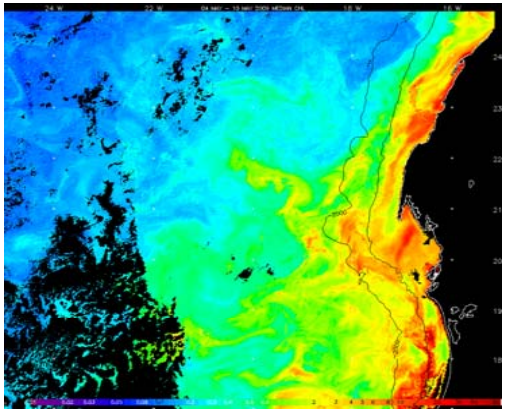


modis_aqua_chl_2009-05-02 _7_day_composite

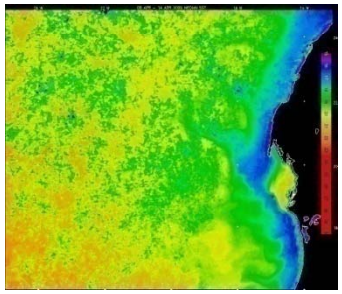


modis_aqua_chl_2009-05-03 _7_day_composite



modis_aqua_chl_2009-05-10 _7_day_composite

Appendix 8 : Satellite images : AVHRR SST (1)



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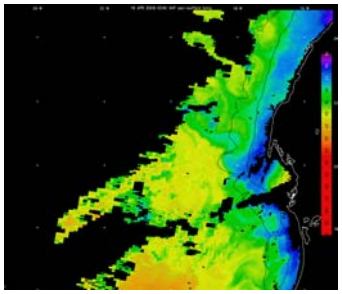

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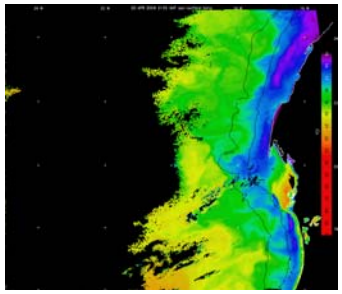

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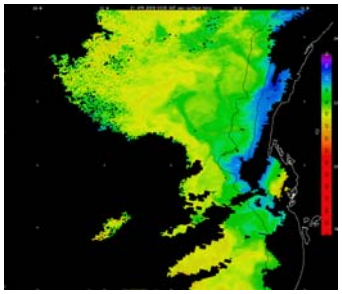

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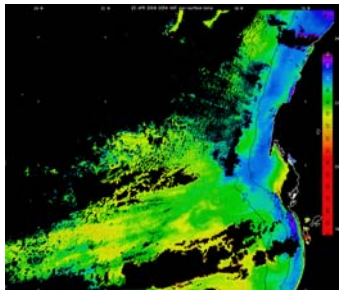

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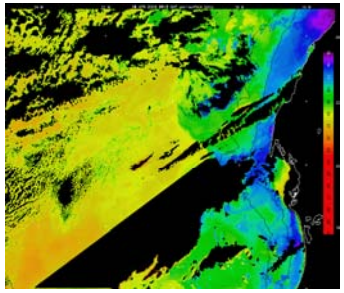

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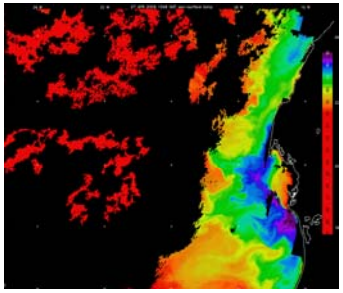

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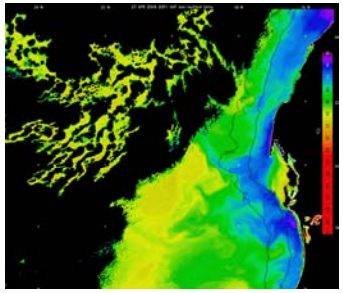

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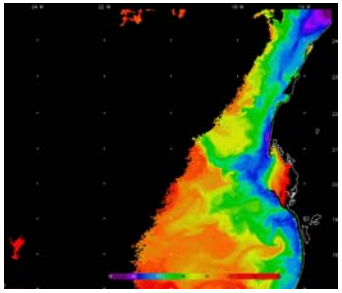

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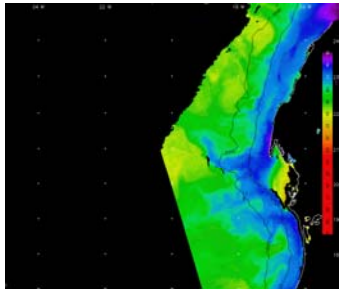

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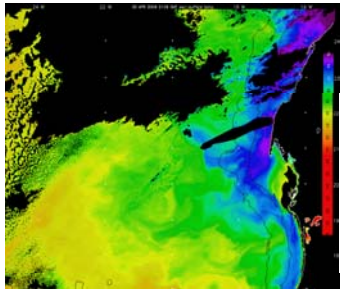

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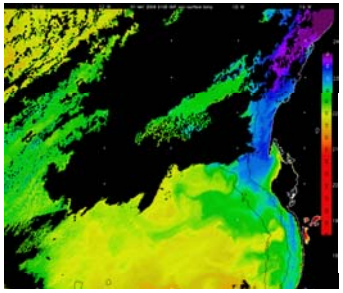

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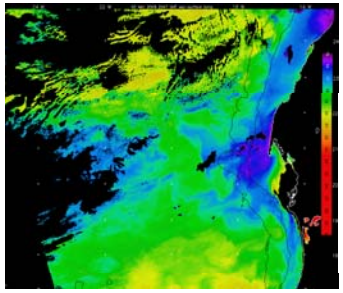

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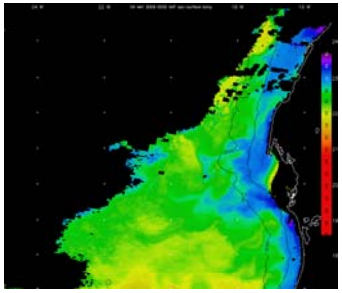

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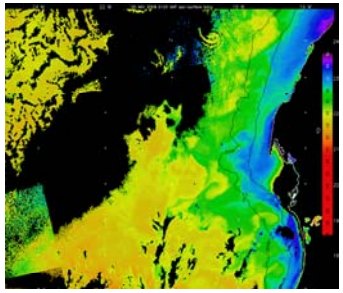

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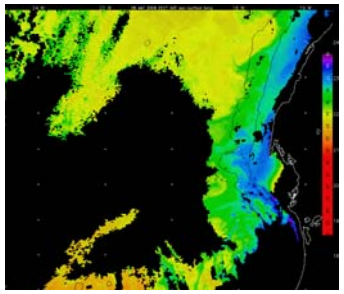
Appendix 8 : Satellite images : AVHRR SST (2)



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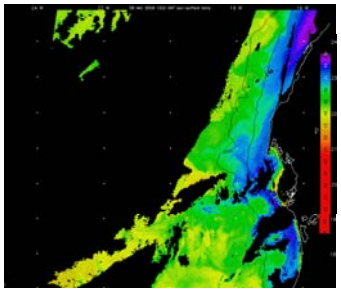

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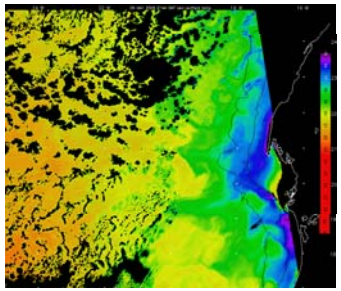

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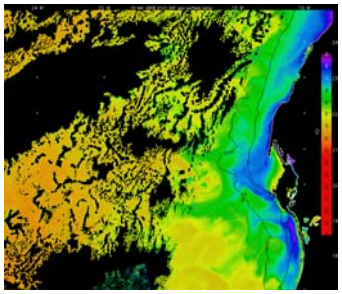

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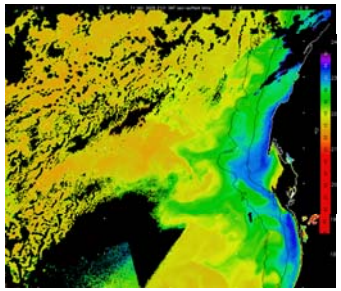

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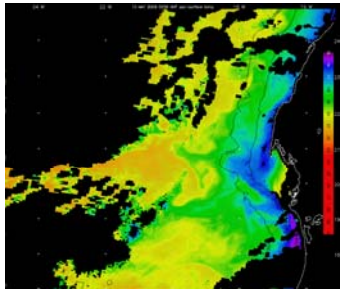

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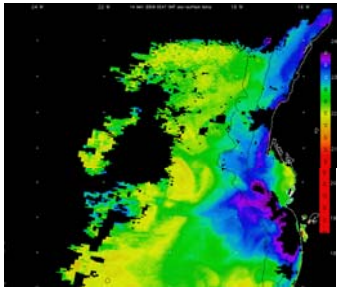

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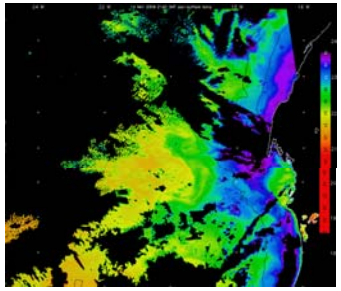

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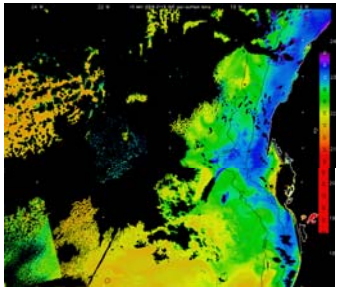

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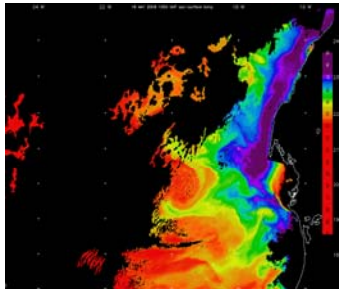

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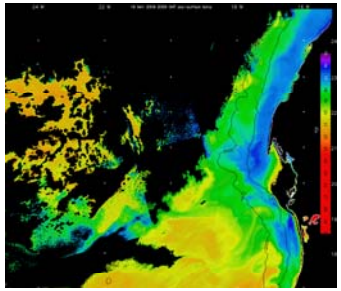

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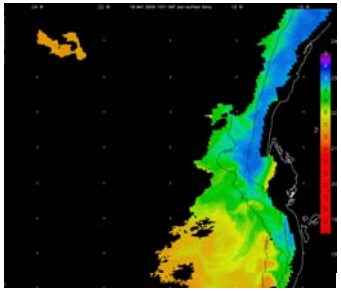

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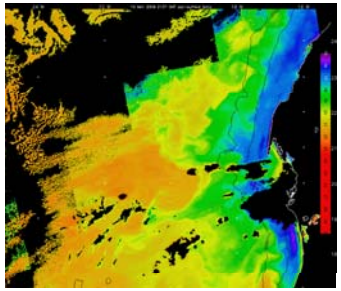

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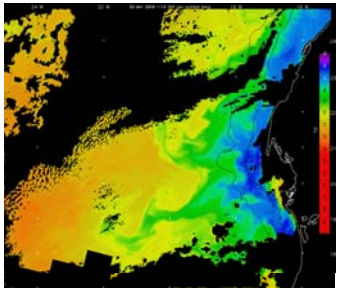

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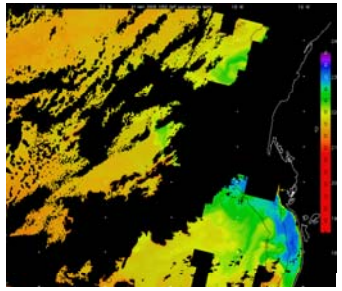


avhrr_sst_2009-05-21_1052

Surfmet Sensor Information

Ship	RRS Discovery
Cruise	D336T
Technician	Chris Barnard
Date	13/03/09

D338.
Martin Bridger
27.05.09

Manufacturer	Sensor	Serial no	Comments
SeaBird	SBE 38 Digital Thermometer	3853440-0476	Remote Seawater Temperature
SeaBird	SBE 45 microTSG	0233	Housing Temperature and Conductivity
Wetlabs	fluorometer	WS3S-247	
Wetlabs	transmissometer	CST-114R	
Vaisala	Barometer PTB100A	S361008	Port Foremast
Vaisala	Temp/humidity HMP45	B4950010	Port Foremast
Skye	PAR	28557	Port
Skye	PAR	28556	Starboard
Kipp and Zonen	TIR CMB6	994133	Port
Kipp and Zonen	TIR CMB6	994132	Starboard
Sensors without cal			
FSI	OCM conductvity		TSG Housing
Gill	Windsonic	071123	Port Foremast

SPARES

Manufacturer	Sensor	Serial no	Comments
Seabird	SBE 38 Digital Thermometer	416, 475	
Seabird	SBE 45 MicroTSG	N/A	
Wetlabs	fluorometer	N/A	
Wetlabs	transmissometer	N/A	
Vaisala	Barometer PTB100A	N/A	
Vaisala	Temp/humidity HMP45	N/A	
Skye	PAR	N/A	
ELE	PAR	N/A	
Kipp and Zonen	TIR CMB6B	N/A	
Kipp and Zonen	TIR CMB6B	N/A	
Sensors without cal			
FSI	OCM conductvity	N/A	
Gill	Windsonic	071121	

Surfmet : The Sensor List

Met Platform Sensors

Wind Speed and Direction

Manufacturer : Gill
Model : Windsonic (Option 3)

Ultrasonic Output Rate	1, 2, 4Hz
Wind Speed	Range 0-60 m/s
Wind Direction Range	0-359 no dead band
Operating Temp Range	-35 ºC to +70 ºC
Moisture Protection	IP65
External Construction	Luran
Digital O/P Options	RS232 / 422 / 485 / SDI-12
NMEA O/P	Yes
Analogue Outputs	2 (optional)
Calibration	Generic

Total Incidental Radiation

Manufacturer : Kipp and Zonen
Model Number : CM6B

Spectral range	305...2800 nm (50%points)
Sensitivity	9...15 µV/Wm-2
Impedance	70...100 Ohm
Response time	1/e 5 s, 99 % 55 s
Non-linearity	<1.5 % (<1000 W/m 2)
Tilt error	<1.5 % at 1000 W/m 2
Operating temperature	-40...+90 _C
Temperature dependence of sensitivity	_2 % (-10...+40_C)
Maximum irradiance	2000 W/m2
Directional error	< _20 W/m2 at 1000 W/m2
Weight	0.85 kg
Cable length	10 m

Surfmet Sensor List V1.2 CVB 14/03/2009

Temperature and Humidity

Manufacturer : Vaisala
Model Number : HMP45A

Relative humidity measurement

HMP45A	
Measurement range	0.8 ... 100 % RH
Accuracy at +20 °C (+68 °F)	± 2 % RH (0 ... 90 % RH)
	± 3 % RH (90 ... 100 % RH)
Sensor	Vaisala HUMICAP® 180

Temperature measurement

HMP45A	
Measurement range	-39.2 ... +60 °C (-38.6 ... +140 °F)
Accuracy +20 °C (+68 °F)	± 0.2 °C (± 0.36 °F)
Sensor	Pt 1000 IEC 751

Operating environment

Temperature	
operation	-40 ... +60 °C (-40 ... +140 °F)
storage	-40 ... +80 °C (-40 ... +176 °F)

Inputs and outputs

Operating Voltage	7 ... 35 VDC
Power consumption	< 4 mA
Output load	> 10 kohm (to ground)
Output scale	-40 ... +60 °C (-40 ... +140 °F) equals to 0...1V
Output signal	resistive 4-wire connection

Surfmet Sensor List V1.2 CVB 14/03/2009

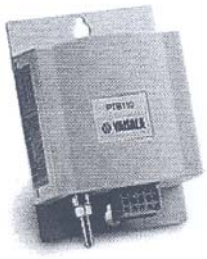
Photosynthetic Active Radiation

Manufacturer : Skye Instruments
Model Number : SKE 510

Spectral Range	400-700nm
Sensitivity Current	3.5µA/100Wm^2
Sensitivity Voltage	1mV/100Wm^2
Working Range	0 – 5000Wm^2
Linear Error	<0.2%
Absolute Calibration Error	typ <3% max 5%
Cosine Error	3%
Azimuth Error	<1%
Temperature coefficient	+/-0.1%/ºC
Longterm Stability	+/-2%
Response Time	10ns
Internal Resistance	300Ohms
Temperature Range	-35ºC … +70ºC
Humidity Range	0 – 100% RH

Barometric Pressure

Barometric pressure measurement



Pressure range	800 ... 1100 hPa
Accuracy at +20 °C (+68 °F)	±0.3 hPa
Sensor	Vaisala BAROCAP®

Operating environment

Temperature range	-5 ... +45 °C (+23 ... +113 °F)
Humidity range	<80 % RH

Inputs and outputs

Operating voltage	9 ... 16 VDC
Power consumption:	
operation mode	2 mA (typical)
shutdown mode	150 µA (typical)
Output voltage	0 ... 2.5 VDC

Surfmet Sensor List V1.2 CVB 14/03/2009

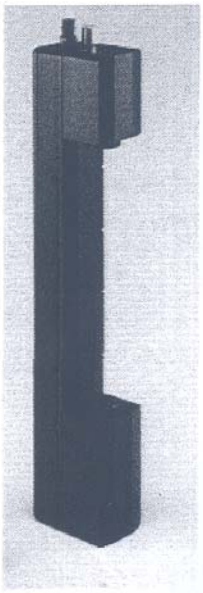
Sea Surface Instruments

Fluorimeter

Manufacturer : WetLabs
Model Number : WetStar

Temperature Range	0-30 C
Depth Rating	600m
Response time	0.17s
Input Voltage	7-15vdc
Current Draw	< 40 mA
Output	0-5VDC

Transmissometer

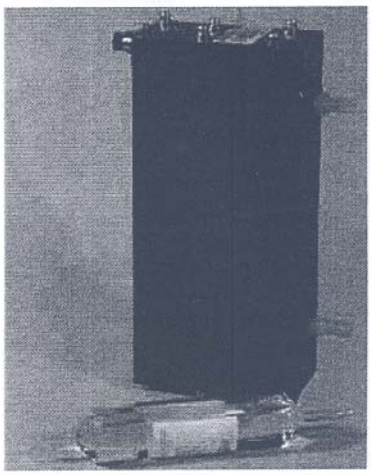


Manufacturer : WetLabs
Model Number : CStar

Pathlength	25cm
Wavelength	660nm
Bandwidth	~ 20nm
Rated Depth	600m
Temperature	0-30°C
Power Input	7-15VDC
Current Draw	< 40mA
Data Output	0-5Volts
Time Constant	0.167 sec
Temperature Error	0.02 percent F.S./deg C

Surfmet Sensor List V1.2 CVB 14/03/2009

Seabird Micro TSG SBE45



Measurement Range
Conductivity: 0-7 S/m (0-70 mS/cm)
Temperature *: -5 to 35 °C

Initial Accuracy
Conductivity: 0.0003 S/m (0.003 mS/cm)
Temperature *: 0.002 °C
Salinity: 0.005 PSU, typical

Typical Stability *(per month)*
Conductivity: 0.0003 S/m (0.003 mS/cm)
Temperature *: 0.0002 °C
Salinity: 0.003 PSU, typical

Resolution
Conductivity: 0.00001 S/m (0.0001 mS/cm)
Temperature *: 0.0001 °C
Salinity: 0.0002 PSU, typical

Calibration Range
Conductivity: 0-6 S/m (60 mS/cm); physical calibration 2.6-6 S/m (26-60 mS/cm), plus zero conductivity (air)
Temperature *: +1 to +32 °C

Time Resolution	1 second
Clock Stability	13 seconds/month
Input Power	8-30 VDC
Acquisition Current	34 mA at 8 VDC; 30 mA at 12-30 VDC
Quiescent Current	10 microamps
Acquisition Rate	1 Hz maximum
Operating Pressure	34.5 decibars (50 psi) maximum
Flow Rate	10 to 30 ml/sec (0.16 to 0.48 gal/min)
Materials	PVC housing
Weight	4.6 kg (10.2 lbs)

Surfmet Sensor List V1.2 CVB 14/03/2009

Seabird SBE 38 Digital Oceanographic Thermometer

Measurement Range	-5 to +35 °C
Initial Accuracy	± 0.001 °C (1 mK)
Typical Stability certified	0.001 °C (1 mK) in 6 months,
Resolution	0.00025 °C (0.25 mK)
Calibration	-1 to +32 °C
Response Time	500 milliseconds
Self-Heating Error	less than 200 µK

RMS Noise
(at temperature equivalent of 8.5 °C)

NAvg	**Noise (°C)**
1	0.000673
2	0.000408
4	0.000191
8	0.000133
16	0.000081
32	0.000052

Note:
NAvg = number of A/D cycles per sample.
Interval between samples (seconds)
= (0.133 * **NAvg**) + 0.339

External Power	*RS-232 (standard):* 8 – 15 VDC at 10 milliamps average *RS-485 half-duplex (optional):* 8 – 15 VDC at 6 milliamps average
Materials	Titanium pressure case rated at 10,500 meters (34,400 feet)
Weight	In water: 0.5 kg (1.2 lbs) In air: 0.9 kg (2.0 lbs)

Surfmet Sensor List V1.2 CVB 14/03/2009