UK-SOLAS Cruise Report: RRS *Discovery* Cruise D320, 16 June – 18 July, 2007.

DOGEE-II: air-sea gas exchange in the Atlantic Ocean

Frontispiece: An artificial surfactant patch edge showing clear suppression of capillary waves (Robin Pascal).

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Contents

Appendices:

List of Figures

List of Tables

Disclaimer

All data in this Cruise Report are provisional; some are fully calibrated whereas others are not. No data from this report should be published or otherwise presented without the express permission of the originators (see **Individual Scientific Reports**). The full data set will eventually be lodged with the British Oceanographic Data Centre (BODC).

Acknowledgements

We would like to thank the Master, Peter Sarjeant and all of the officers, engineers and crew of RRS *Discovery* for their help and enthusiastic support during D320, which helped to make this a hugely successful cruise and lessen the disappointment of D313. Peter was particularly helpful. His expert interpretations of the prevailing wind and current movements enabled him to predict with impressive accuracy, the centres of each of the three tracer patches. Without this we would almost certainly have achieved significantly less than we did.

Once more the onboard service was superb and a special note of thanks must go to *Discovery's* catering staff (a plea to ship's management: please, please do not abandon the current system of catering in favour of a "cheaper" option).

On the technical side Chris Barnard once more provided expert computing back-up and was always on-hand to provide advice. Jon Wynar never once complained at being asked to do yet another CTD at an unreasonable hour, and Dan Comben and Kevin Smith worked tirelessly to service the PML drifters and other vital equipment. Our thanks must also go to Ian Slater and his engineering colleagues who (assisted by Dan and Kevin) re-commissioned the heavily damaged NIOZ catamaran following a near-fatal capsize on its "maiden voyage". Many of the rest of us thought the damage too serious for on-board repair!

Malcolm Woodward and Julia Crocker at PML once more handled all the pre- and post-cruise logistics, which saved the Principal Scientist a great deal of worry and hence rescued him from several potentially sleepless nights.

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D320 Ship's Party (photo: Mike Hood)

Cruise Objectives

RRS *Discovery* cruise D320 (*DOGEE-II*) was the second of two UKSOLAS cruises assigned to the research project *DOGEE-SOLAS* (The UKSOLAS Deep Ocean Gas Exchange Experiment: P.I. Rob Upstill-Goddard, Newcastle University, UK). The primary goals of *DOGEE* are to determine sea-air gas transfer velocities and to examine the physical and biogeochemical controls of air-sea gas exchange in the open ocean. This information is important for quantifying the behaviour of the ocean sink for CO_2 in global climate models. 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.

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 (Siengenthaler and Sarmiento, 1993) and climate forcing involving other marine biogenic gases such as DMS (Charlson et al., 1987) and iodocarbons (O'Dowd et al., 2002). 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. For some gases, such as CO_2, this is now the dominating uncertainty in global budgets. Modelling the impact on global biogeochemistry of all trace gases requires a sound parameterization of their fluxes. If one were to name a single advance that would most enhance our understanding of ocean-atmosphere interactions, improving the parameterisation of air-sea gas exchange would be it.

Gas exchange at the air-sea interface depends strongly on the turbulent wind stress at the surface. Although many existing gas exchange parameterizations that relate the gas transfer velocity (k_w) solely to mean wind speed are widely used for data interpretation and in modelling (e.g. Nightingale et al., 2000; McGillis et al., 2001), observational and theoretical evidence show such descriptions to be incomplete; air-sea exchange depends in a complex fashion on many additional factors, including wave state, the presence of surfactants, and the relative directions of wind and swell. Whitecaps and bubble bursting also directly influence gas transfer. Very different values of k_w may therefore be expected at different locations at identical wind speeds. Significantly improving the existing parameterizations requires that the second order effects be included. *DOGEE* aims to address some of these issues by making simultaneous real-time estimates of k_w and gas fluxes by various techniques alongside measurements of surfactants, wave state, whitecap coverage, bubble populations, and measures of near-surface turbulence.

The specific scientific objectives of D320 were:

1. To carry out deliberate dual-tracer (^3He & SF_6) release experiments in the North Atlantic with subsequent sampling underway and via the CTD rosette system, in order to derive several estimates of the gas transfer velocity (k_w) of CO_2 (UNEW & PML).
2. To examine the effect of surfactant on k_w by carrying out a second deliberate dual-tracer release several km away but with an added surfactant (oleyl alcohol) laid as a

discrete patch directly over the combined $^3He/SF_6$ tracer patch (UNEW & PML). .

3. To release two ASIS air-sea interaction spars, one adjacent to each of the tracer patches, in order to measure meteorological parameters and water mass properties (CTD, pCO_2, PAR, DO) and to examine the effect of added surfactant on the fluxes of CO_2, H_2O, heat and momentum (eddy correlation), surface wave properties (mean square slopes and spectra), and near surface turbulence (RSMAS, Univ. Miami).
4. To use a spar buoy developed at NOC to simultaneously record (by video) and measure (by capacitance wave wires) whitecap coverage and wave breaking, and to develop an improved parameterisation of wave breaking and its contribution to gas exchange (NOC/ISVR, SOTON).
5. To measure total gas tension, dissolved O_2, and CO_2 in underway mode using the ship's non toxic seawater supply, and throughout the mixed layer using drifting mixed layer Lagrangian Floats, and to thus obtain independent estimates of air-sea gas exchange.
6. To quantify the bubble populations produced by breaking waves both at the sea surface and beneath it using acoustic methods (NOC/IRVR, SOTON).
7. To measure directly air-sea fluxes of CO_2, sensible heat, latent heat and momentum (by direct covariance (EC) and inertial dissipation) using the automated sensor array AUTOFLUX (NOC).
8. To quantify flow distortion biases in the direct flux measurements through comparison of eddy correlation latent heat fluxes to the inertial dissipation latent heat fluxes after the latter have been corrected using Computational Fluid Dynamics, and to correct other direct fluxes by analogy (NOC).
9. To use an atmospheric pressure ionization mass spectrometer (APIMS) to measure DMS fluxes by eddy-covariance and to make accompanying measurements of the 3 dimensional wind speed, and fluxes of heat and momentum..
10. To deploy a "Near Surface Sampler" (NSS) to collect detailed profiles of surfactant, tracers and other dissolved gases in the uppermost 2m of the water column (PML).
11. To make high-precision measurements of near surface DMS concentrations both in underway mode (sampling fish) and in discrete samples collected with the NSS (10 above) and to combine these with DMS fluxes determined under (9) above to derive k_w for DMS.
12. To continuously measure a suite of key meteorological variables (wind speed and direction, air temperature and humidity, sea surface temperature, IR surface temperature, downwelling long- and short-wave radiation and air pressure (NOC).
13. To sample the sea surface microlayer and investigate near-surface gradients in DMS during a series of short, 1 hr, sampling cruises, using a remotely controlled catamaran (NIOZ).
14. To determine spatial and temporal variability of biological methanol uptake, including fine scale variability in the upper 2m of the water column using the NSS (PML).
15. To assess the relationship between heterotrophic bacterial production and rates of methanol uptake in the euphotic zone, the upper 2m and the micro-layer (PML)
16. To compare heterotrophic bacterial production and biological methanol uptake in the surface micro-layer (PML).
17. To continue developing a GC-FID method for OVOC's in seawater (PML).

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18. To develop and improve a system for making accurate measurements of 15 atmospheric OVOC's (University of Bristol).

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Cruise Narrative

Mobilisation for cruise D320 commenced on 12th June 2007 (JD 163). *Discovery* departed Falmouth at around 17.00 UTC on 16th June 2007 (JD 167) and headed for a nominal position ~ 45°N, 20°W. Departure was initially planned for the early morning of the 16th but was delayed in order to take afternoon delivery of a replacement transformer unit for the NIOZ group. The cruise track is shown in **Figure 1**.

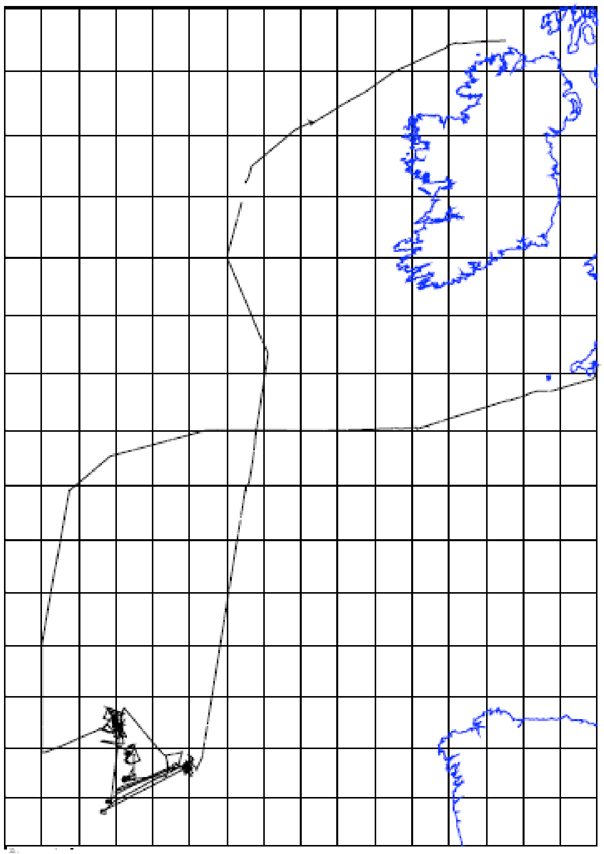

Figure 1. D320 cruise track, 16th June – 18th July 2007.

The operational strategy of D320 was to release two $^{3}He/SF_6$ tracer patches ~ 20 km apart, with one of these overlain with a patch of oleyl alcohol surfactant (PML/UNEW), and to deploy an ASIS (air-sea interaction spar) buoy (RSMAS, Miami) and a lagrangian profiling float (URI) adjacent to each, to be retrieved at the end of the cruise. The plan for the remainder of the cruise was to carry out a number of continuous underway surveys for SF_6 (PML), with periodic CTD's at each of the patch centres (12-24 hour intervals) to be used for estimating gas transfer velocities and for other sample requirements (see individual cruise reports). Each CTD was then to be followed by deployments (seastate permitting) of a RIB (UNEW), a remotely controlled catamaran (NIOZ) and a near-surface sampler (PML), for sampling the seasurface microlayer and for obtaining detailed dissolved gas concentration profiles in the top 2 m of the water column. A number of deployments of the NOC spar buoy for periods of up to several days each and of ASIP (Air-Sea Interaction Profiler; Old Dominion University) for periods of up to 48 hours each were also planned. Periods during which *Discovery* was not in underway survey mode or involved in the deployments described above were to be used for atmospheric sampling (head-to wind) for estimating air-sea fluxes of DMS (Univ Hawaii) and CO_2 (NOC). Broadly speaking this strategy was successfully adhered to. Full details of all over-side deployments including dates, locations and times, are given in **Appendix 1** and a full diary of events is presented in **Appendix 2**. Major events during the cruise are outlined below.

The first scientific activity post-departure was a successful test lift of ASIS #1 on 17th June, (JD 168) followed by a CTD at 49.04^{o} N, 09.88^{o} W to provide water to a number of scientific personnel for various purposes. Filling and tracer saturation of the tracer tank also began and was completed on 18th June (JD 169).

The next activity was to initiate a CTD survey of a potential tracer release site on 20th -21st June (JD 171-172). This involved a series of 9 CTD's in an area bounded by 43.2^{o} N - 43.8^{o}N, and 17.8^{o}W - 18.5^{o}W (Stations 3-11, appendix 1). Deployment of tracer patch #1 (without surfactant) centered on ~43.63^{o}N, 18.05^{o}W commenced in the late evening of June 21st (JD 172) and finished during the early hours of June 22nd (JD 173). ASIS #1, a lagrangian profiling float (URI float #43), and the Spar Buoy (NOC), were then successfully deployed. A CTD cast in the vicinity of the URI float established the mixed layer structure for subsequent remote programming of the float mission. The first CTD cast in the centre of tracer patch #1 was also carried out but subsequent deployment of the NIOZ catamaran was unsuccessful. A severe mechanical failure caused a breach of one of the hulls leading to capsize which saturated the electronics. Fortunately the catamaran was retrieved for later repair (with some samples apparently intact). Launch of the RIB was postponed due to worsening weather and the NOC buoy was retrieved.

Tracer patch #2 (with surfactant) and the second langrangian float (URI float #44) were released around ~ 43.50^{o} N, 17.81^{o} W on 26th June (JD 177) and ASIS #2 was released close by on the evening 27th June (JD 178) following a several hour delay due to technical problems. URI float #44 was subsequently recovered on 28th June (JD 179) due to malfunction (the float was not redeployed; see URI report) and the NOC buoy was redeployed.

ASIP was launched over *Discovery's* stern on 1st July (JD 182) following successful test deployments from the RIB during the previous several days. However due to malfunction the float sank and was lost (see report: **Air–Sea Interaction Profiler (ASIP) during DOGEE-II** and **Appendix 3: Loss of Equipment Report- ASIP**). This was the only major loss of equipment during the cruise. The NOC buoy was also recovered on JD 182.

The last CTD (of 7) in tracer patch #1 was on 2nd July (JD 183). No subsequent sampling of patch #1 took place and the PML drifter buoys were retrieved. The NOC buoy was redeployed on 4th July (JD 185).

A surfactant release ahead of ASIS #1 (42.60^{o} N, 16.46^{o} W) was carried out on 5th July (JD 186). Both URI float #43 and the NOC buoy were recovered and a third tracer patch (tracer patch #3, without surfactant) was deployed. The last CTD in tracer patch #2 occurred on 6th July (JD 187), the patch #2 PML drifters were finally recovered and URI float #43 was redeployed.

ASIS #1, ASIS #2 and URI float #43 were finally recovered on 11th July (JD 192) and on 13th July (JD 194) the final CTD cast was carried in tracer patch #3, and the PML drifters and the NOC spar buoy were recovered for the final time. Discovery then left the vicinity of tracer patch #3 and headed on a course for Govan passing to the west of Ireland.

The final scientific activity was a surfactant release around 54.20^{o} N, 12.72^{o} W on 16th July (JD 197), for measuring DMS fluxes, and *Discovery* arrived Govan to commence demobilisation on 18th July (JD 199).

In summary some 116 scientific stations involving over side activities were occupied during D320. These included the release of three $^{3}He/SF_6$ "dual tracer" patches, four surfactant patches ($^{3}He/SF_6$, around ASIS #1 and the NOC buoy, and for DMS fluxes), 44

CTD deployments, 22 of which were for tracers “in-patch” (of which 10 were “in surfactant”), 1 deployment and recovery each of ASIS #1 and #2 (as planned, excluding test dip), 12 RIB deployments (including 2 for ASIP tests), 8 NIOZ catamaran deployments, 3 deployments of URI floats, 4 deployments of the NOC spar buoy, 3 deployments of ASIP (2 tests, one lost during operation), and 4 deployments of the PML near-surface sampler.

D320: Work area selection

Real-time thermosalinograph (surface) data were used a select tracer deployment/work area bounded approximately by 43.2° N - 43.8°N, and 17.8°W - 18.5°W (**Figure 2**).

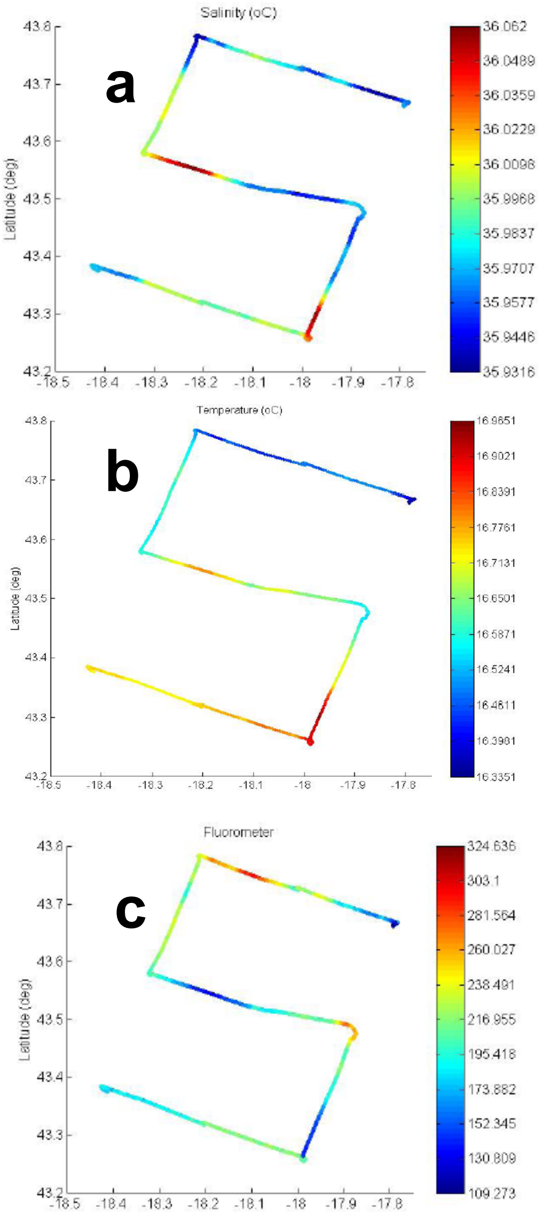

Figure 2. (a) surface salinity (b) surface temperature and (c) surface fluorescence in the vicinity of the tracer release/work area.

The mixed layer hydrography of the area was established through a series of 9 CTD's down to ~ 100m, at the locations indicated in **Figure 3**. These indicated a uniform mixed layer ~ 40-50 m deep throughout the region. It was therefore decided to make the first tracer release in a 4 km by 4 km box centered on ~43.63°N, 18.05°W.

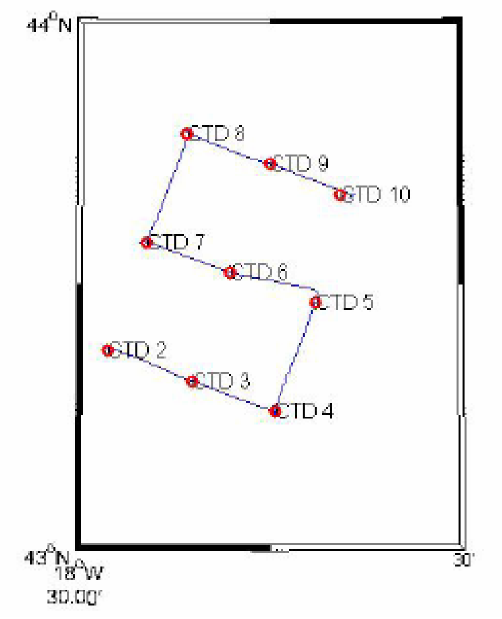

Figure 3. Locations of CTD casts to 100 m during an initial survey of the selected work area.

Scientific Reports

Dual tracer experiment: SF_6 and ^3He sea water saturation and release during DOGEE II

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Objective: Dual volatile tracer release for estimating gas transfer velocities.

Introduction: The roles of a number of geophysical variables in controlling the gas transfer velocity, k_w, are major uncertainties in the estimate of air-sea gas exchange fluxes. The dual tracer method for estimating k_w is based on the time-dependant change in the concentration ratio of the inert gaseous tracers sulphur hexafluoride (SF_6) and helium-3 (^3He), and is now well established (Watson et al., 1991; Nightingale et al., 2000; Wanninkhof et al., 2004; Ho et al., 2006). During DOGEE-II we released three separate tracer 'patches' and monitored their SF_6 concentrations underway in near-real time, for periods of 9 days (Patch #1), 12 days (Patch #2) and 5 days (Patch #3). At intervals we collected samples from vertical hydrocasts close to the patch centres and determined their dissolved SF_6 concentrations to high precision on board ship. Sub-samples for dissolved ^3He analysis were stored in specially commissioned sealed copper tubes for subsequent mass spectrometric analysis post-cruise. One patch (patch #2) was overlain with a much larger patch of oleyl alcohol in order to evaluate the role of surfactants in air-sea gas exchange. This is the first ever time that a combined dual tracer-surfactant release has been carried out. The SF_6 data will also be used to estimate diapycnal diffusivity, K_z, to aid quantifying cross-thermocline dissolved gas fluxes.

Tracer Preparation: Approximately 6.5 m^3 of seawater contained within a steel tank were saturated with sulphur hexafluoride (SF_6). The SF_6 was pumped at ~ 120 ml. min^{-1} into a glass tank headspace and vented to the atmosphere over the stern of *Discovery* in order to minimise contamination. Headspace contents were re-circulated through the tank seawater via 3 steel metal air-stones and using a leak-tight 110V diaphragm pump; flow rate was ~1 litre min^{-1}. Saturation was initiated at 17:45 UTC on 17/06/07 and ceased at 13:02 UTC on 18/06/07. An additional 'top-up' was required to re-establish SF_6 saturation, from 13:10 UTC to 16:45 UTC on 21/06/07. During the saturation procedure tank seawater samples collected in syringes at intervals were analysed by thermal conductivity detection - gas chromatography (TCD-GC) in order to ascertain when full saturation had been achieved. Due to movement of the ship during saturation the TCD-GC integrator baseline was not steady, hence the integrated peak areas were not considered reliable. Peak heights were therefore used to determine SF_6 concentrations relative to a 0.02% SF_6 standard. The peak heights and concentrations are shown in **Figure 4**. The point by which full saturation had been reached was independently established by monitoring the decline in oxygen levels during saturation.

Helium-3 (^3He) was added to the tank immediately prior to the tracer release. To do this the tank headspace water level was first adjusted until it was about halfway up by carefully venting some of the headspace SF_6. A total of 25 litres of ^3He were then added directly to the headspace, in aliquots of ~ 5 litres, over a period of 1-2 min. The headspace water level initially fell during this operation as a result of the increased internal headspace pressure, and then gradually rose again as ^3He dissolving into the tank water increased more rapidly than the displaced SF_6 transferred out. Once the water level had stabilised after 10 - 15 minutes a water sample was collected in order to establish the amounts of ^3He added and SF_6 removed (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 (**Figure 5**).

Tracer Releases: We released a total of three separate tracer patches (Patch #1, Patch #2 and Patch #3) from a single charge of tracers in the tank. Prior to each release the non-toxic seawater supply was used to flush the release hose. The tank taps were then opened slowly and closed to clear the air out of the flow meter. In order to ensure the required release depth a 60 kg depressor was attached to the hose outlet. To support the depressor weight the release hose was attached to the winch cable with duct tape (**Figure 6**). A TD-minilog was attached just above the outlet to monitor the release depth and temperature. The non-toxic was kept running at a low rate while the hose was attached to prevent air locks. Approximately 15 m of hose was used. The average depths of release (m) were: Patch #1, 6.5±1.0; Patch #2, 10.5±0.50; Patch #3, 7.35±0.83. When ready for tracer release the tank taps were opened and the gate valve closed as quickly as possible. At this point, the non-toxic flushing line was closed off and the outflow was adjusted to the required rates (**Tables 1-3)** to compensate for the dilution of tracer remaining in the tank, using the tank outlet tap. Non-toxic flow into the header tank was adjusted as required to balance flows and prevent air-leakage into the system. Owing to substantial dilution of the tank tracers during the releases of Patch #1 and Patch #2, an increased flow rate was required during the release of Patch #3. This entailed using both tank outlet taps and an additional top up line to the header tank via the ship's fire hose.

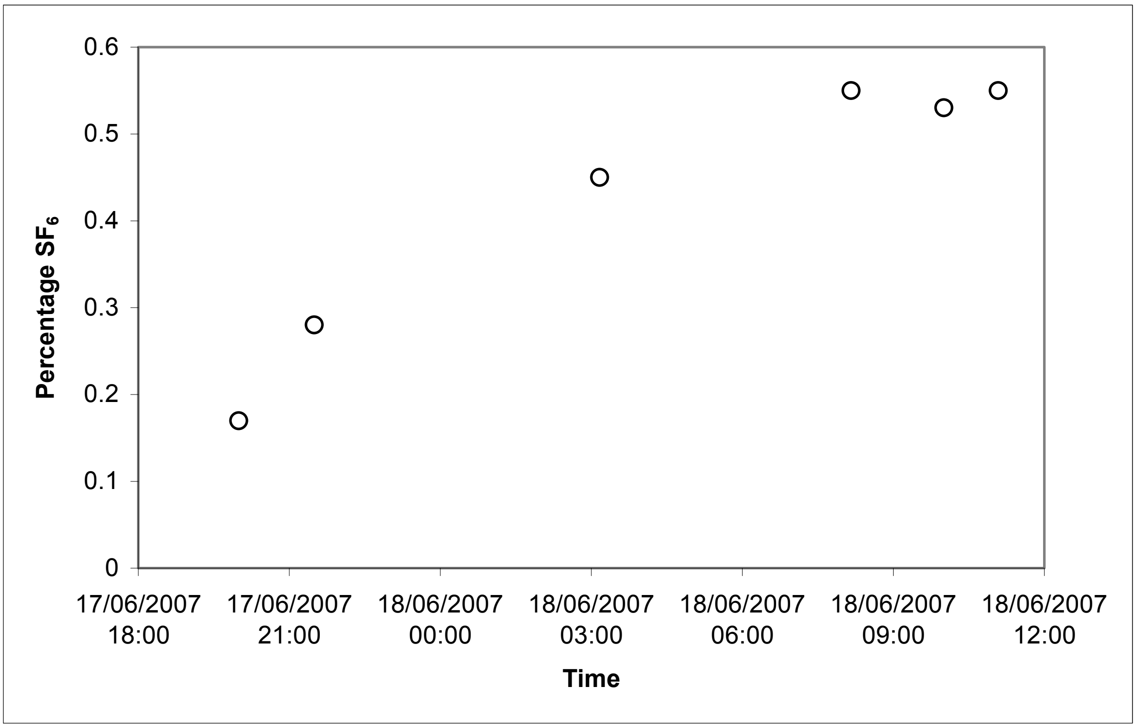

Figure 4: Change in percentage SF_6 over the seawater tank saturation period.

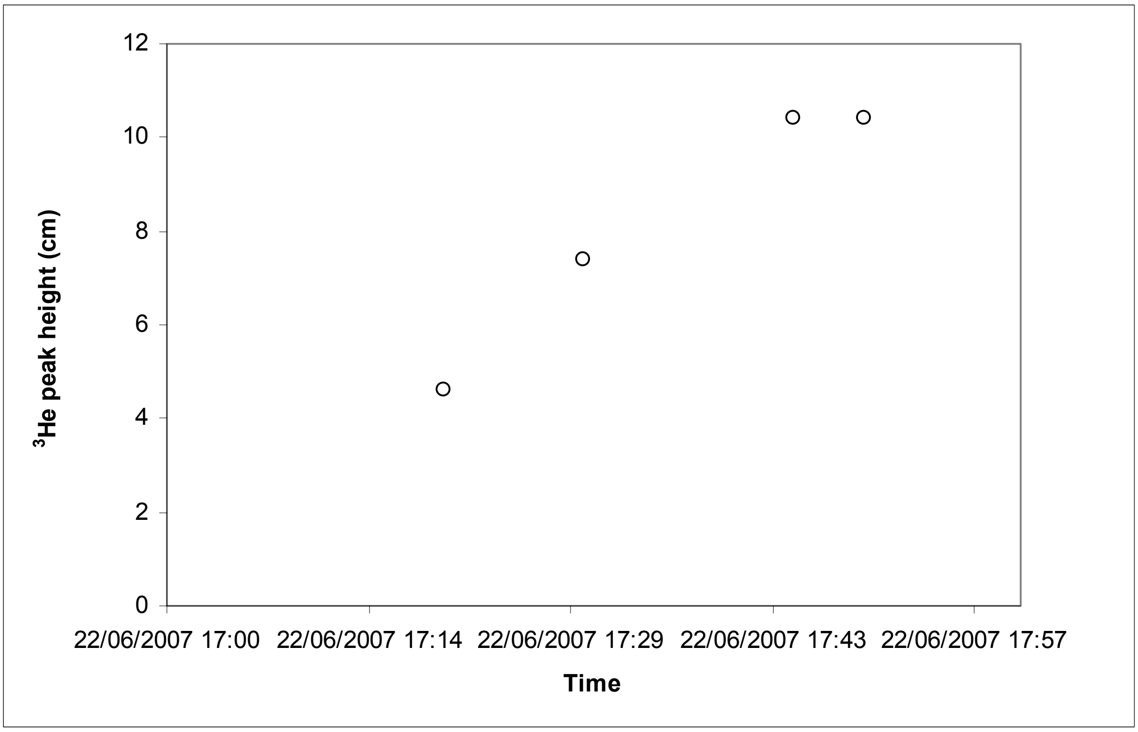

Figure 5: Change in ^{3}He peak height over the ^{3}He addition period.

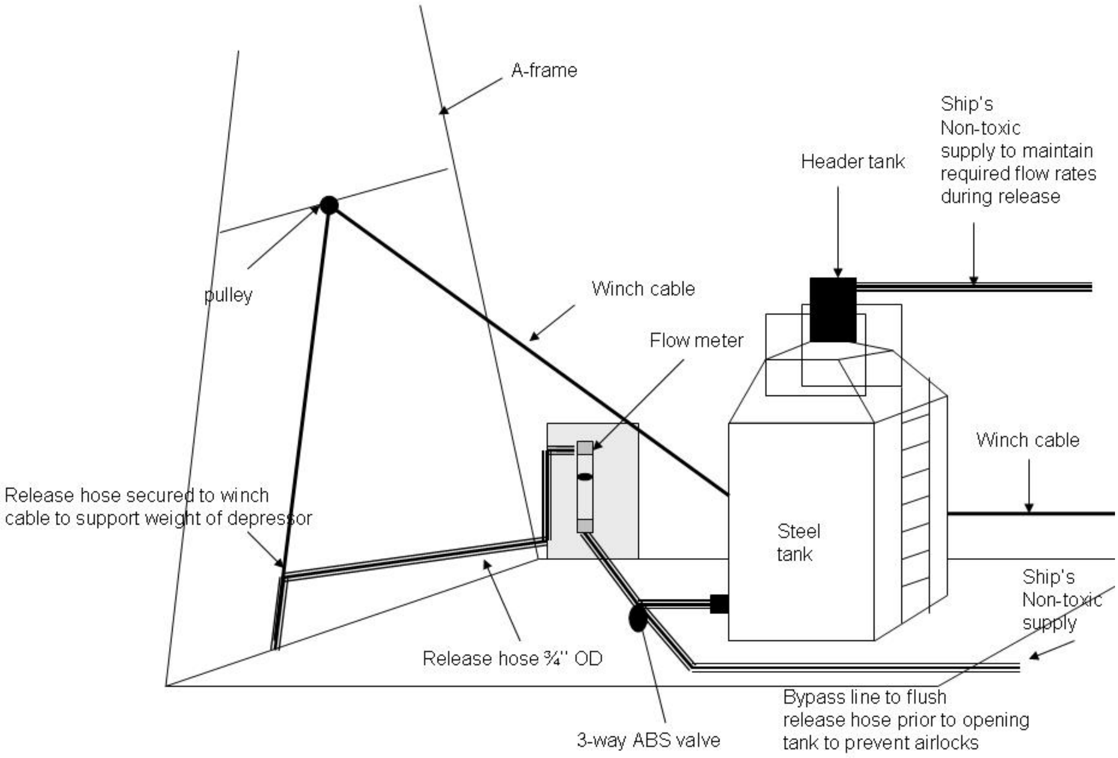

Figure 6: Schematic detailing the tank, hosing and water supply setup during the release of ^{3}He and SF_6.

The duration of Patch #1 release was 5 hours, from 20:50 UTC on 22/06/07 until 01:50 UTC on 22/06/07. Patches #2 and #3 were released over 3 hour periods (from 06:11 UTC on

26/06/07 and from 21:52 UTC on 07/07/07 respectively (see **Appendix 1**). Directly post-release the approximate patch areas were: Patch #1, 4 km^2; Patch #2, 1 km^2; Patch#3, 2 km^2. Patch #2 was subsequently overlain with a surfactant (See **Artificial surfactant releases during DOGEE II**).

Drogued Lagrangian drifter buoys (Pacific Gyre International) were used to adjust the ship's track during each release, to compensate for water mass movement and to aid in subsequent patch relocation. **Figures 7-9** show the ship's tracks and drifter positions during the 3 patch releases and **Figures 10-12** show the ship's tracks corrected to allow for water movement, as determined from buoy drift during release. For Patch #1 a buoy was released at the nominal patch centre prior to tracer release while for the other 2 patches, due to their reduced size, the buoys were released at calculated offsets from their notional centres. *Patch Deploy* software (PML) was used to receive and plot the buoy and ship's position data. The buoys were equipped with both ARGOS and radio transmitters to permit tracking over long and short (4-5 km) ranges, respectively.

Table 1: Flow rates used (set by non-toxic supply to header tank) for each hour of release with actual times of release of Patch #1 (GMT) listed.

Hour	Actual time (GMT)	Flow rate (dm^3 h^{-1})
1	20:50	700
2	21:50	725
3	22:50	850
4	23:50	900
5	00:50	1000
6	01:50	1100

Table 2: Flow rates used (set by non-toxic supply to header tank) for each hour of release with actual times of Patch #2 release listed.

Hour	Actual time (GMT)	Flow rate (dm^3 h^{-1})
1	07:00	1000
2	08:00	1200
3	09:00	1400

Table 3: Flow rates used (set by non-toxic supply to header tank) for each hour of release with actual times of Patch #3 release listed.

Hour	Actual time (GMT)	Flow rate (dm^3 hr^{-1})
1	22:00	1000
2	22:30	2000
3	23:00	2500
4	00:00	3000

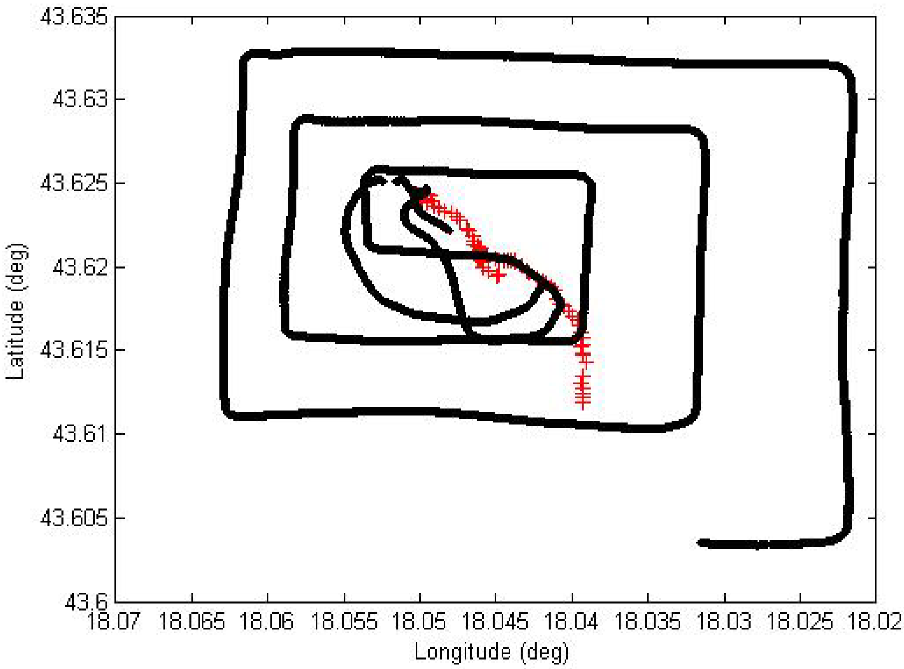

Figure 7: Ship track (black line) and Lagrangian drifter buoy positions (red crosses) during the release of Patch 1.

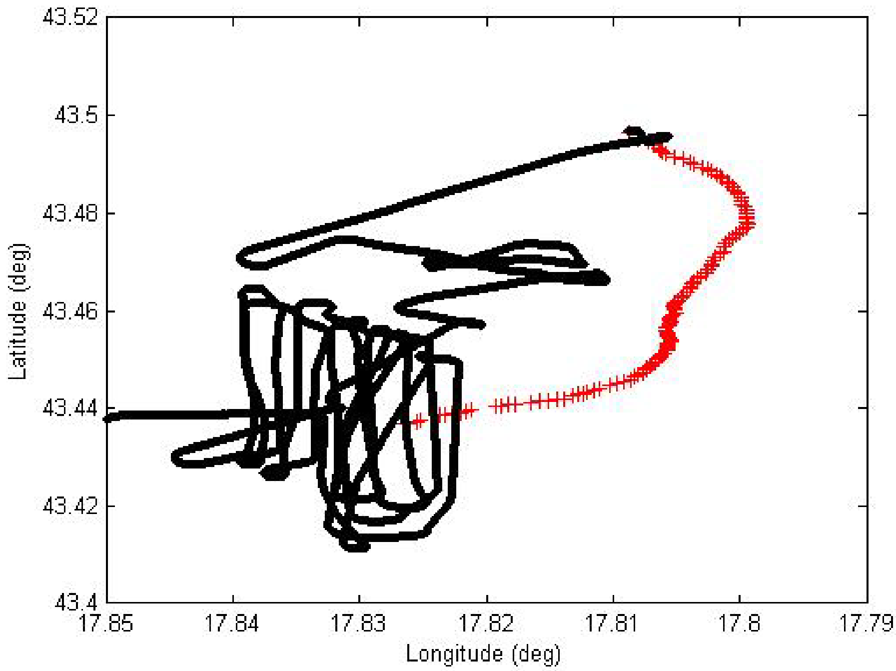

Figure 8: Ship track (black line) and Lagrangian drifter buoy positions (red crosses) during the release of Patch 2.

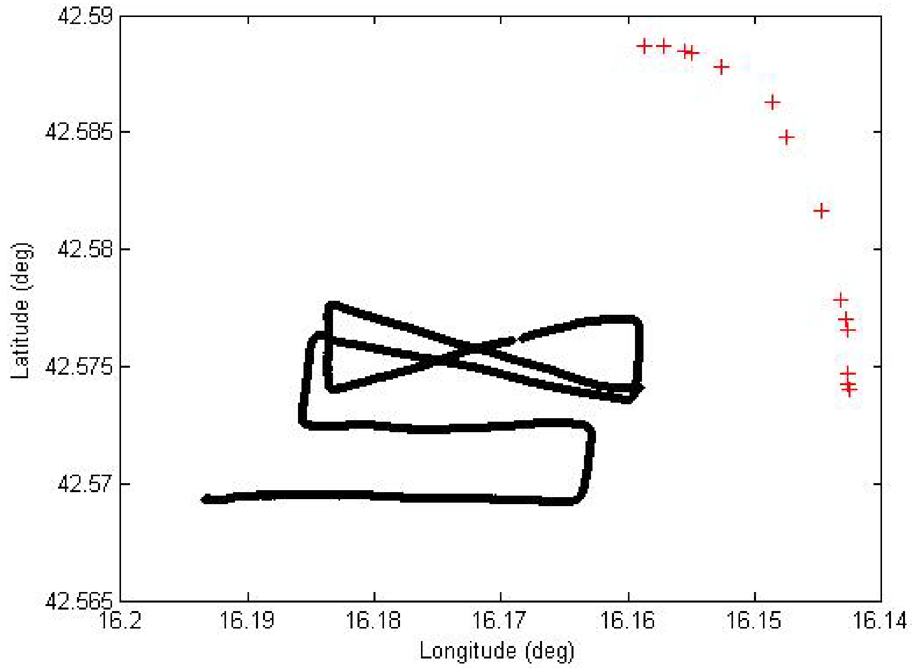

Figure 9: Ship track (black line) and Lagrangian drifter buoy positions (red crosses) during the release of Patch 3.

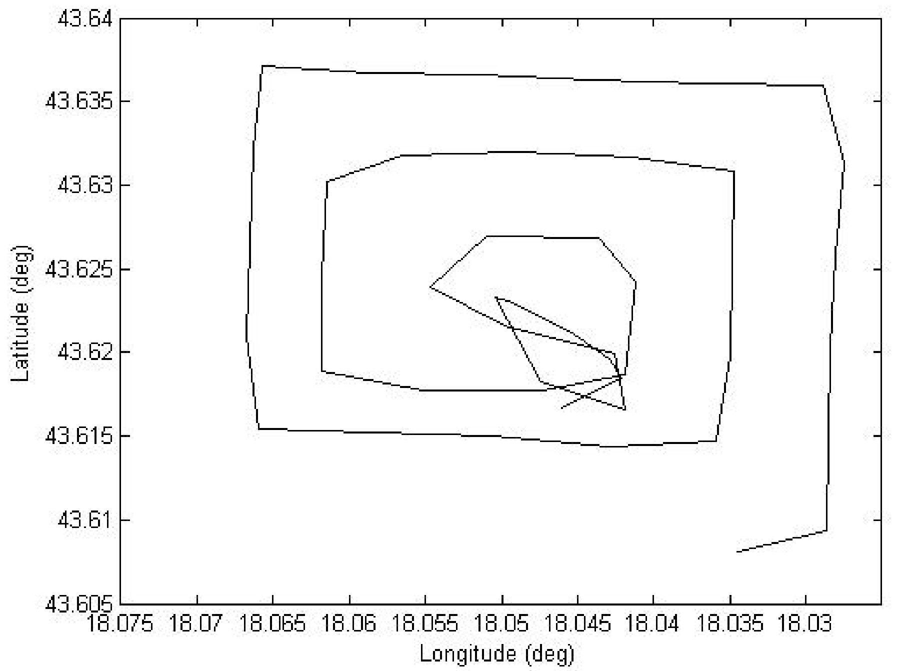

Figure 10: Corrected ship's track based on Lagrangian drifter buoy movement for Patch 1 release.

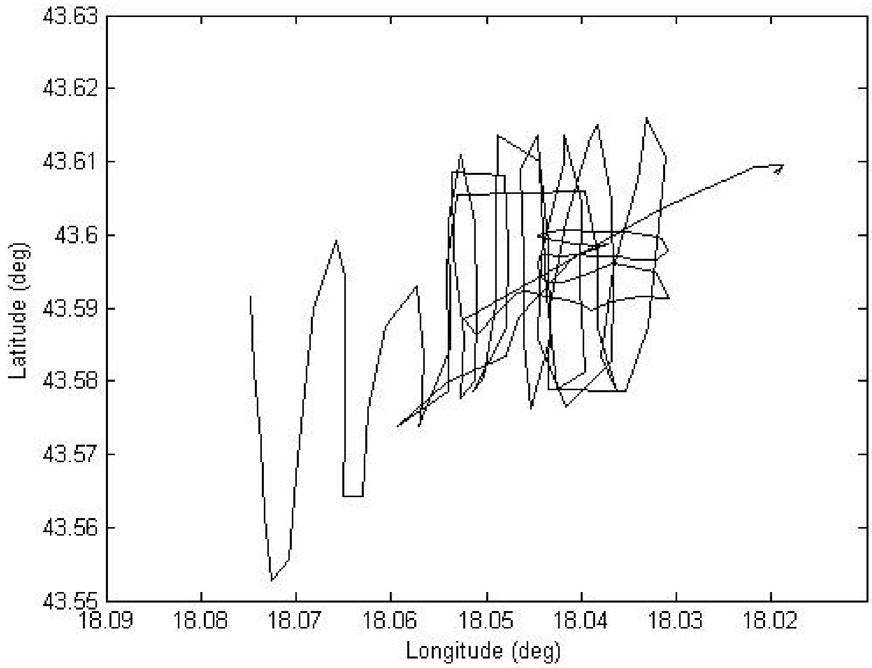

Figure 11: Corrected ship's track based on Lagrangian drifter buoy movement for Patch 2 release.

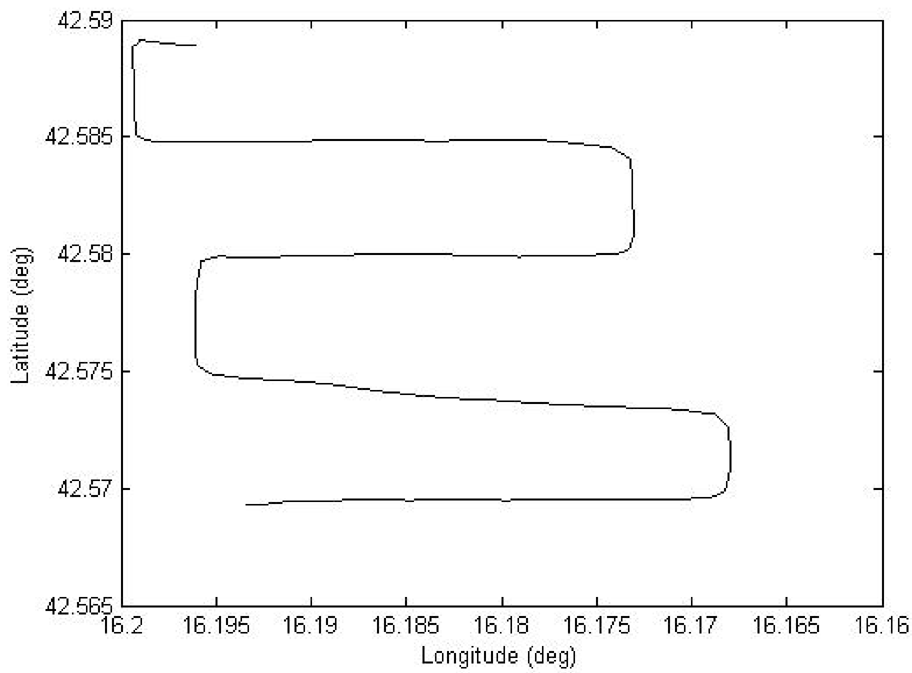

Figure 12: Corrected ship's track based on Lagrangian drifter buoy movement for Patch 3 release.

Ancillary data: Thermistor chains, each with a combination of temperature and pressure loggers (Vemco and Star Oddi) at nominal depths of 5, 10, 20, 25, 30, 35, 40, 45, 50, 55, 75, and 90 m, were attached to each of three "patch centre" buoys. These were used to estimate the scales of internal waves and degrees of stratification in the mixed layer, and temporal changes in mixed layer depths. The logger configuration in each chain is shown in **Table 4**. Due to wind slippage the Patch #1 and Patch #2 drifter buoys required repositioning close to the respective patch centres during their deployment periods. Repositioning times are listed in

Table 4. Temperature data from Patches #2 and #3 are shown in **Figures 13 and 14**. The two patches had similar mixed layer depths. Near-surface water temperatures were however lower in Patch #2; strong surface heating and a consequent large temperature gradient developed between 5 and 10 metres depth towards the end of the Patch #2 monitoring period.

Table 4: Configuration and deployment periods of Thermistor chains in Patches #1, #2 and #3. Shaded loggers did not acquire any data due to malfunction.

Depth	Patch	Deployment	Type	ID
5	1	21/06/07-02/07/07*	CTD	n/a
10	1	21/06/07-02/07/07*	Vemco	2699E
20	1	21/06/07-02/07/07*	Star Oddi	3237
25	1	21/06/07-02/07/07*	Vemco	8517
30	1	21/06/07-02/07/07*	Star Oddi	3235
35	1	21/06/07-02/07/07*	Vemco	8516
40	1	21/06/07-02/07/07*	Star Oddi	3233
45	1	21/06/07-02/07/07*	Vemco	9756A
50	1	21/06/07-02/07/07*	Star Oddi	3232
55	1	21/06/07-02/07/07*	Vemco	9714A
65	1	21/06/07-02/07/07*	Star Oddi	3231
75	1	21/06/07-02/07/07*	Vemco	8519
90	1	21/06/07-02/07/07*	Star Oddi	3228
5	2	26/06/07-08/07/07+	Star Oddi	3217
10	2	26/06/07-08/07/07+	Vemco	2701E
20	2	26/06/07-08/07/07+	Star Oddi	3216
25	2	26/06/07-08/07/07+	Star Oddi	3215
30	2	26/06/07-08/07/07+	Star Oddi	3209
35	2	26/06/07-08/07/07+	Star Oddi	3211
40	2	26/06/07-08/07/07+	Star Oddi	3214
45	2	26/06/07-08/07/07+	Star Oddi	3207
50	2	26/06/07-08/07/07+	Vemco	7169
55	2	26/06/07-08/07/07+	Star Oddi	3218
75	2	26/06/07-08/07/07+	Star Oddi	3220
90	2	26/06/07-08/07/07+	Star Oddi	3213
5	3	07/07/07-13/07/07	Star Oddi	3237
10	3	07/07/07-13/07/07	Star Oddi	3247
20	3	07/07/07-13/07/07	Star Oddi	3232
25	3	07/07/07-13/07/07	Star Oddi	3242
30	3	07/07/07-13/07/07	Star Oddi	3235
35	3	07/07/07-13/07/07	Star Oddi	3231
40	3	07/07/07-13/07/07	Star Oddi	3229
45	3	07/07/07-13/07/07	Star Oddi	3246
50	3	07/07/07-13/07/07	Star Oddi	3239
55	3	07/07/07-13/07/07	Star Oddi	3233
65	3	07/07/07-13/07/07	Star Oddi	3221
75	3	07/07/07-13/07/07	Star Oddi	3228
90	3	07/07/07-13/07/07	Star Oddi	3222

*- drifter buoy repositioned at patch centre 14:10-21:30 24/06/07

+- drifter buoy repositioned at patch centre 12:00-19:20 27/06/07

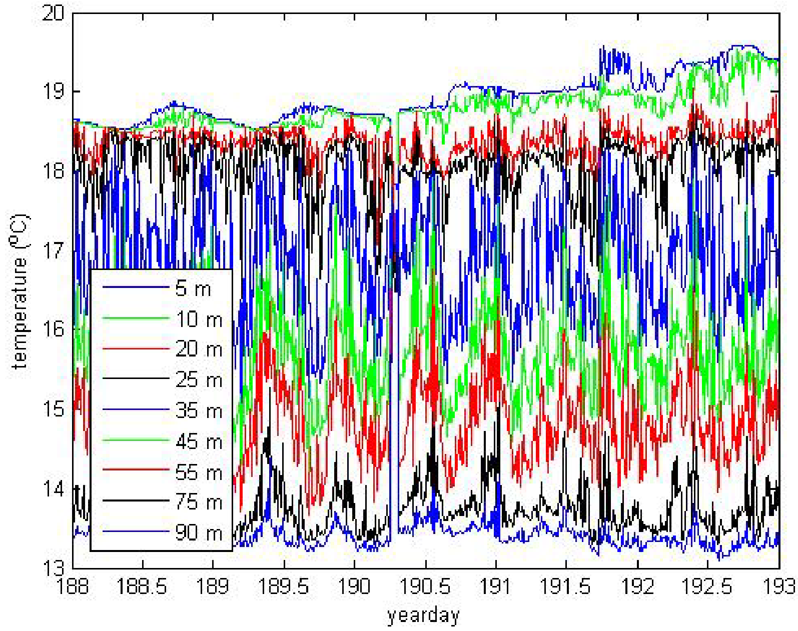

Figure 1: Thermistor chain data from Patch 2 (21/06/07 – 08/07/07 repositioned on 27/06/07 from 12:00 to 19:20).

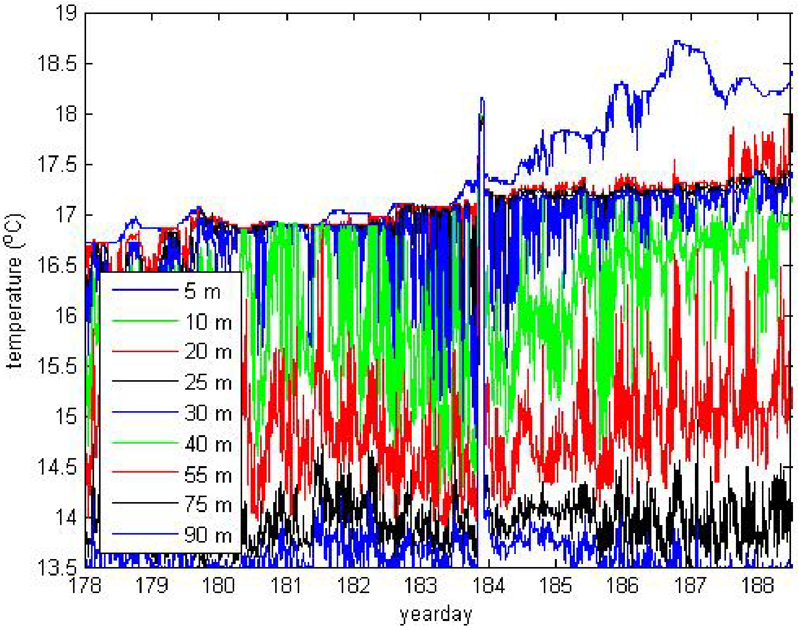

Figure 14: Thermistor chain data from Patch 3 (07/07/07 – 13/07/07).

Sampling strategy: Water samples for determining SF_6/^3He ratios were routinely collected from the CTD sampling rosette. We collected and analysed SF_6 and ^3He samples from a total of 7 CTD's from Patch #1, 11 CTD's from Patch #2, and 5 CTD's from Patch #3. For each we sampled a minimum of 10 depths for SF_6 and a minimum of 3 depths for ^3He. Example profiles of SF_6 concentrations in Patch #2 determined in CTD samples shortly after tracer release are shown in **Figure 12**. **Figure 13** shows the SF_6 profiles for the remainder of the Patch #2 monitoring period. A further 4 sites outside of the three tracer patches were sampled by CTD rosette in order to establish background tracer concentrations. **Table 5** is a comprehensive list of CTD samples collected.

Additionally we used a near surface sampler to examine small scale gradients in surface water tracer concentrations, and a CAT micro-layer skimmer (H. Zemmelink, NIOZ/UEA) to examine the efficiency of skimmer micro-layer gas sampling.

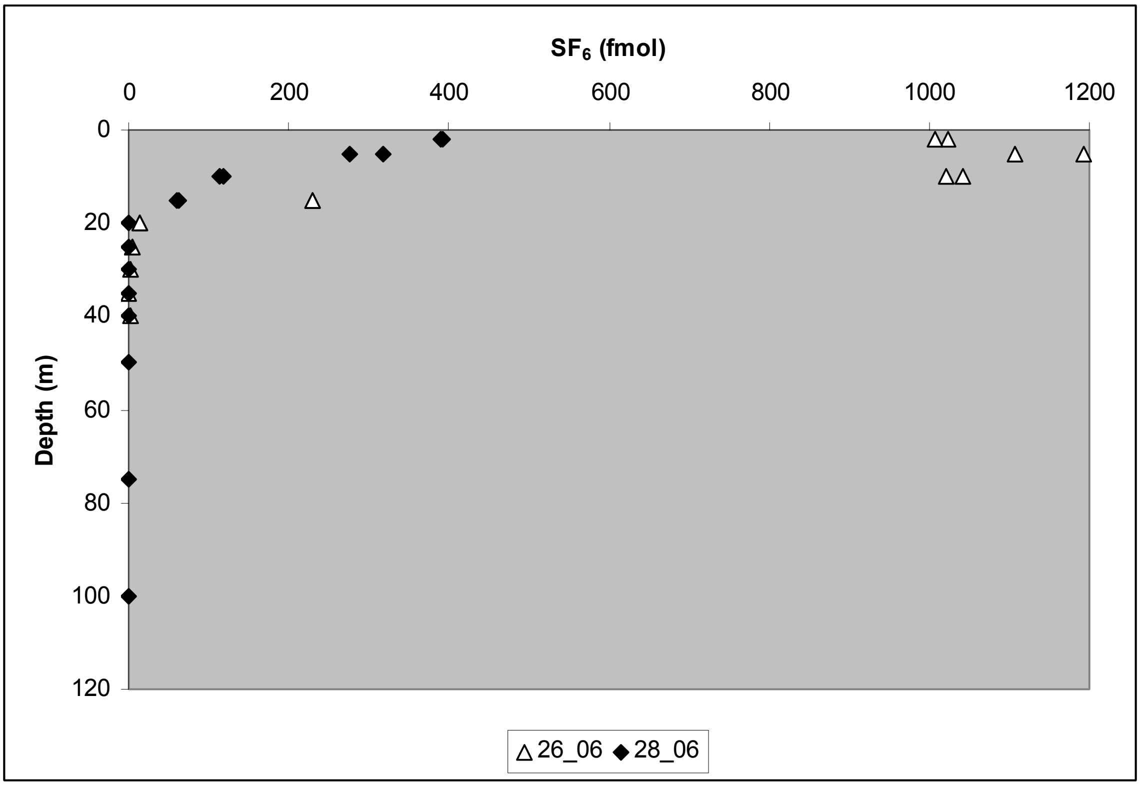

Figure 2: Example high concentration SF_6 profiles from Patch #2 following release (26/06/07-28/06/07).

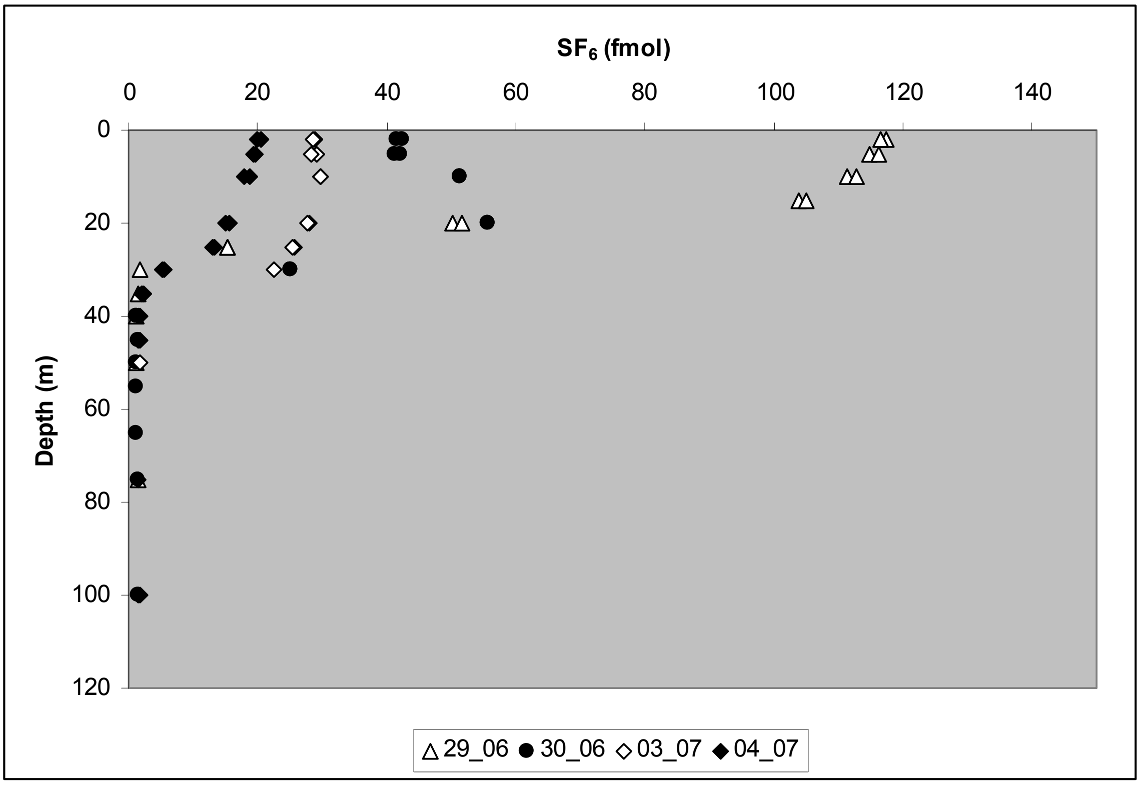

Figure 16: Example SF_6 profiles from Patch 2 for the remainder of the monitoring period (29/06/07 to 04/07/07).

Table 5: All samples collected for SF_6 analysis; shaded samples indicate which samples were also collected for ^3He analysis. Duplicate samples were taken for 3He analysis for the depths shaded in grey.

Type	Station	Cast	Date	Time	Latitude	Longitude	Depth	Niskin
Background	4	3	20/06/2007		43.31731	-18.2019	**2**	**14**
Background	4	3	20/06/2007		43.31731	-18.2019	**5**	**12**
Background	4	3	20/06/2007		43.31731	-18.2019	10	10
Background	4	3	20/06/2007		43.31731	-18.2019	20	9
Background	4	3	20/06/2007		43.31731	-18.2019	25	8
Background	4	3	20/06/2007		43.31731	-18.2019	30	7
Background	4	3	20/06/2007		43.31731	-18.2019	40	6
Background	4	3	20/06/2007		43.31731	-18.2019	**50**	**4**
Background	4	3	20/06/2007		43.31731	-18.2019	75	2
Background	4	3	20/06/2007		43.31731	-18.2019	100	1
Pre-release	11	10	20/06/2007		43.6692	-17.783	2	14
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	5	11
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	10	10
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	20	9
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	25	8
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	30	7
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	40	6
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	50	5
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	75	2
Pre-release	**11**	**10**	**20/06/2007**		**43.6692**	**-17.783**	100	1
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	2	18
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	5	17
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	10	16
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	20	15
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	30	14
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	35	12
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	40	11
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	50	10
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	75	8
Tzero P1	**19**	**3**	22/06/2007	20:59	43.58586	-18.0285	100	7
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	2	20
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	5	19
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	10	18
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	15	17
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	20	16
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	25	15
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	30	14
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	35	12
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	40	11
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	50	10
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	75	8
P1	**20**	**14**	23/06/2007	09:30	43.59472	-18.0119	100	7
P1	**21**	**15**	23/06/2007	20:48	43.57186	-18.021	2	17
P1	**21**	**15**	23/06/2007	20:48	43.57186	-18.021	10	15
P1	**21**	**15**	23/06/2007	20:48	43.57186	-18.021	20	11
P1	**21**	**15**	23/06/2007	20:48	43.57186	-18.021	30	8
Type	Station	Cast	Date	Time	Latitude	Longitude	Depth	Niskin
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	2	20
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	5	19
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	10	18

P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	15	17
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	20	16
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	25	15
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	30	14
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	35	12
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	40	11
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	45	10
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	50	8
P1	**25**	**16**	24/06/2007	16:08	43.540833	-18.03633	100	7
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	2	20
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	5	19
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	10	18
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	15	17
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	20	16
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	25	15
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	30	14
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	35	12
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	40	11
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	45	10
P1	**27**	**17**	24/06/2007	20:46	43.523833	-18.011667	50	8
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	2	18
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	5	17
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	10	16
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	15	15
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	20	14
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	25	12
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	30	11
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	35	10
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	40	8
P2	**34**	**18**	26/06/2007	18:47	43.428167	-18.850167	100	7
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	2	20
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	5	19
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	10	18
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	15	17
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	25	16
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	30	15
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	35	14
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	40	12
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	45	11
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	50	10
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	100	8
P2	**39**	**19**	27/06/2007		43.36132	-17.8546	100	7
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	2	20
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	5	19
Type	Station	Cast	Date	Time	Latitude	Longitude	Depth	Niskin
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	10	18
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	15	17
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	20	16
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	25	15
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	30	14
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	35	12
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	40	11
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	50	10
P2	**45**	**20**	28/06/2007		43.24297	-17.8297	75	9

P2	45	20	28/06/2007		43.24297	-17.8297	100	8
P2	47	21	28/06/2007		43.22395	-17.8117	2	20
P2	47	21	28/06/2007		43.22395	-17.8117	5	19
P2	47	21	28/06/2007		43.22395	-17.8117	10	18
P2	47	21	28/06/2007		43.22395	-17.8117	15	17
P2	47	21	28/06/2007		43.22395	-17.8117	20	16
P2	47	21	28/06/2007		43.22395	-17.8117	25	15
P2	47	21	28/06/2007		43.22395	-17.8117	30	14
P2	47	21	28/06/2007		43.22395	-17.8117	35	12
P2	47	21	28/06/2007		43.22395	-17.8117	40	11
P2	47	21	28/06/2007		43.22395	-17.8117	50	10
P2	47	21	28/06/2007		43.22395	-17.8117	75	9
P2	47	21	28/06/2007		43.22395	-17.8117	100	8
P1	49	22	29/06/2007		43.41187	-17.9107	2	20
P1	49	22	29/06/2007		43.41187	-17.9107	5	19
P1	49	22	29/06/2007		43.41187	-17.9107	10	18
P1	49	22	29/06/2007		43.41187	-17.9107	15	17
P1	49	22	29/06/2007		43.41187	-17.9107	20	16
P1	49	22	29/06/2007		43.41187	-17.9107	25	15
P1	49	22	29/06/2007		43.41187	-17.9107	30	14
P1	49	22	29/06/2007		43.41187	-17.9107	35	12
P1	49	22	29/06/2007		43.41187	-17.9107	40	11
P1	49	22	29/06/2007		43.41187	-17.9107	50	10
P1	49	22	29/06/2007		43.41187	-17.9107	75	9
P1	49	22	29/06/2007		43.41187	-17.9107	100	8
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	2	20
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	5	19
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	10	18
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	15	17
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	20	16
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	25	15
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	30	14
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	35	12
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	40	11
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	50	10
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	75	9
P2	50	23	29/06/2007	19:37	43.07077	-17.7862	100	8
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	2	20
Type	Station	Cast	Date	Time	Latitude	Longitude	Depth	Niskin
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	5	19
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	10	18
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	20	17
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	30	16
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	40	15
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	45	14
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	50	12
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	55	11
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	65	10
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	75	9
P2	51	24	01/07/2007	12:27	42.71664	-17.7096	100	8
P1	58	28	02/07/2007	17:07	42.89754	-17.7139	2	20
P1	58	28	02/07/2007	17:07	42.89754	-17.7139	5	19
P1	58	28	02/07/2007	17:07	42.89754	-17.7139	10	18
P1	58	28	02/07/2007	17:07	42.89754	-17.7139	20	17

P1	**58**	**28**	02/07/2007	17:07	42.89754	-17.7139	30	16
P1	**58**	**28**	02/07/2007	17:07	42.89754	-17.7139	35	15
P1	**58**	**28**	02/07/2007	17:07	42.89754	-17.7139	40	14
P1	**58**	**28**	02/07/2007	17:07	42.89754	-17.7139	45	12
P1	**58**	**28**	02/07/2007	17:07	42.89754	-17.7139	50	11
P1	**58**	**28**	02/07/2007	17:07	42.89754	-17.7139	60	10
P1	**58**	**28**	02/07/2007	17:07	42.89754	-17.7139	75	9
P1	**58**	**28**	02/07/2007	17:07	42.89754	-17.7139	100	8
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	2	20
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	5	19
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	10	18
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	20	17
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	25	16
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	30	15
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	35	14
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	40	12
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	45	11
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	50	10
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	75	9
P2	**60**	**29**	03/07/2007		42.35196	-17.7712	100	8
Background	**65**	**31**	04/07/2007	08:39	42.5822	-16.5615	10	20
Background	**65**	**31**	04/07/2007	08:39	42.5822	-16.5615	15	18
Background	**65**	**31**	04/07/2007	08:39	42.5822	-16.5615	25	16
Background	**65**	**31**	04/07/2007	08:39	42.5822	-16.5615	50	14
Background	**65**	**31**	04/07/2007	08:39	42.5822	-16.5615	75	11
Background	**65**	**31**	04/07/2007	08:39	42.5822	-16.5615	100	9
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	2	19
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	5	20
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	10	19
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	20	17
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	25	16
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	30	15
Type	Station	Cast	Date	Time	Latitude	Longitude	Depth	Niskin
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	35	14
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	40	12
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	45	11
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	50	10
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	75	9
P2	**70**	**32**	04/07/2007	21:15	42.12336	-17.9939	100	8
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	2	20
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	5	19
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	10	18
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	20	17
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	30	16
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	35	15
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	40	14
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	45	12
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	50	11
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	55	10
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	75	9
P2	**75**	**33**	06/07/2007	11:33	41.88212	-18.1269	100	8
P2	**78**	NSS	06/07/2007				0.2	1
P2	**78**	NSS	06/07/2007				0.4	2
P2	**78**	NSS	06/07/2007				0.8	4

P2	**78**	NSS	06/07/2007				1	5
P2	**78**	NSS	06/07/2007				1.3	6
P2	**78**	NSS	06/07/2007				1.6	7
P2	**78**	NSS	06/07/2007				20	8
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	2	20
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	5	19
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	10	18
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	15	17
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	20	16
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	30	15
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	40	14
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	45	12
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	50	11
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	55	10
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	75	9
P2	**87**	37	08/07/2007	15:05	41.72564	-18.3977	100	8
P2	**89**	NSS	08/07/2007				0.2	1
P2	**89**	NSS	08/07/2007				0.4	2
P2	**89**	NSS	08/07/2007				0.6	3
P2	**89**	NSS	08/07/2007				0.8	4
P2	**89**	NSS	08/07/2007				1	5
P2	**89**	NSS	08/07/2007				1.3	6
P2	**89**	NSS	08/07/2007				2	7
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	2	20
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	5	19
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	10	18
Type	Station	Cast	Date	Time	Latitude	Longitude	Depth	Niskin
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	15	17
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	20	16
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	30	15
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	40	14
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	45	12
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	50	11
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	55	10
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	75	9
P3	**92**	38	09/07/2007	15:26	42.59744	-16.121	100	8
P3	**100**	39	10/07/2007		42.59112	-16.1578	2	19
P3	**100**	39	10/07/2007		42.59112	-16.1578	5	18
P3	**100**	39	10/07/2007		42.59112	-16.1578	10	17
P3	**100**	39	10/07/2007		42.59112	-16.1578	15	16
P3	**100**	39	10/07/2007		42.59112	-16.1578	20	15
P3	**100**	39	10/07/2007		42.59112	-16.1578	25	14
P3	**100**	39	10/07/2007		42.59112	-16.1578	30	12
P3	**100**	39	10/07/2007		42.59112	-16.1578	40	11
P3	**100**	39	10/07/2007		42.59112	-16.1578	45	10
P3	**100**	39	10/07/2007		42.59112	-16.1578	50	9
P3	**100**	39	10/07/2007		42.59112	-16.1578	100	8
P3	**103**	NSS	10/07/2007				0.2	1
P3	**103**	NSS	10/07/2007				0.4	2
P3	**103**	NSS	10/07/2007				0.6	3
P3	**103**	NSS	10/07/2007				0.8	4
P3	**103**	NSS	10/07/2007				1	5
P3	**103**	NSS	10/07/2007				1.3	6
P3	**103**	NSS	10/07/2007				1.6	7

P3	**103**	NSS	10/07/2007				2	8
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	2	20
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	5	19
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	15	18
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	20	17
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	30	16
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	40	15
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	50	14
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	60	11
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	75	10
Background	**105**	40	11/07/2007	07:07	42.7605	-15.932	100	8
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	2	19
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	5	18
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	10	17
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	15	16
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	20	15
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	25	14
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	30	12
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	35	11
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	40	10
Type	Station	Cast	Date	Time	Latitude	Longitude	Depth	Niskin
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	50	9
P3	**107**	41	11/07/2007	14:26	42.65661	-16.0919	100	8
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	2	19
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	5	18
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	10	17
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	15	16
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	20	15
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	25	14
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	30	12
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	35	11
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	40	10
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	50	9
P3	**111**	43	12/07/2007	10:46	42.66027	-16.0772	100	8
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	2	19
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	5	18
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	10	17
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	15	16
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	20	15
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	25	14
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	30	12
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	35	11
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	40	10
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	50	9
P3	**112**	44	13/07/2007	07:09	42.6761	-16.0408	100	8

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Artificial surfactant releases during DOGEE II

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Background: A total of 5 separate surfactant releases were successfully carried out during the cruise, as summarised below.

Test release (JD 176; 13:00; 43º 36.92 N 17º 51.13 W): A small scale release ~ 30-40 l of Oleyl Alcohol was carried out in order to test-run the proposed release. We estimated this amount to be sufficient to cover an area ~ 1.5 km^2 (as a 0.5 km by 3 km rectangle: **Figure 17**) at 20 mg surfactant m^{-2}. This we estimate to be one order of magnitude larger than the amount theoretically required for a monolayer of this surface area. At a ship's speed of 8 kt the required release time was ~25 minutes for a surfactant release rate of 1.4 l min^{-1}. The release was carried out by pumping the surfactant directly from one of the 205 litre steel drums in which it was supplied. A hand operated pump was used to obtain the moderate rate of flow required and to ensure ease of setup and use. Photographs taken during the test release show clearly the damping of capillary waves on the sea surface by the surfactant **(Picture 1).**

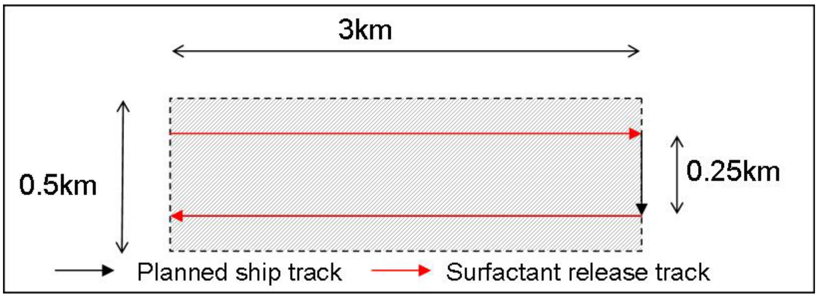

Figure 17. Surfactant test release planned pattern

Picture 1a (left) shows the view from the stern of the ship as the surfactant is released and Picture 1b (above) shows the surfactant slowly spreading out following the release

Combined surfactant and tracer release (JD 176 10:30-17:15 43º 25.69 N 17º 51.00 W: The SF_6 tracer release was completed at 10:00 UTC, JD 176 (26/06/07). The surfactant release commenced 30 minutes later (10:30 UTC, JD 176 (26/06/07) following the protocol developed for the test release (see above). A 10 m long, 2.5 cm bore hose was run from the outlet of the hand pump and directed over the side of the ship, down the sampling fish line with the end of the hose ~ 30 cm above the water surface. Surfactant was released only during the 2.5 km legs **(Figure 18)** and pumping was ceased during all turns. The surfactant release was completed at 17:15 UTC. **Figure 19** shows the actual ship and drifter buoy tracks during the surfactant release and **Figure 20** shows the ship's track corrected for movement of the buoy.

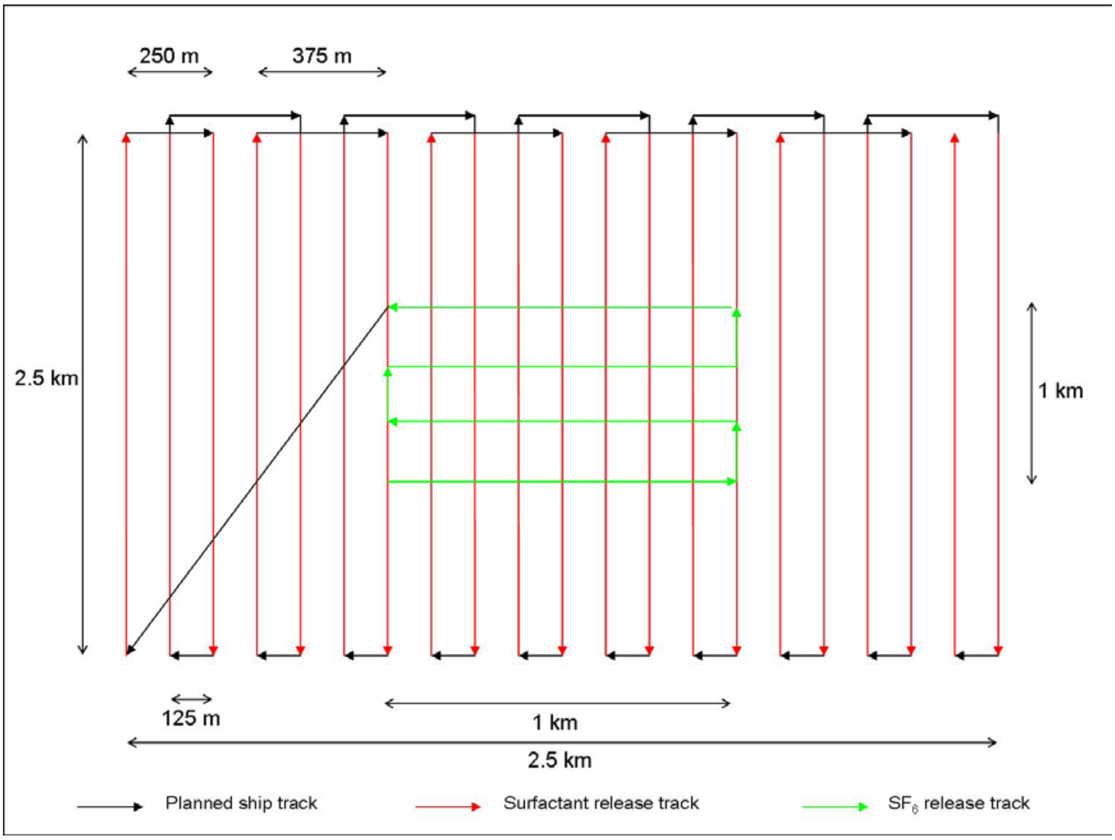

Figure 18. Planned schematic of release superimposed on second SF_6 tracer patch

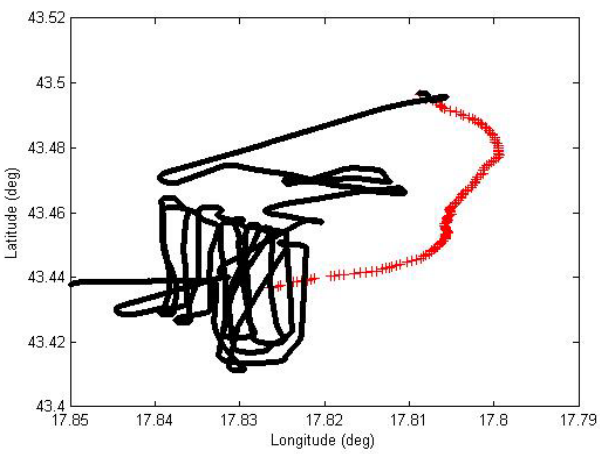

Figure 19. Uncorrected positions of the ship (black line) and drifter buoy (red line) during the release.

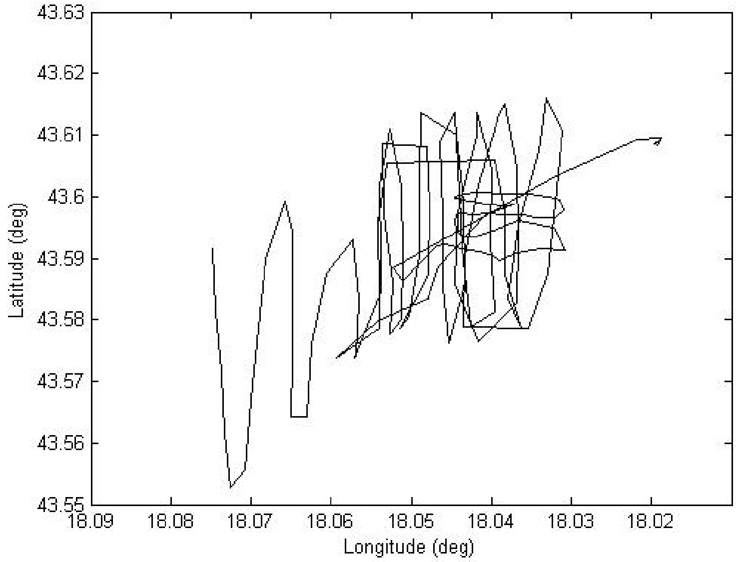

Figure 20. Ship's track during release corrected for marker buoy position.

ASIS surfactant release (JD 186 08:30-12:30 UTC, 42º 35.40 N 16º 27.23 W): Initially a 3 hour, 1 km by 4 km release was planned downwind of ASIS #1; the expectation was that ASIS #1 would pass through the surfactant patch. However, subsequent to the start of the release ASIS #1 changed course and began to advance ahead of the developing surfactant patch. The release was therefore modified in response to the movement of ASIS #1. During the course of the ~210 l of oleyl alcohol was released, at an average release rate of ~1 l min^{-1}.

NOC buoy surfactant release (JD 191 08:15-09:30 UTC, Station 99): A small expanding box release around the NOC Spar buoy was initially planned. However due to changes in the movement of the Spar Buoy the release was carried out in a similar fashion to that for the ASIS release. The buoy was observed to enter the surfactant patch at ~09:00 UTC and was still in the patch at ~10:15 UTC.

DMS flux release (JD 202 12:00-14:00 54º 12.7 N 12º 42.97 W): A further release was initiated to examine the influence of surfactant on DMS fluxes measured in a high DMS region. DMS measurements were made for a period prior to the surfactant release in order to obtain "non surfactant" fluxes. A similar release to that overlying the dual tracer patch was initially envisaged (**Figure 18**). However this was precluded by strong winds and an increasing sea state. The ship therefore travelled repeatedly back and forth along a ~ 2 km line perpendicular to the wind direction, which enabled the surfactant to spread out downwind. Immediately following the end of the release DMS measurements were made in order to obtain "surfactant" flux measurements. Samples of the sea surface microlayer were collected throughout this sampling period for subsequent surfactant measurements that would establish the ship's location in relation to the surfactant patch.

Microlayer and sub-surface water sampling: Microlayer and sub-surface water samples were routinely collected at intervals throughout the cruise for surfactant activity measurements and bacterial community analysis, both within and outside the artificial surfactant patches. Microlayer samples for surfactant analysis were collected using both a Garrett Screen and a Glass Plate while bacteria samples were collected on polycarbonate membranes and Sterivex filters. The ships RIB was mainly used for sampling some distance off the ship in order to avoid contamination although some Garrett Screen samples were collected from over the side of the ship. A number of near surface profiles were also obtained using the near surface sampler (NSS) and a surface skimmer (NIOZ catamaran) with a rotating glass drum. **Table 6** lists all samples collected during the cruise.

It was initially planned to analyse all surfactant samples on board ship, however instrument failure early precluded this. Instead all surfactant samples had to be stored for later on-shore analysis. Samples for bacterial community analysis were frozen for subsequent DNA analysis (Emma Harrison, Newcastle University) in the School of Biological Sciences, University of Warwick.

Table 6 (next page). Details of surfactant samples collected during D320.

Date	Julian Day	Time (GMT)	St. No	Sample type	Sample ID	Hours in fridge	Stored - 20°C	Stored - 80°C	Comment
24/06/07	175	10:30	22	Bulk (10cm pipette)	GS 18C	118.5	✓	✓	Natural microlayer
24/06/07	175	10:30	22	Bulk (10cm pipette)	GS 6C	118.5	✓	✓	
24/06/07	175	10:30	22	Bulk (10cm pipette)	GS 4A	118.5	✓	✓	
24/06/07	175	10:30	22	Bulk (10cm pipette)	GS K3B	118.5	✓	✓	
24/06/07	175	10:30	22	µlayer (Garrett screen)	GS 2A	118.5	✓	✓	
24/06/07	175	10:30	22	µlayer (Garrett screen)	GS 6B	118.5	✓	✓	
24/06/07	175	10:30	22	µlayer (Garrett screen)	GS K2C	118.5	✓	✓	
24/06/07	175	10:30	22	µlayer (Garrett screen)	GS 17C	118.5	✓	✓	
25/06/07	176	18:15	32	Bulk (10cm pipette)	GS 11 C	96.75	✓	✓	Oleyl slick
25/06/07	176	18:15	32	Bulk (10cm pipette)	GS 18A	96.75	✓	✓	
25/06/07	176	18:15	32	Bulk (10cm pipette)	GS 10C	96.75	✓	✓	
25/06/07	176	18:15	32	Bulk (10cm pipette)	GS 10B	96.75	✓	✓	
25/06/07	176	18:15	32	Bulk (10cm pipette)	GS 16C	96.75	✓	✓	Natural microlayer
25/06/07	176	18:15	32	Bulk (10cm pipette)	GS 5A	96.75	✓	✓	
25/06/07	176	18:15	32	Bulk (10cm pipette)	GS K4B	96.75	✓	✓	
25/06/07	176	18:15	32	Bulk (10cm pipette)	GS 5B	96.75	✓	✓	
25/06/07	176	18:15	32	µlayer (Garrett screen)	GS 12C	96.75	✓	✓	Oleyl slick
25/06/07	176	18:15	32	µlayer (Garrett screen)	GS 2C	96.75	✓	✓	
25/06/07	176	18:15	32	µlayer (Garrett screen)	GS 19C	96.75	✓	✓	
25/06/07	176	18:15	32	µlayer (Garrett screen)	GS 17A	96.75	✓	✓	
25/06/07	176	18:15	32	µlayer (Garrett screen)	GS 19B	96.75	✓	✓	Natural microlayer
25/06/07	176	18:15	32	µlayer (Garrett screen)	GS K2A	96.75	✓	✓	
25/06/07	176	18:15	32	µlayer (Garrett screen)	GS 5C	96.75	✓	✓	
25/06/07	176	18:15	32	µlayer (Garrett screen)	GS 18B	96.75	✓	✓	
26/06/06	177	19:00	34	µlayer (Glass plate)	GS 7C	72	✓	✓	Oleyl slick Bucket sample
26/06/06	177	19:00	34	µlayer (Glass plate)	GS K4A	72	✓	✓	
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 1A	56	✓	✓	Oleyl slick
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 12A	56	✓	✓	
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 13A	56	✓	✓	

27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 4C	56	✓	✓	
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 11B	56	✓	✓	
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 16A	56	✓	✓	
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 9C	56	✓	✓	
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS K1C	56	✓	✓	
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 7B	56	✓	✓	
27/06/07	178	11:00	37	Bulk (10cm pipette)	GS 14B	56	✓	✓	
Date	Julian Day	Time (GMT)	St. No	Sample type	Sample ID	Hours in fridge	Stored -20°C	Stored -80°C	Comment
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS 14A	56	✓	✓	Oleyl slick
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS K1A	56	✓	✓	
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS 9A	56	✓	✓	
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS 11A	56	✓	✓	
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS K4C	56	✓	✓	
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS 7A	56	✓	✓	
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS 2B	56	✓	✓	
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS K3C	56	✓	✓	
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS 1C	56	✓	✓	
27/06/07	178	11:00	37	µlayer (Garrett screen)	GS 12B	56	✓	✓	
28/06/07	179	15:00	46	Bulk (10cm pipette)	GS 18C	4	✓	✓	Possible oleyl slick + 3 Stations for bacterionueston work
28/06/07	179	15:00	46	Bulk (10cm pipette)	GS 6C	4	✓	✓	
28/06/07	179	15:00	46	Bulk (10cm pipette)	GS 4A	4	✓	✓	
28/06/07	179	15:00	46	Bulk (10cm pipette)	GS K3B	4	✓	✓	
28/06/07	179	15:00	46	µlayer (Garrett screen)	GS 2A	4	✓	✓	
28/06/07	179	15:00	46	µlayer (Garrett screen)	GS 6B	4	✓	✓	
28/06/07	179	15:00	46	µlayer (Garrett screen)	GS K2C	4	✓	✓	
28/06/07	179	15:00	46	µlayer (Garrett screen)	GS 17C	4	✓	✓	
01/07/07	182	14:45	52	µlayer (Garrett screen)	GP 7A	0	✓	✓	Oleyl slick seen. Garrett over side
01/07/07	182	14:45	52	µlayer (Garrett screen)	GP 1A	0	✓	✓	
03/07/07	184	15:30	60	µlayer (Garrett screen)	GP 17A	0	✓	✓	Possible Oleyl slick Garrett over side
03/07/07	184	15:30	60	µlayer (Garrett screen)	GP 3A	0	✓	✓	

04/07/07	185	11:15	67	µlayer (Skimmer)	Skim 1-2	96	✓	✓ - not FF	Natural microlayer
04/07/07	185	11:15	67	10 cm (Skimmer)	Skim 1-1	96	✓	✓ - not FF	
04/07/07	185	11:15	67	1 m (Skimmer)	Skim 1-3	96	✓	✓ - not FF	
04/07/07	185	11:15	67	2 m (Skimmer)	Skim 1-4	96- no LN	✓	✓ - not FF	
04/07/07	185	14:00	68	µlayer (Garrett screen)	GP K3B	92 - no LN	✓	✓ - not FF	Natural microlayer + Bacteria
04/07/07	185	14:00	68	µlayer (Garrett screen)	B3 1145	92 - no LN	✓	✓ - not FF	
04/07/07	185	14:00	68	µlayer (Garrett screen)	B7 1600	92 - no LN	✓	✓ - not FF	
04/07/07	185	14:00	68	µlayer (Glass plate)	GP 10A	92 - no LN	✓	✓ - not FF	
04/07/07	185	14:00	68	µlayer (Glass plate)	GP 9B	92 - no LN	✓	✓ - not FF	
04/07/07	185	14:00	68	µlayer (Glass plate)	GP 1B	92 - no LN	✓	✓ - not FF	
04/07/07	185	14:30	69	Surface profile -20cm	Pro 1-1	92 - no LN	✓	✓ - not FF	Natural profile
04/07/07	185	14:30	69	Surface profile -40cm	Pro 2-1	92 - no LN	✓	✓ - not FF	
04/07/07	185	14:30	69	Surface profile -80cm	Pro 4-1	92 - no LN	✓	✓ - not FF	
04/07/07	185	14:30	69	Surface profile -100cm	Pro 5-1	92 - no LN	✓	✓ - not FF	
Date	Julian Day	Time GMT	St No.	Sample type	Sample ID	Hours in fridge	Stored - 20°C	Stored - 80°C	Comment
04/07/07	185	14:30	69	Surface profiler -160cm	Pro 7-1	92 - no LN	✓	✓ - not FF	"
04/07/07	185	14:30	69	Surface profiler -200cm	Pro 8-1	92 - no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	µlayer (Garrett screen)	GP 1B	70- no LN	✓	✓ - not FF	ASIS Oleyl slick Looked non-slick but hard to define + 4 Bacteria stations
05/07/07	186	14:00	72	µlayer (Garrett screen)	GP 6A	70- no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	µlayer (Garrett screen)	GP 13A	70- no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	µlayer (Garrett screen)	GP 2A	70- no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	µlayer(GS)/Bulk(10cm)	GP K1B	70- no LN	✓	✓ - not FF	As above
05/07/07	186	14:00	72	µlayer(GS)/Bulk(10cm)	GS K2B	70- no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	µlayer (Garrett screen)	GS 10A	70- no LN	✓	✓ - not FF	ASIS Oleyl slick Should definitely be slick + 4 Bacteria stations
05/07/07	186	14:00	72	µlayer (Garrett screen)	GS 4B	70- no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	µlayer (Garrett screen)	GS 3C	70- no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	µlayer (Garrett screen)	GS 13B	70- no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	µlayer (Garrett screen)	GS 19A	70- no LN	✓	✓ - not FF	
05/07/07	186	14:00	72	Bulk (10cm pipette)	GS K1B	70- no LN	✓	✓ - not FF	
05/07/07	186	19:00	74	µlayer (Skimmer)	Skim 2-2	65- no LN	✓	✓ - not FF	Possible Oleyl slick

05/07/07	186	19:00	74	10 cm (Skimmer)	Skim 2-1	65- no LN	✓	✓ - not FF	
05/07/07	186	19:00	74	1 m (Skimmer)	Skim 2-3	65- no LN	✓	✓ - not FF	
05/07/07	186	19:00	74	2 m (Skimmer)	Skim 2-4	65- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	Bulk (10cm pipette)	B1	46- no LN	✓	✓ - not FF	Natural microlayer + 4 µlayer filters and 3 bulk sterivex for Bacteria
06/07/07	187	14:00	77	Bulk (10cm pipette)	S4 1245	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	Bulk (10cm pipette)	GP 10A	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	Bulk (10cm pipette)	B5 1345	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	Bulk (10cm pipette)	B2 1045	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	µlayer (Garrett screen)	S3 1145	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	µlayer (Garrett screen)	S1	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	µlayer (Garrett screen)	GS 103	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	µlayer (Garrett screen)	GS 104	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	µlayer (Garrett screen)	B4 1245	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	µlayer (Skimmer)	Skim 3-2	46- no LN	✓	✓ - not FF	Natural microlayer + 4 (1 from each depth) sterivex filters (~500 ml each)
06/07/07	187	14:00	77	10 cm (Skimmer)	Skim 3-1	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	1 m (Skimmer)	Skim 3-3	46- no LN	✓	✓ - not FF	
06/07/07	187	14:00	77	2 m (Skimmer)	Skim 3-4	46- no LN	✓	✓ - not FF	
08/07/07	189	16:00	88	µlayer (Garrett screen)	GP 11A	0	✓	✓ - not FF	Possible natural µlayer + 4 µlayer filters and 2 bulk sterivex for Bacteria
08/07/07	189	16:00	88	µlayer (Garrett screen)	GP K4A	0	✓	✓ - not FF	
08/07/07	189	16:00	88	µlayer (Glass plate)	S2 1045	0	✓	✓ - not FF	
08/07/07	189	16:00	88	Bulk (10cm pipette)	GP 5B	0	✓	✓ - not FF	
Date	Julian Day	Time GMT	St No.	Sample type	Sample ID	Hours in fridge	Stored -20°C	Stored -80°C	Comment
08/07/07	189	16:00	88	Bulk (10cm pipette)	GP 2B	0	✓	✓ - not FF	“
08/07/07	189	16:00	88	Bulk (10cm pipette)	GP 4B	0	✓	✓ - not FF	
08/07/07	189	16:30	89	Surface profiler -20cm	Pro 2-1	0	✓	✓ - not FF	Natural profile
08/07/07	189	16:30	89	Surface profiler -40cm	Pro 2-2	0	✓	✓ - not FF	
08/07/07	189	16:30	89	Surface profiler -60cm	Pro 2-3	0	✓	✓ - not FF	
08/07/07	189	16:30	89	Surface profiler -80cm	Pro 2-4	0	✓	✓ - not FF	
08/07/07	189	16:30	89	Surface profiler -100cm	Pro 2-5	0	✓	✓ - not FF	

08/07/07	189	16:30	89	Surface profiler -200cm	Pro 2-8	0	✓	✓ - not FF	
08/07/07	189	18:30	90	µlayer (Skimmer)	Skim 4-2	42	✓	✓	Centre patch 2 Surfactant patches noted in vicinity-Oleyl slick
08/07/07	189	18:30	90	10 cm (Skimmer)	Skim 4-1	42	✓	✓	
08/07/07	189	18:30	90	1 m (Skimmer)	Skim 4-3	42	✓	✓	
08/07/07	189	18:30	90	2 m (Skimmer)	Skim 4-4	42	✓	✓	
09/07/07	190	19:00	95	1 l Garrett screen	1 l Bottle 1	In Fridge for storage Exp.			Natural microlayer
09/07/07	190	16:45	94	10 cm (Skimmer)	Skim 5-2	0	✓	✓	Natural microlayer. 500 ml of µlayer sample into 1 L bottle 4 to be added to for storage Exp.
09/07/07	190	16:45	94	µlayer (Skimmer)	Skim 5-1	0	✓	✓	
09/07/07	190	16:45	94	1 m (Skimmer)	Skim 5-3	0	✓	✓	
09/07/07	190	16:45	94	2 m (Skimmer)	Skim 5-4	0	✓	✓	
09/07/07	190	16:45	94	µlayer (Skimmer)	1 l Bottle 4	In Fridge for storage Exp.			
10/07/07	191	14:00	101	10 cm (Skimmer)	Skim 6-1	0	✓	✓	Natural microlayer in SF6 patch 3
10/07/07	191	14:00	101	µlayer (Skimmer)	Skim 6-2	0	✓	✓	
10/07/07	191	14:00	101	1 m (Skimmer)	Skim 6-3	0	✓	✓	
10/07/07	191	14:00	101	2 m (Skimmer)	Skim 6-4	0	✓	✓	
10/07/07	191	16:00	102	µlayer (Garrett screen)	GP 7B	0	✓	✓	Natural µlayer in SF6 patch 3 + 4 µlayer filters and 2 bulk sterivex for Bacteria
10/07/07	191	16:00	102	µlayer (Garrett screen)	GP 15A	0	✓	✓	
10/07/07	191	16:00	102	Bulk (10cm pipette)	GP 5A	0	✓	✓	
10/07/07	191	16:00	102	Bulk (10cm pipette)	S 1B	0	✓	✓	
10/07/07	191	19:00	103	Surface profiler -20cm	Pro 5-1	0	✓	✓	Natural microlayer in SF6 patch 3
10/07/07	191	19:00	103	Surface profiler -40cm	Pro 5-2	0	✓	✓	
10/07/07	191	19:00	103	Surface profiler -60cm	Pro 5-3	0	✓	✓	
10/07/07	191	19:00	103	Surface profiler -80cm	Pro 5-4	0	✓	✓	
10/07/07	191	19:00	103	Surface profiler -200cm	Pro 5-8	0	✓	✓	
11/07/07	192			10 cm (Skimmer)	Skim 7-2	0	✓	✓	Natural microlayer
11/07/07	192			µlayer (Skimmer)	Skim 7-1	0	✓	✓	
11/07/07	192			1 m (Skimmer)	Skim 7-3	0	✓	✓	
11/07/07	192			2 m (Skimmer)	Skim 7-4	0	✓	✓	

Air-Sea Interaction Spar (ASIS) Buoys during DOGEE-II

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Michael DeGrandpre and Cory Beatty*, University of Montana, USA
Craig McNeil*, University of Rhode Island, USA
(* indicates participation in DOGEE cruise D320)

The role of ASIS in DOGEE is to make high resolution Lagrangian measurements of the air-sea interface, including fluxes, turbulence, waves, and water mass properties. Two ASIS buoys were deployed during DOGEE: ASIS1 and ASIS2. The two were identical, equipped with very similar sensor suites (see below). The original plan was to deploy one ASIS in a patch with surfactant plus tracer, and the second in a tracer patch. These buoys being Lagrangian, the intent was that they would move with the respective water masses, continuously collecting data relating to meteorological, air-sea interface, water column, and surface mixing parameters.

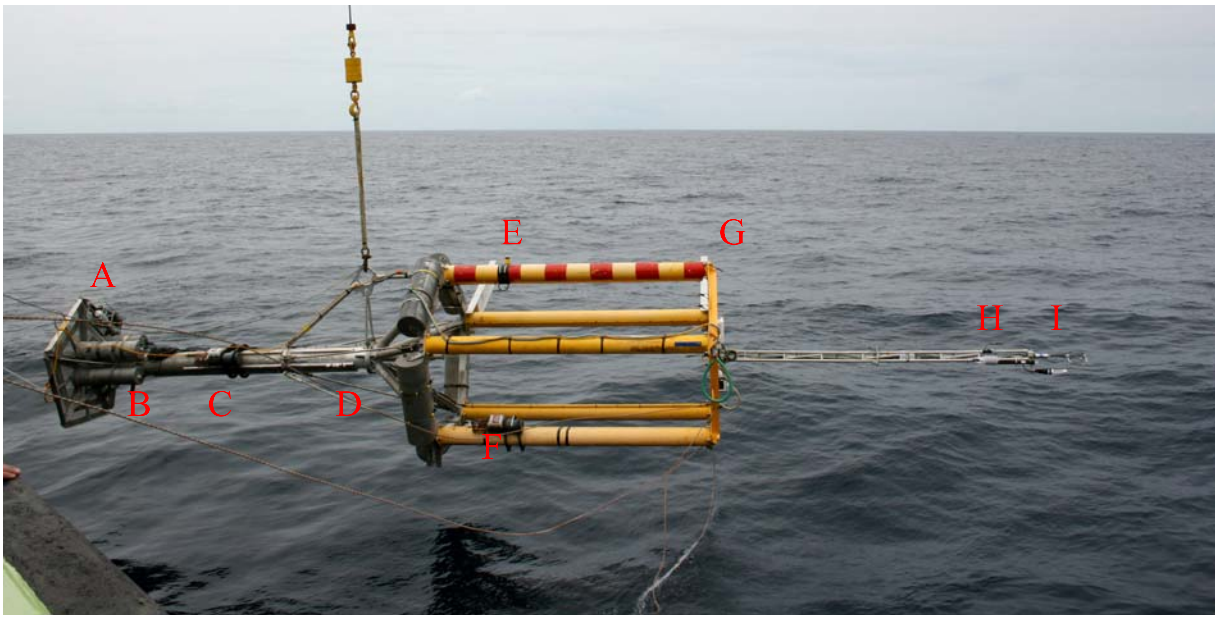

Figure 21. Photo of ASIS2 being deployed from RSS Discovery. Once deployed, ASIS becomes vertical, with the mean waterline at the middle red stripe. Each strip is ~30cm wide. Sensors visible on ASIS are: A: URI package; B: Data acquisition systems, including motion package, and batteries; C: SAMI package; D: SST; E: Dopbeam; F: SAMI; G: Wave-staff array (outrigger visible); H: Air temperature, humidity; I: Sonic anemometer, Licor.

Figure 22**.** ASIS#2 deployed during DOGEE-II.

Figure 21 shows one of the Air Sea Interaction Spar (ASIS) buoys being deployed during DOGEE. ASIS buoys were developed specifically for high resolution measurements close to the air-sea interface (Graber *et al*. 2000). The buoy is a multispar design, employing a pentagonal cage of slender cylinders (20cm diameter) with an overall diameter of 1.85m. The five spar elements are joined to a central spar element approximately 2m below the mean surface, and this central spar is terminated with a drag plate. The overall length of the buoy is 9m; the mast is an additional 4m. **Figure 22** shows a photo of ASIS#2 after deployment.

A similar suite of sensors was deployed on each ASIS during DOGEE. The list of sensors deployed, along with nominal height/depth, quantities measured, and responsible institution, is given in **Table 7**. Two additional thermistors were deployed in the water column on ASIS#2. Further details on sensors are available from the respective PIs.

Table 7: List of equipment deployed on ASIS#1

Sensors	Inst	Measurement	Nominal Height
Solent R2A sonic anemometer	UM	3D wind, virtual temp.	5m
LICOR LI-7500 CO_2/H_20 analyzer	UM	CO_2/H_2O fluctuations	5m
Rotronic MP101A-T7	UM	Humidity, air temp	4m
Huygrun Seamon thermistor	UM	Air temperature	3m
Wave staff array (8 gauges)	UM	Surface elevation, MSS	0 m
SonTek Dopbeam current meter	UM	mean current, turbulence	-1.5m
SAMI pCO_2 sensor	UMT	CO_2 in water column	-1.5, -5m
LICOR PAR sensor	UMT	Light intensity	-1.5m
Aanderaa O_2 sensor	UMT	DO in water column	-1.5, -5m
Huygrun Seamon	UM	Water temperature	-3.5m
Fluorometer	UMT	Chlorophyll-a	-5m
Columbia Res Lab accelerometer	UM	Linear acceleration	-6.5m
Systron Donner Rate Gyros	UM	Angular motion (rates)	-6.5m
Precision Navigation compass	UM	Compass angle (yaw)	-6.5m
URI Gas tension device	URI	Total dissolved gas	-7m
SBE19plus	URI	DO + CTD + Chl-a	-7m

A summary list of proposed measurements from each ASIS is:

- eddy correlation fluxes of momentum, sensible heat, latent heat and CO_2
- pCO_2, light intensity (PAR), DO and *chl-a* fluorescence in the water (1-3 depths)
- total dissolved gas, N_2
- mean values of wind speed and direction, air temperature, humidity and pCO_2 in the air
- directional wave spectra and surface slopes (MSS),
- near surface (oceanic) profiles of sea surface temperature (4 depths, 0.5 – 5m), and salinity
- TKE dissipation rates

The time line for ASIS operations during the experiment was as follows:

16 June, 18h:	Departure from Falmouth
17 June, 13h:	Dunk test of ASIS1
22 June, 09h:	ASIS#1 deployed at 43° 41.5'N, 18° 8.5' W, 5nm NE of tracer patch 1.
27 June, 15h:	ASIS#2 deployed at 43° 22.4' N, 17° 51.4'W, 20nm N of ASIS1. ASIS2 due west of patch 2 marker buoy, at NE corner of surfactant patch.
4 July 04h:	Visual sighting of ASIS1 at 42° 34.3'N, 16° 36.3 W, following 4 days of ARGOS silence
5 July, 8-13h:	Surfactant release around ASIS1, 42° 37'N, 16° 27'W
8 July, 02h:	URI float 43 deployed N of ASIS1 $SF_6/^3He$ release (patch 3) in vicinity of ASIS1

11 July, 06h: Recovery of ASIS2, 42° 45.6'N, 15° 55.8 W; followed by CTD at site
11 July, 18h: Recovery of ASIS1, 42° 29.6'N, 15° 55.3 W; followed by CTD at site

The ASIS buoys drift in response to a combination of wind and current forcings, depending on the relative strength of each. During DOGEE, wind was the dominant factor in determining ASIS position. Following deployment, ASIS1 drifted initially to the E, then S in response to weak and variable winds. Following the deployment of ASIS2 five days later, both buoys drifted toward the SE then E ,in parallel courses, maintaining their roughly 20nm N-S spacing (**Figure 23**). Their speed averaged around 0.8kts. ASIS drift speed was roughly equal with that of the NOC spar, and faster than that of the PML marker buoys (by a factor of two on 26/06).

The different advection speeds of ASIS and the O(4km) length scale of a typical patch meant that ASIS did not stay within a patch for more than about 6hrs. This should not be a significant factor when considering the dual tracer patches, as the tracers are entirely passive, and do not affect gas transfer rates or any other aspect of the patch. Hence assuming homogeneity over the region on scales of 100km (which will be tested using ship, ASIS and other data), comparisons between ASIS and the dual tracer patch regions should be valid. Clearly this is not the case with the surfactant patches. Here we will use the decrease of energy in the high frequency waves (measured by the array on ASIS) as a marker of when ASIS was in a surfactant patch.

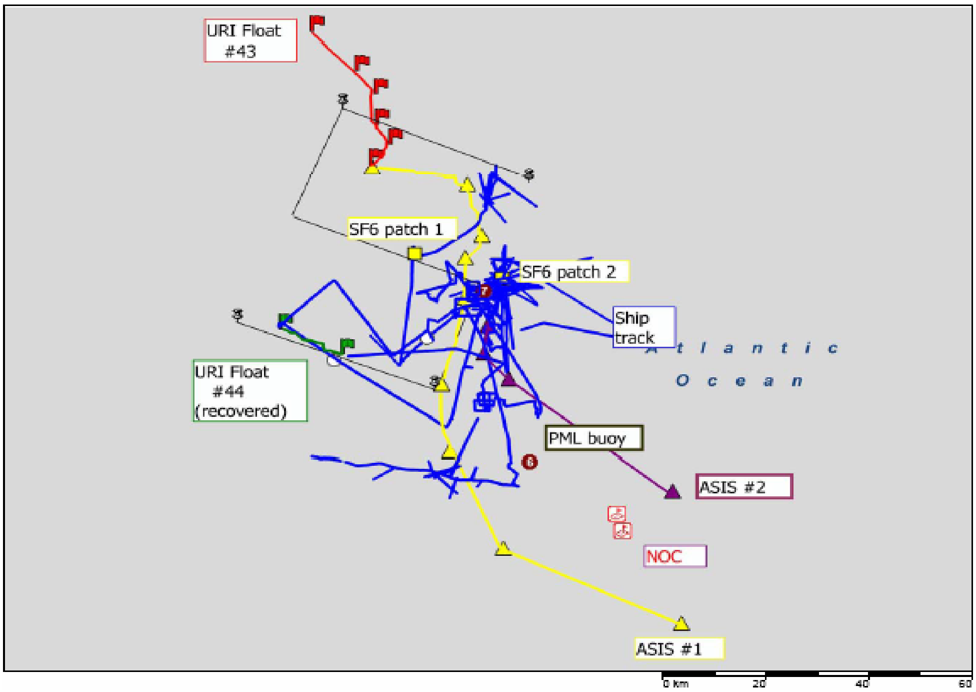

Figure 23: Tracks of various DOGEE platforms and floats to 30 June

At this point in time, very little of the data have been looked at. In **Figure 24** we show air and water temperatures from the two buoys during the experiment. In general the air temperatures track each other well, as expected given the ca. 30km separation distance. The difference in SST is coincident with different salinity values (not shown here) indicating the presence of different water masses. The reason for the large increase in T_air on ASIS#2 during day 185 is not clear. It may be an effect of radiative heating, as this thermistor was not shielded – this will be checked against the shielded data when they become available.

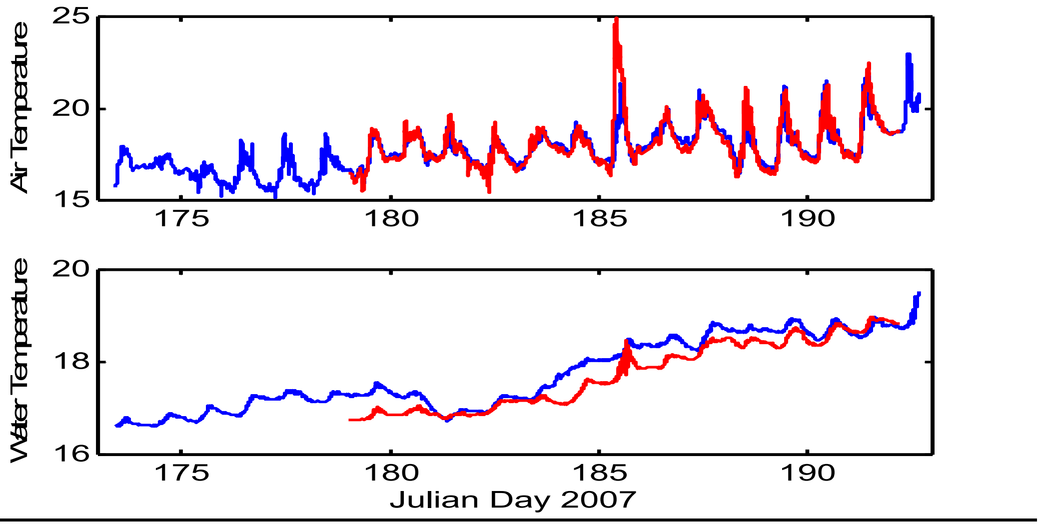

Figure 24: Air temperature, top (non shielded thermistor), and water temperature, bottom. Blue and Red curves are ASIS#1 and ASIS#2 respectively.

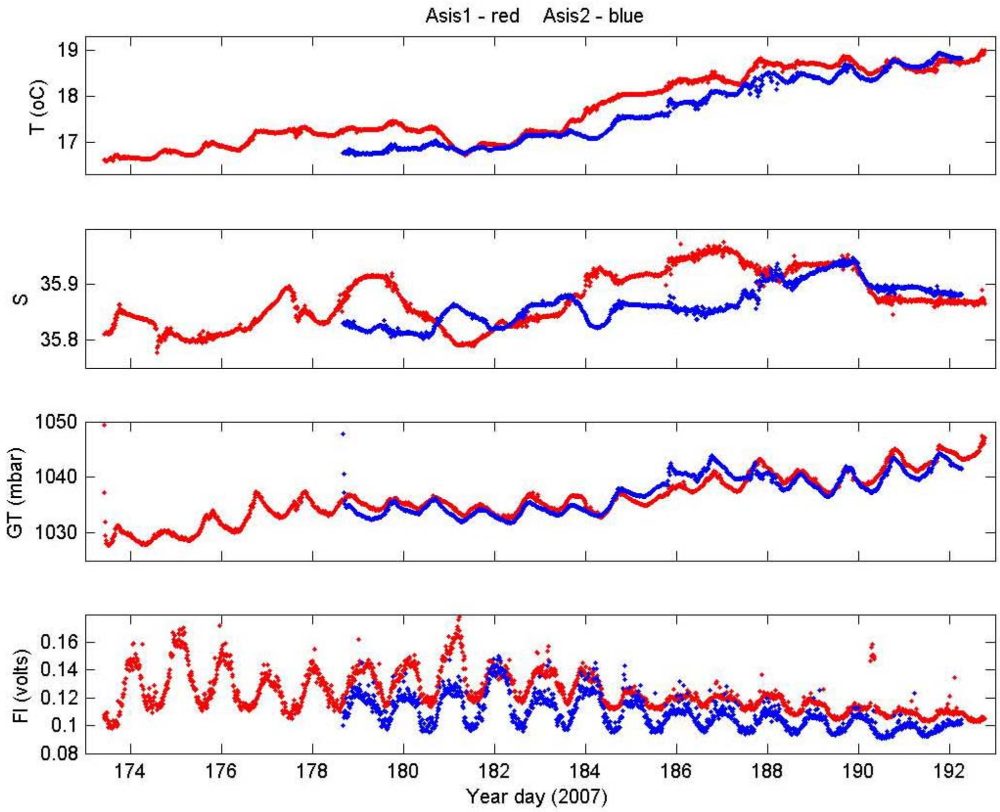

Figure 25: URI time series records of seawater temperature, salinity, gas tension, and fluorometer voltage at 7 m depth on both ASIS buoys

Figure 25 shows the URI time series records of seawater temperature, salinity, gas tension, and fluorometer voltage at 7 m depth on both ASIS buoys. Only unprocessed data is shown. During the period of observations, the mixed layer was observed to warm by approximately 2

^{o}C. Corresponding with this warming is a decrease in gas solubility and a resultant increase in the observed gas tension. Spatial variability is evident since both time series records are not the same.   Data analysis will continue through the fall term.

Air–Sea Interaction Profiler (ASIP) during DOGEE-II

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The ASIP component of DOGEE-II was funded by the National Science Foundation in collaboration with William Drennan. The primary objective for ASIP during DOGEE-II was to quantify the near surface oceanic turbulence, and investigate its impact on air-sea gas exchange. The hypothesis was that in the presence of surfactant, small-scale waves are effectively damped, thereby reducing the upper ocean turbulence and inhibiting gas exchange. ASIP was deployed on two occasions from the Rigid Inflatable Boat (RIB). On the first occasion (June 25 2007 15:00 UTC), there were problems with the thruster which was attributed to a grounding issue in the electrical system. No profiles were acquired during this test deployment. No satellite transmissions were received from ASIP due to an error in the script which resided on a server at WHOI. The grounding issue and satcom problem were subsequently resolved on *Discovery*. ASIP was deployed again from the RIB (June 27 16:00 UTC). Several profiles were acquired during this deployment, and satellite transmissions of its position were received back to the ship. **Figures 26-29** show plots of temperature from these profiles.

On July 01 at 17:00 UTC, ASIP was deployed from the stern *Discovery*. The preferred method for mission release was to carefully hand-drop the instrument over the stern with the vessel making slight headway with the propeller stopped. No release lines were to be attached for fear of damaging sensors. This was the last that was seen or heard from ASIP (see **Appendix 3: Loss of Equipment Report- ASIP**). No further data exist other than those acquired during the second deployment.

Acknowledgments: We are grateful to the PSO, captain and crew of the RRS Discovery for providing us with technical and moral support. We look forward to having the opportunity to repeat this experiment sometime in the near future with the ASIP version II, which is currently being built.

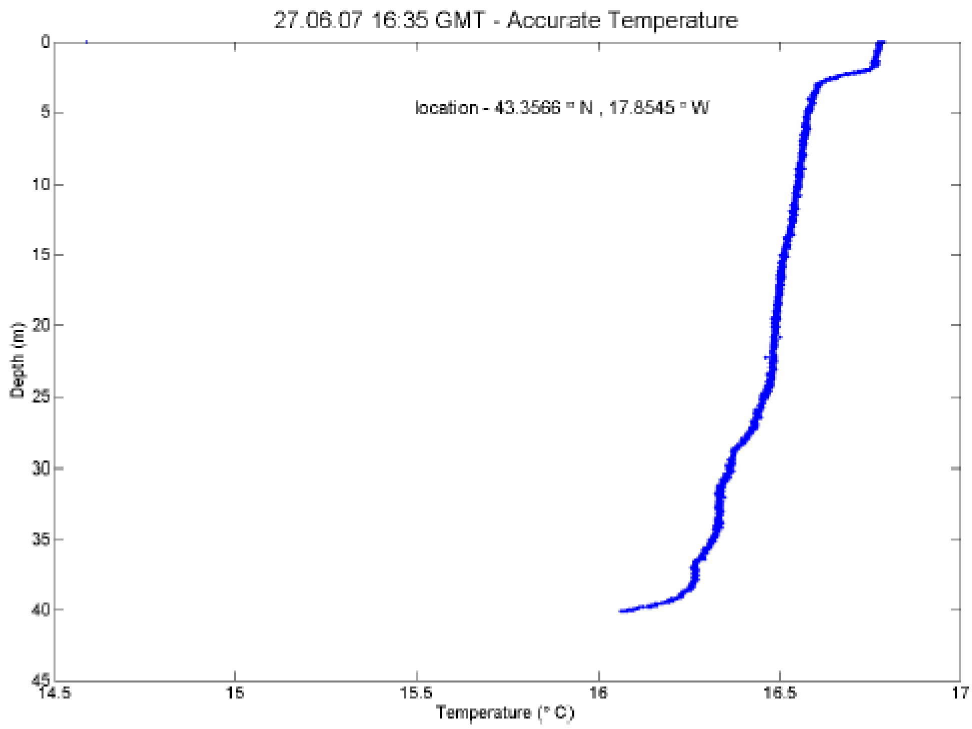

Figure 26. ASIP temperature profile.

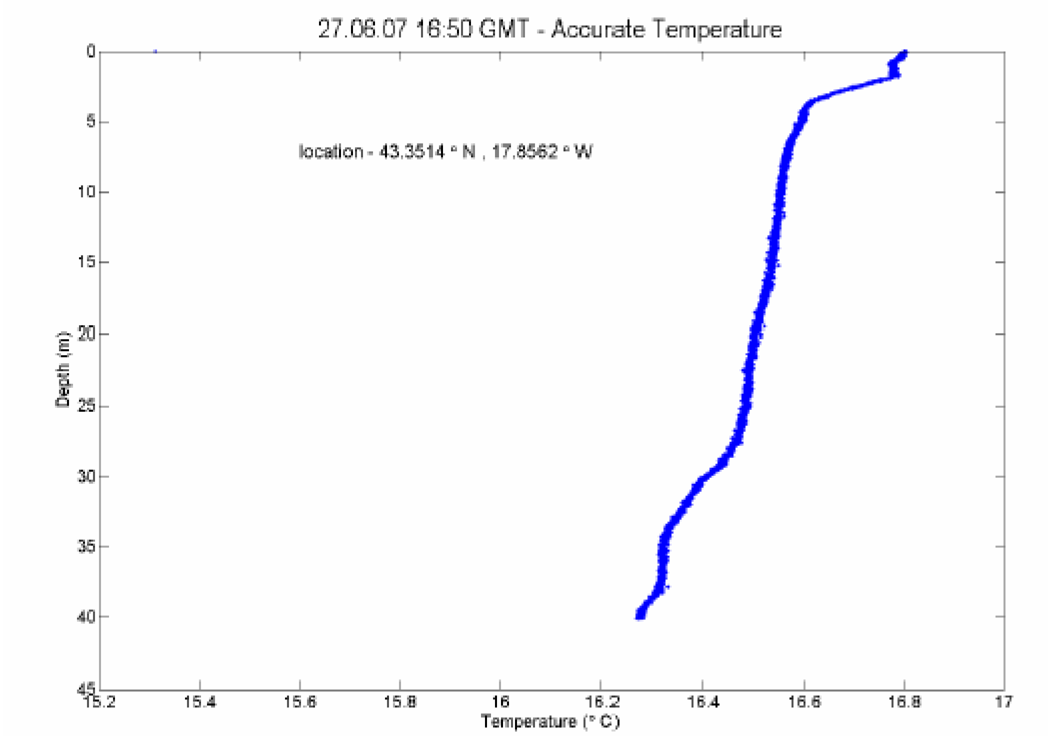

Figure 27. ASIP temperature profile.

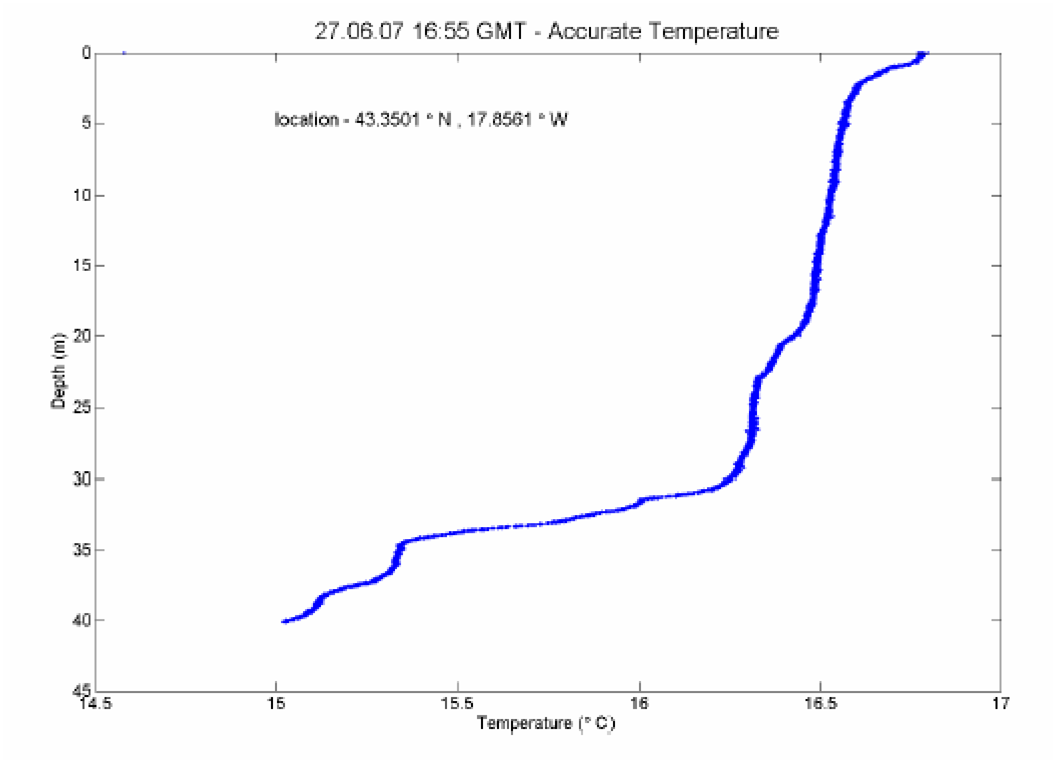

Figure 28. ASIP temperature profile.

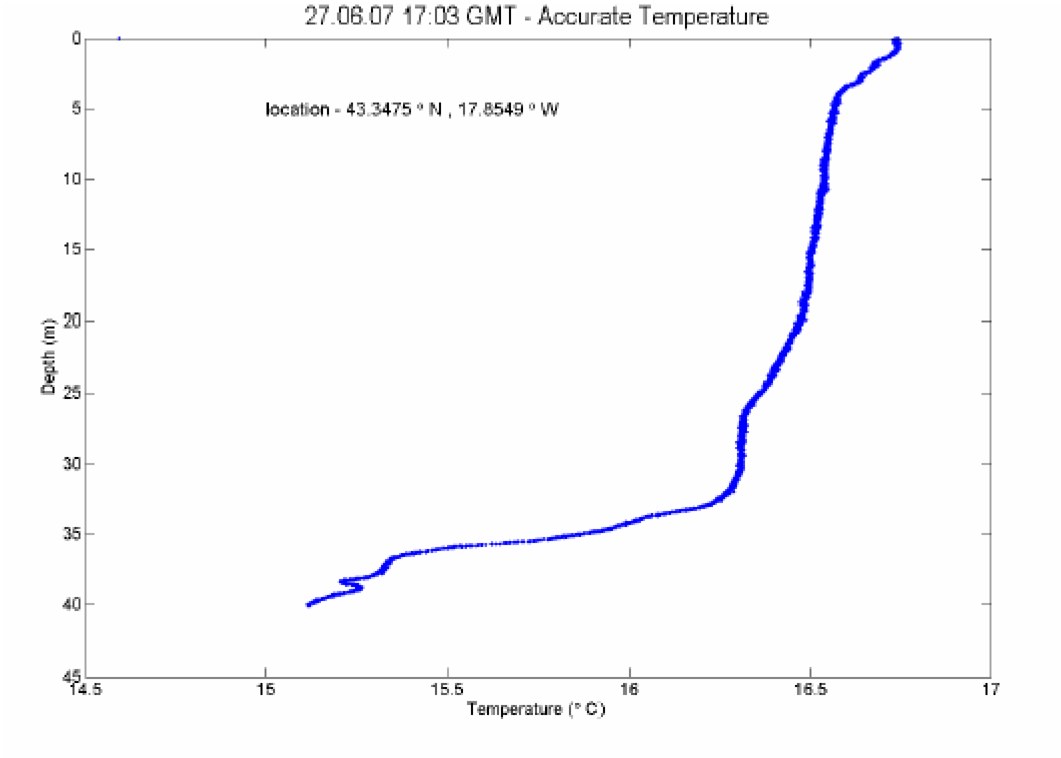

Figure 29. ASIP temperature profile.

University of Rhode Island /University of Washington contributions to the 2007 UK- SOLAS DOGEE-II Experiment

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As part of a larger project to study air-sea gas exchange at extreme wind speeds, McNeil and D'Asaro were funded by the National Science Foundation (NSF) to participate in the UK DOGEE SOLAS experiments. Our goal is to compare covariance and budget derived O_2/N_2 fluxes and exchange rates with those derived from $^3He/SF_6$, CO_2, DMS measurements - made under surfactant and non surfactant conditions - with the goal of improving parameterizations of air/sea gas flux.

Sampling methods

Underway sampling: Continuous shipboard underway sampling for dissolved O_2 and N_2 (via the gas tension method) was performed using the procedures described in ref [2]. Seawater pumped from the bow intake was piped to the wetlab (CTD annex) and used to flush a sampling container. The container was thermally insulated and approximately 25 L in volume and had a fill time of several minutes. Inside the sampling container were placed the dissolved gas sensors: a Pro-Oceanus Systems Inc. gas tension device (GTD) equipped with a flow-through plenum was used to measure seawater gas tension and an Aanderaa Inc. optode was used to measure dissolved O_2 concentration and seawater temperature. A small submergible SBE-5T seawater pump was used to flush the GTD plenum and equilibrate the sensor and mix the sampling container.

The seawater that supplied the sampling container was run from the non-toxic seawater supply opposite the machine shop in the aft-deck hanger. This supply was used as it was independent of the supply used for the thermosalinograph (TSG) and avoided complications associated with reduced flow to the TSG. The seawater supply was split and most of the seawater was disposed of overboard to provide a clean seawater supply for the sampling container. Another branch was used for the underway SAMI sensor. The ship's TSG provided continuous measurements of seawater salinity and temperature (as did the optode in the sampling container). The temperature of the seawater in the sampling container was slightly warmer than the seawater intake temperature due to the pump heat dissipation inside the sampling container and warming of the water in the ship's pipes. Dissolved N_2 was estimated from T, S, GT, and O_2, accounting for the slight changes in warming inside the sampling container.

Seawater samples were frequently siphoned from the sampling container and analyzed by the Winkler titration method for dissolved O_2. The Winkler system used was designed by Chris Langdon at LDEO and uses a amperometric end-point detection system. Standards were calibrated according to the recommendations of Emerson et al. [3].

A Pro-Oceanus Systems, Inc (Halifax, NS, Canada) pCO_2 sensor was also plumbed into the seawater line described above. These instruments provided a continuous record of $O_2/N_2/CO_2$ at 5m depth during the cruise.

Rosette samples: Seawater samples for Winkler analysis were routinely taken at 15m depth at hydrocast stations to keep track of the calibration of the SBE43 on the ship's rosette CTD. These data will be compared to the samples taken from the underway system and used to calibrate the rosette CTD's SBE43 O_2 sensor. The profiles will also be used to provide checks on the float dissolved O_2 sensors described below.

Float sampling: Two neutrally buoyant floats equipped with SBE O_2 sensors and GTD's were deployed on the experiment. The floats are the same sort used in the hurricane deployments [refs. 7, 8]. Both were deployed, but one float (#44) had a malfunction after its first dive and was recovered but not redeployed. The float that did work (#43) performed very well.

The hurricane floats were adapted for use during DOGEE-II by implementing a duty-cycle pumped GTD. The pulse-pumping reduced the power consumption and allowed the float to last up to one month on batteries rather than the previous four days typically used in hurricane deployments. The float was programmed to have two modes of operation. In 'profile' mode, the float leveled off at the target isopycnal then waited some period of time until the GTD fully equilibrated. The float took a gas tension reading then moved to the next target isopycnal using the float's adjustable buoyancy control piston. This sampling scheme allowed the float to measure profile information on dissolved O_2 and N_2. In 'covariance' mode, the float was ballasted in the mixed layer to be neutrally buoyant. The float then opened up its drogue and followed the mixed layer eddy motions. From the data collected during this free drift period, covariance estimates of the air-sea O_2 flux and heat flux were made (see D'Asaro & McNeil, 2007 for details on these techniques). Thus, a full sampling cycle of the float included a period in each mode (ie., 'float cycle' ~ 'profile mode' + 'covariance mode'). Continuous cycling of the float every 1->2 days provided dissolved gas depth profiles for use in budget calculations and periods of covariance O_2 flux for comparison.

ASIS timeseries: Mounted at the base of each ASIS buoy, at approximately 7 m depth, was a SBE19plus CTD equipped with an SBE43 O_2 sensor, a Wetlabs fluorometer, and a GTD. The times series records will primarily be used for water mass identification and 1-D model intercomparisons.

Experimental results- overview

Rosette samples: The time and depth of Winkler samples is shown in **Figure 30**. The data processing is not yet complete at the time of writing this report and so the values are not reported here, but they will be made available as soon as possible.

Float data: A summary of float locations relative to other drifting packages is shown in **Figure 31**. After initial deployment, float #43 drifted away from the ASIS buoys and continued to drift northwards, in pretty much the opposite direction to the other gear! We suspect the deeper currents below the mixed layer were in the opposite direction (Ekman spiral) and the time spent in these deeper waters during the profile mode caused the float to drift northward while most of the other deployed gear drifted southwards. This necessitated repositioning of the float during days 189->190. One problem for analysis is that during the storm period the floats were separated from the ASIS buoys by some 80 km, and nearly 150 km just prior to their repositioning. This makes direct comparison of the float derived data more difficult and will require interpolation of meteorological data at the float positions for detailed analysis.

Float #43 data collection is shown in **Figure 32**. The float provided 16 complete cycles ('profile' + 'covariance' mode) during the experiment. The measured O_2 and N_2 concentration profiles are shown in **Figure 33.** The profiles are easily interpreted in terms of a depth dependent profile of net community production (see figure caption).

Float covariance data: Analysis of the covariance data collected during the DOGEE-II storm period revealed the following preliminary results:

- The mixed layer vertical turbulent kinetic energy to be 1.5 → 2 times higher than would normally be expected at those wind speeds (max 15 m s^{-1}). This is probably due to unusual wave conditions (perhaps very old seas since we are on the edge of a storm). We look forward to working with other PI's to understand this result.

- The covariance heat flux was dominated by entrainment from below, with an observed cooling of 150 ± 45 W m^{-2}.

- The covariance O_2 flux had approximately equal contributions from air-sea exchange and entrainment from below, with the observed air-sea flux of 800 ± 250 nmolO_2 m^{-2} s^{-1}, into the ocean.

Underway sampling: The pCO_2 data recorded during the experiment are shown in **Figure 34** and show a very nice 4.23% per ^oC temperature dependence, as one would expect when the waters are dominated by seasonal warming (Takahashi et al., 1993). Not shown are the underway dissolved N_2 and O_2 records, since they await final analysis of the Winkler data for calibration of the dissolved gas levels. Cursory analysis has shown the data to be of good quality.

ASIS time series: **Figure 35** shows the time series records on both ASIS buoys at approximately 7 m depth. The time series records, including gas tension, are remarkably clean. Unfortunately, however, the dissolved O_2 measurements were corrupted (the result of a miscalculation in the pump cycle setting), but we hope to be able to fully recover this missing information using DeGrandpre's SAMI instrument that independently measured dissolved O_2 (note that the dissolved O_2 time series is required to calculate dissolved N_2). Collaboration on this analysis should provide a complete time series record of $O_2/N_2/CO_2$ on both ASIS buoys.

Sensor calibrations

The above raw data require application of calibration information, especially the dissolved O_2 data, using the Winkler samples. **Figure 36** shows results of the first attempt at an inter-comparison of O_2 profiles measured by the rosette CTD's SBE43 profiling probe, the float's O_2 sensor, and rosette CTD Winkler analyzed seawater samples.

Other calibration information for the CTD's was collected during the cruise and will be incorporated into the processing of the raw data.

Discussion- next steps

The next step after quality control of the float data will be to perform budgets of temperature, salinity and dissolved O_2 and N_2. The gas budgets will be used to estimate air-sea gas fluxes which, after appropriate model scaling, will provide estimates of the gas transfer rates for comparison with estimates derived using the duel-tracer technique. As mentioned, meteorological data will need to be interpolated to the float locations to perform these analyses. The ~7m depth time series data from ASIS will provide a reliable check on the expected gas fluxes since the temporal changes are related to the integral of the fluxes, notwithstanding horizontal advection effects which will be assessed using the heat and salt budgets.

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Acknowledgements

We are grateful to the captain and crew of the RRS *Discovery* for their role in making DOGEE-II the success that it was. We are also grateful to the Chief Scientist for making it all happen. We thank Malcolm Woodward for helping with logistics, Rachael Beale for assistance with ordering chemicals, and Chris Barnard for giving many hours of additional help at sea to install antennas and other equipment.
This research was funded by grants NSF-OCE-0550000 and NSF-OCE-0549887.

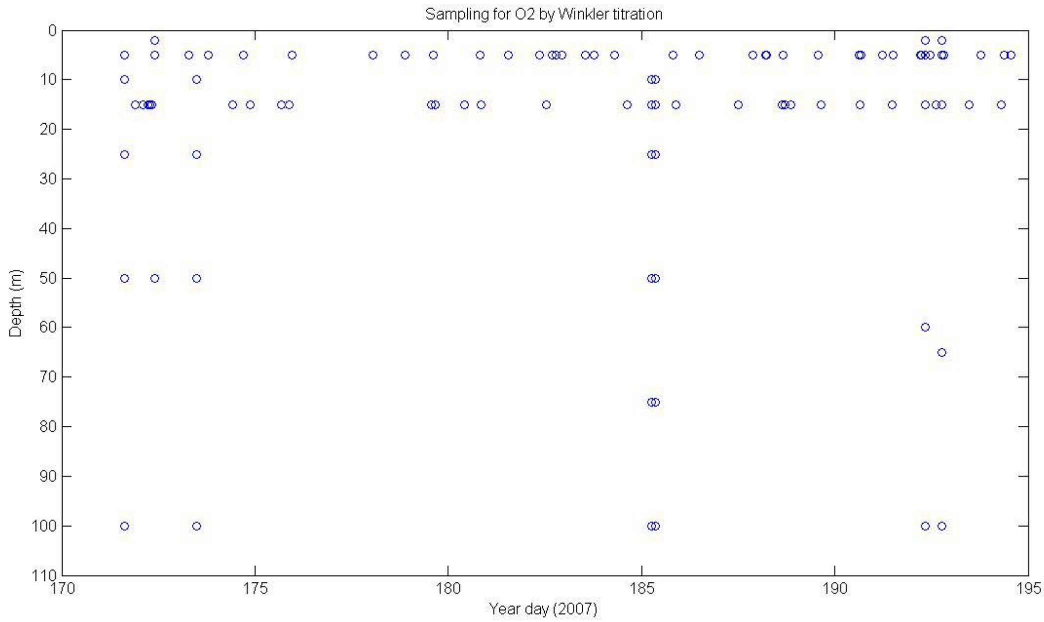
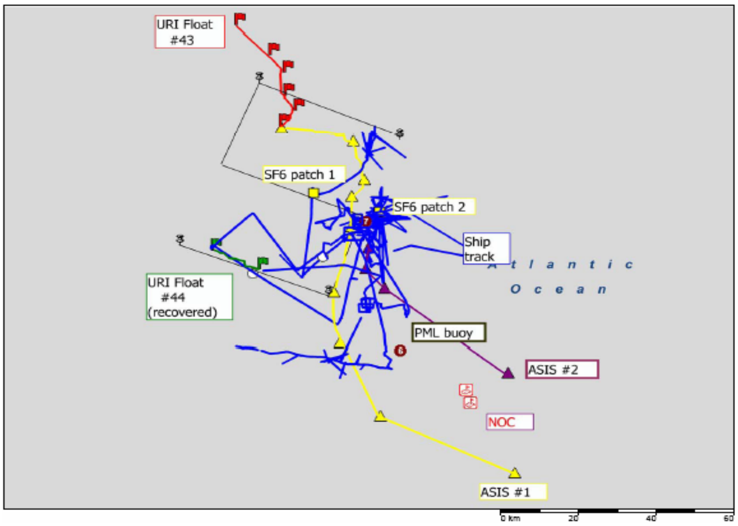


Figure 30: This plot shows the time and depth that seawater samples were analyzed for dissolved O2 by the Winkler titration method. Several deep casts were taken, and a standard 15m rosette CTD Niskin bottle was used for keeping track of the drift in the rosette CTD's SBE43 profiling O2 sensor. Many other samples were also drawn, by siphon, from the underway sampling system which was supplied from the ship's 5m seawater intake line.



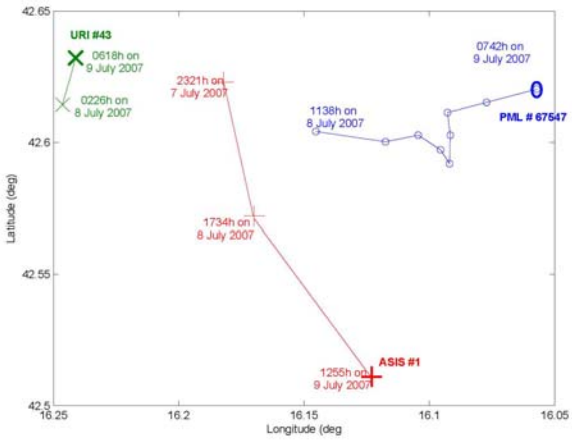


Figure 31: Maps of float positions. Top panel show the first deployment and lower panel the postions after the float was relocated near the end of the experiment. Notice that in the first deployment float #43 drifted northward while ASIS and other gear drifted southward.

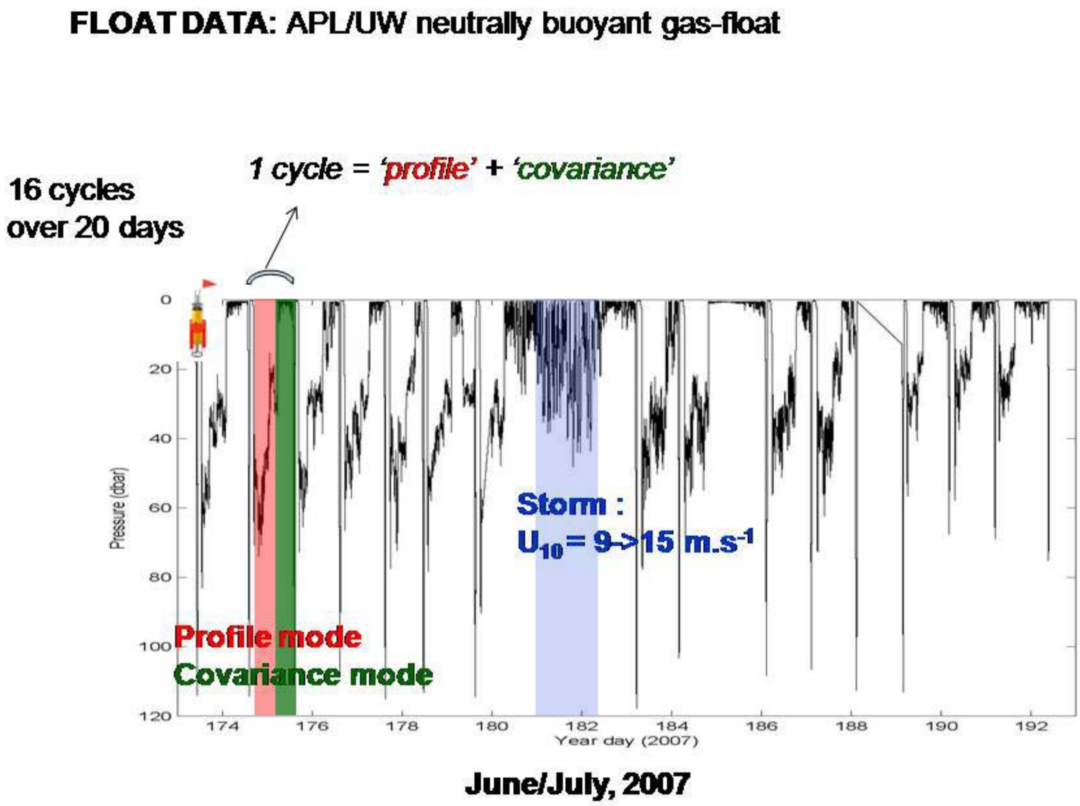


Figure 32: This plot shows the trajectory of float #43 over time and hyrostatic pressure. Sixteen complete sampling cycles (as described in the main text) were collected during the cruise. The period of storm activity is highlighted in blue. Note that the float was repositioned beside the ASIS buoy during days 188 -> 189.

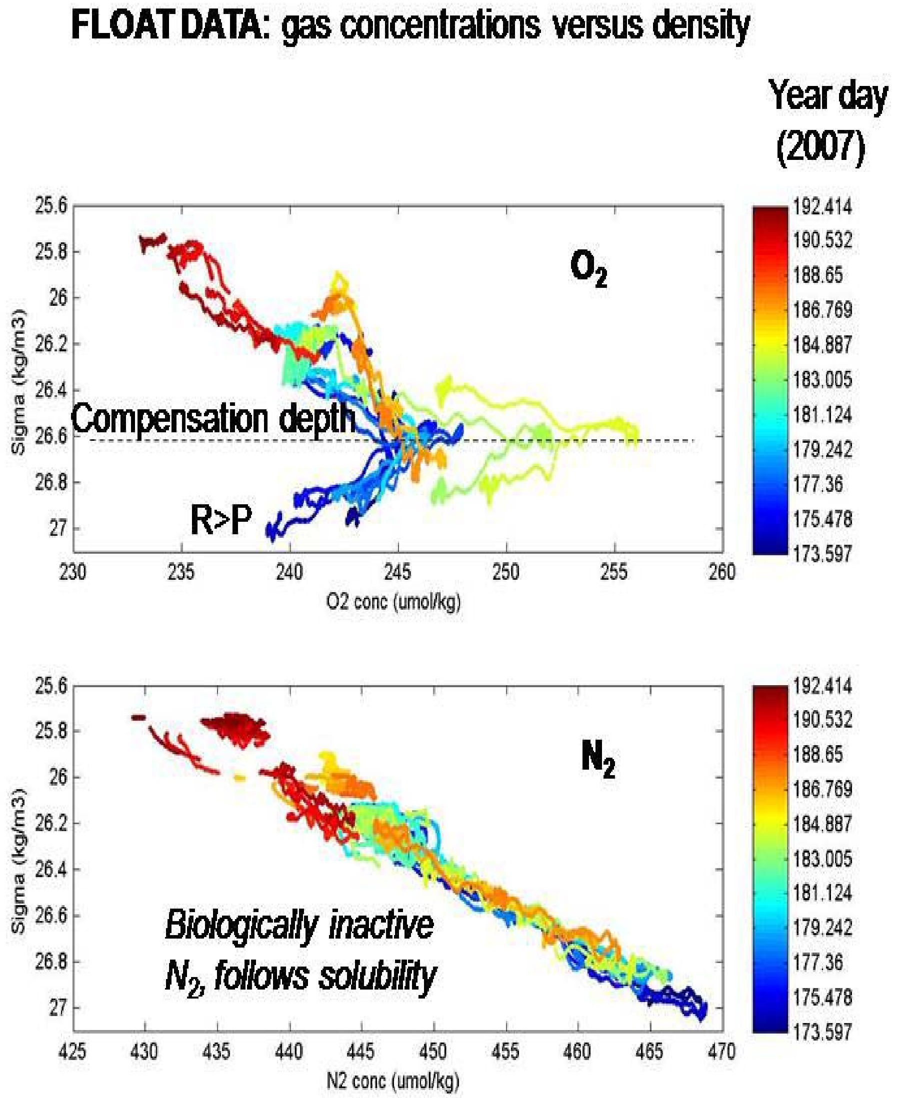


Figure 33: This plot shows float data from all 16 profiles collected during the cruise as O_2 versus density (top panel) and N_2 versus density (lower panel). The density surface on which O_2 production exceeds O_2 respiration (i.e., the 'compensation depth') is seen to be sigma = 26.6 kg/m^3. Since N_2 is essentially biologically inactive, its depth profile shows follows that of solubility (deeper colder waters are more soluble than shallow warmer waters and hence have higher concentrations).

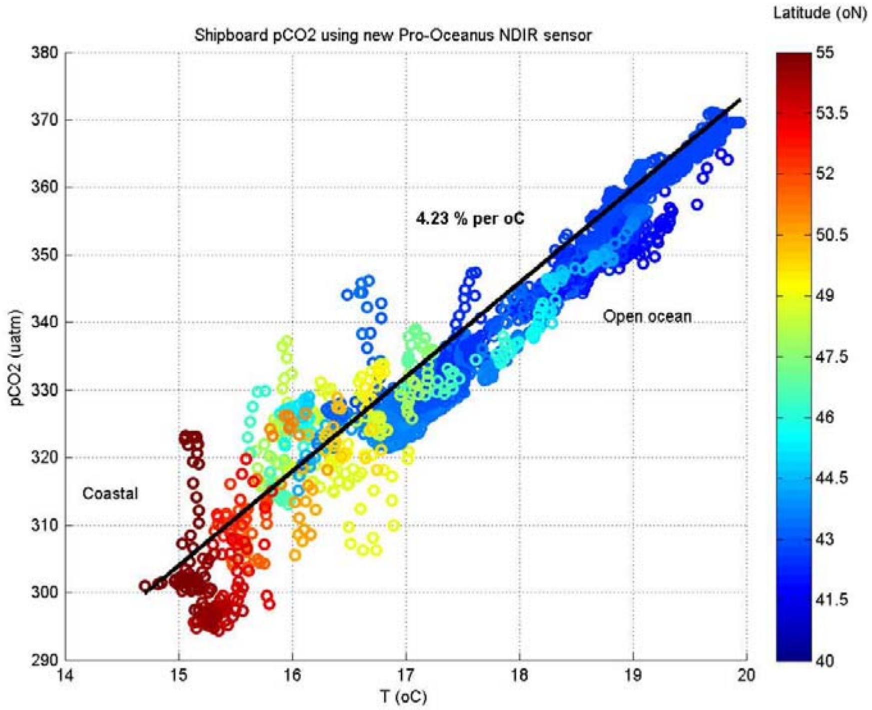


Figure 34: All underway pCO2 data recorded by the Pro-Oceanus pCO2 sensor, supplied by seawater from the ship's intake at 5m depth. The data show some variability in coastal waters and a clear thermodynamic relationship which corresponds closely with the typical high latitude value of 4.23% per ^{o}C [see Takahashi et al., 1993].

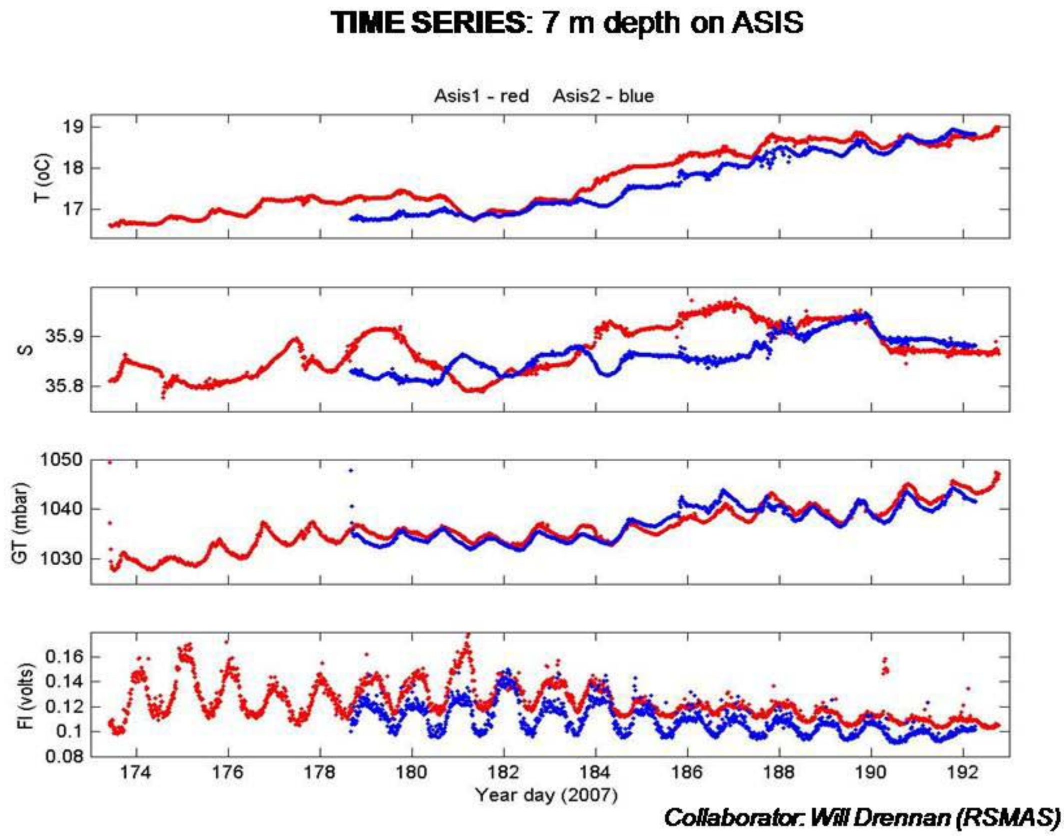


Figure 35: This plot shows the time series records collected using the gas equipped SBE 19plusCTD's that were attached to the base of each ASIS buoy.

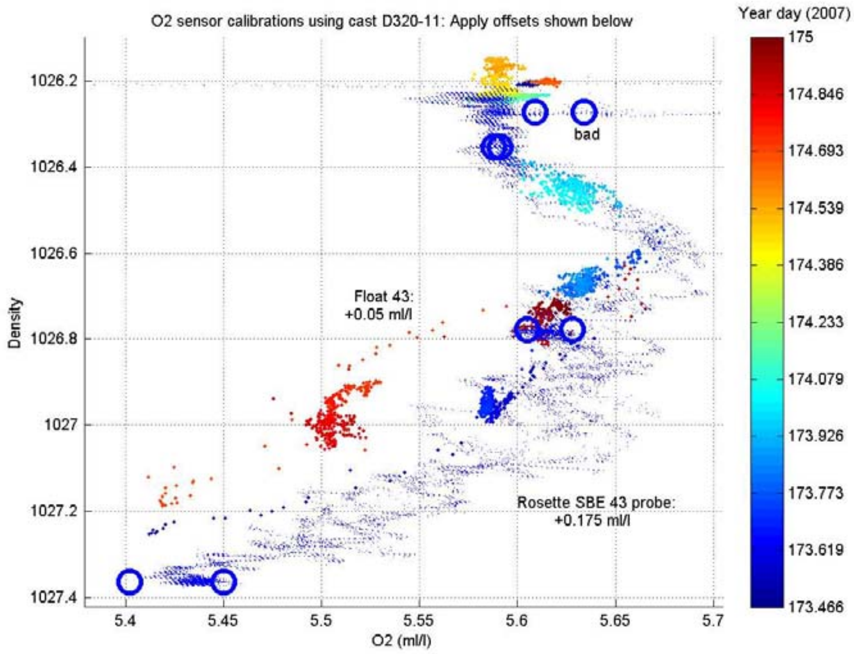


Figure 36: A first attempt at inter-calibrating the rosette CTD's O_2 sensor data (small blue dots) and Float 43's O_2 sensor data against the Winkler samples (large blue circles). Color of each data indicates time, so discrete calibrations in the same vicinity will have to consider how far apart in the time the data were collected. The analysis of the underway data should prove very useful for checking the calibration of the floats at times when the ship was in the vicinity of the floats. Pre- and post factory calibrations of the float's O_2 sensors were remarkably good, showing drift of less than 0.1 % saturation (which is e which is excellent!).

AutoFlux - the autonomous air-sea interaction system

Robin Pascal, National Oceanography Centre, Southampton.

1.1 Introduction

AutoFlux is an autonomous, stand-alone system which obtains direct, near real-time (2 hr) measurements of the air-sea turbulent fluxes of momentum and sensible and latent heat in addition to various mean meteorological parameters. The two main aims of the present deployment were 1) to continuously measure a suite of key meteorological variables (wind speed and direction, air temperature, and humidity, sea surface temperature, short wave radiation and air pressure) and 2) to measure directly the air-sea fluxes of CO_2, sensible heat, latent heat and momentum (by the eddy covariance (EC) and inertial dissipation (ID methods)). The AutoFlux system was installed on RRS Discovery in February 2004 and has been running autonomously, with occasional service visits, until the beginning of cruise D320. The ID method relies on good sensor response at frequencies up to 10 Hz. The ID method has the advantage that the flux results a) are insensitive to the motion of the ship and b) can be corrected for the effects of the presence of the ship distorting the airflow to the sensors. Momentum and latent heat flux measurements have been successfully made using this method for a number of years. Sensible heat and CO_2 flux measurements are made more difficult by the lack of sensors with the required high frequency response. For these fluxes the EC method provides an alternative. This method requires good sensor response up to only about 2 to 3 Hz, but is a) very sensitive to ship motion and b) the fluxes can not be directly corrected for the effect of air flow distortion. Once EC fluxes are obtained they can be corrected for flow distortion effects by comparison with the corrected ID fluxes where available. Since the scalar fluxes (sensible and latent heat and CO_2) are all affected by flow distortion in the same fashion, only one ID scalar flux is required in order to quantify the effects of flow distortion on EC scalar fluxes.

This report describes the AutoFlux instrumentation (Section 1.2). A brief discussion of the performance of the mean meteorological sensors is given in Section 1.3, where comparisons are made between the ship's instruments with those of AutoFlux where possible. Initial flux results are described in Section 1.4. Appendix A lists significant events such as periods when data logging was stopped, and Appendix B contains figures showing time series of the mean meteorological data. All times refer to GMT.

More information on air-sea fluxes and the AutoFlux project in particular can be found under;

http://www.noc.soton.ac.uk/ooc/CRUISES/AutoFlux/index.php

1.2 Instrumentation

The NOC Surface Processes team instrumented the *Discovery* with a variety of meteorological sensors. The mean meteorological sensors (**Table 8**) measured air temperature and humidity, and wind speed and direction. The surface fluxes of momentum, heat, moisture and CO_2 were obtained using the fast-response instruments in **Table 9**. The MR3 and R3 sonic anemometers provided mean wind speed and direction data in addition to the momentum and sensible heat flux estimates.

To obtain EC fluxes, ship motion data from the MotionPak system was synchronised with those from the other fast response sensors. Navigation data were logged in real time at 1 second intervals, using the ship's data stream. These data are used to convert the relative (measured) wind speed and direction to true wind speed and direction. The ship's mean meteorological data were also logged in real time at 2 second intervals. The details of the ship's meteorological instruments are given in **Table 10.**

All data were acquired continuously, using a 58 minute sampling period every hour (the remaining 2 minutes being used for initial data processing), and logged on “ruby”, a Sunfire V210 workstation. Processing of all data and calculation of the ID fluxes was performed automatically on “ruby” during the following hour. Program monitoring software monitored all acquisition and processing programs and automatically restarted those that crashed. A time sync program was used to keep the workstation time synchronised with the GPS time stamp contained in the navigation data. Both “ruby” and all the AutoFlux sensors were powered via a UPS.

All of the instruments were mounted on the ship’s foremast (**Figure 37**) in order to obtain the best exposure. The psychrometers and the fast response sensors were located on the foremast. The heights of the centre of the sensor volume of the instruments above the foremast platform were: R3 sonic anemometer, 2.75 m; MR3 sonic anemometer 2.7 m; psychrometers 1.77 m; both Licor H_2O / CO_2 sensors 1.85 m.

1.3 Mean meteorological parameters

1.3.1 Air temperature and humidity

Two wet- and dry-bulb psychrometers were installed on the foremast and performed well throughout the cruise. The difference between both wet and dry bulb temperatures was well within the sensor specification with a difference of only 0.013ºC (standard deviation of 0.19ºC) for the wet bulb, and 0.099ºC (standard deviation of 0.095ºC) for the dry bulb, with the port psychrometer being the slightly higher in both cases. On day 177 the starboard psychrometer wet bulb dried out, but this was re-primed on day 178 when both water bottles were refilled.

The humidities calculated by the psychrometers were compared to the measurements made using the AutoFlux and ship’s Vaisala sensors. The AutoFlux Vaisala humidity was the more accurate of the two and read low by 1.3% (standard deviation of 0.5%). The ship’s Vaisala read low by 2.7% (standard deviation of 1%). It was also noticeable that the ship Vaisala humidity offset increased with humidity so that at 95% it was typically reading 4% low where as at 65% it was only reading 1% low (See **Figure 38**).

The air temperature measured by the Autoflux Vaisala sensor agreed to within 0.016 ºC (standard deviation of 0.075ºC) of the psychrometer measurements whereas the ship sensor read 0.278ºC (standard deviation of 0.1ºC) high, indicating that the ship’s Vaisala air temperature sensor is performing outside its specification. It is recommended that it should be replaced.

1.3.2 Wind speed and direction.

There were three anemometers mounted on the foremast platform (**Figure 37**). On the port side were the ship’s propeller anemometer and the fast response MR3 sonic anemometer. An R3 sonic anemometer was located on the starboard side. Both sonic anemometers measured all three components of wind speed and both are calibrated on a regular basis. The starboard R3 anemometer was the best exposed and will be used as the reference instrument in the following comparison. The measured wind speeds (uncorrected for ship speed) from the MR3 sonic anemometer was compared to those from the starboard R3 in **Figure 39**, which shows the wind speed ratio (measured / R3 measured) against relative wind direction. A wind blowing directly on to the bows is at a relative wind direction of 180 degrees. For a bow-on wind, the MR3 sonic read high by about 2.5 %. Accurate flow distortion corrections have yet to be determined for the precise anemometer locations, but previous work (Yelland et al. 2002) has shown that the bias at the MR3 sonic anemometer sites should be between -1 and +2%. **Figure 39** also clearly shows that the effects of flow distortion are, as expected, very sensitive to the relative wind direction. The large dips in the speed ratios at 90 and 270 degrees are due to the R3 and MR3 anemometers being in the wake of the foremast extension for winds from the port and starboard beams respectively. **Figure 40** shows the difference in relative wind direction as measured by each anemometer compared to that from the R3. For bow-on winds the direction measured by both the ship and MR3 anemometers agree to within 2 degrees of the R3 anemometer. For the ship's anemometer this difference is significantly smaller than on previous cruises and is explained by the reorientation of the ship's anemometer prior to sailing.

1.3.3 TIR sensors.

The ship carried two total irradiance (TIR) sensors, one (Ptir) on the port side of the foremast platform and the other (Stir) on the starboard. These measure down welling radiation in the wavelength ranges given in **Table 10**. A comparison of the TIR short-wave sensors showed that both sensors were in good agreement. Excluding periods where one sensor was shadowed, the mean difference in the measured short-wave value was 3.3 W/m^2 (standard deviation 11 W/m^2) with the starboard sensor reading high. In addition to the TIR sensors the ship carried two PAR sensors measure down welling radiation in the wavelength ranges given in **Table 10**. Again both sensors agreed very well with a mean difference of 0.3 W/m^2 (standard deviation of 3.4 W/m^2), although both sensors showed a small night time offset of +2 W/m^2.

1.3.4 Sea surface temperature.

Sea surface temperature (SST) data from the thermosalinograph (TSG) was logged on the AutoFlux system as part of the "surfmet" data stream.

1.3.5 Ship borne wave recorder (SBWR).

The SBWR was switched on prior to the ship leaving Govan. Raw and processed data were logged internally and half hourly wave statistics were transferred automatically to the AutoFlux system via a serial link. The raw data were backed up periodically during the cruise. The largest wave measured during the cruise was over 8 m peaks to trough on day 182. Regular time checks were made of the system as it had been observed that the SBWR PC could become some minutes adrift. Before sailing the PC was checked to see that the ship's timeserver was updating the system correctly: updates are scheduled for every 7 days. Even with time server updates the PC would experience random time jumps of about 2 minutes **(Figure 41)**.

1.4 Initial flux results.

1.4.1 Inertial dissipation (ID) flux measurements.

The ID momentum flux data obtained from the starboard R3 sonic anemometer are shown in **Figure 42** where the drag (transfer) coefficient is shown against the true wind speed corrected to a height of 10 m and neutral atmospheric stability. Data has been selected for bow on winds ±30 deg only. The drag coefficient is defined as (10^3 * momentum flux / wind speed^2). The mean drag to wind speed relationship from previous cruises (Yelland et al., 1998) is also shown.

Figure 43 shows the ID latent heat flux for bow on winds ±30 deg only obtained from the Licors' H_2O data. It can be seen that both sensors are producing similar results that agree well with the flux estimated from a bulk formula (Smith, 1988).

1.4.2 Eddy correlation (EC) flux measurements.

The EC fluxes will be worked up post-cruise.

1.5 Summary

The following cruise objectives were met:

a) Meteorological measurements of the key variables were made (wind speed and direction, air temperature and humidity, short wave radiation, sea surface temperature and air pressure).

b) Direct measurements of the air-sea fluxes of sensible heat, latent heat and momentum fluxes were made using the inertial dissipation method. Direct covariance fluxes of these fluxes and the CO2 and sensible heat fluxes will be produced post cruise.

Acknowledgements

The AutoFlux system was developed under MAST project MAS3-CT97-0108 (AutoFlux Group, 1996) and developed with support from the NOCS Technology Innovation Fund. Participation in cruise D320 was supported by the UK-SOLAS project DOGEE (NERC grant number NE/C001834/1).

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Table 8. The mean meteorological sensors. From left to right the columns show; sensor type, channel number, Rhopoint address, serial number of instrument, calibration applied, position on ship and the parameter measured.

Sensor	Channel, variable name	Address	Serial No.	Calibration Y = C0 + C1*X + C2*X^2 + C3 *X^3	Sensor position	Parameter (accuracy)
Psychrometer 1	1 pdp1	$ARD	HS1031 DRY	C0 -1.013810E+00 C1 3.938293E-2 C2 4.512680-7 C3 7.723984E-10	Starboard side of foremast platform	Wet and dry bulb air temperatures and humidity (0.05°C)
Psychrometer 1	2 pwp1	$BRD	HS031 WET	C0 -1.363188E+00 C1 4.086030 E-2 C2 -2.335829E-6 C3 2.432825E-9		
Psychrometer 2	3 pds2	$CRD	HS1029 DRY	C0 -1.264959E+00 C1 3.9241630E-2 C2 9.7851460E-7 C3 3.994788E-10	starboard side of foremast platform	Wet and dry bulb air temperatures and humidity (0.05°C)
Psychrometer 2	4 pws2	$DRD	HS1029 WET	C0 -1.370587E+00 C1 4.0089460E-2 C2 9.4633060E-7 C3 7.926318E-10		
Vaisala	5	$ERD	B4440006 Hum	C0 0.0 C1 0.1	port side of foremast platform	0 – 100 %
Vaisala	6	$FRD	B4440006 Air	C0 -40.00 C1 0.1		-20-60 degC

Table 9. The fast response sensors.

Sensor	Program	Location	Data Rate (Hz)	derived flux / parameter
Gill R3 Research Ultrasonic Anemometer serial no. **000227**	Gillr3mpd	starboard side of foremast platform	20 Hz	momentum and sensible heat
Licor-7500 CO_2 / H_2O sensor serial **no. 75H0825**	licor3		20 Hz	latent heat and CO_2
Gill MR3 Research Ultrasonic Anemometer serial no. **00038**	gillmr3d	Port side of foremast platform	20 Hz	momentum and sensible heat
Licor-7500 CO_2 / H_2O sensor serial **no. 75H0614**	licor3b		20 Hz	latent heat and CO_2
MotionPak ship motion sensor serial no. 0682	via gillr3mpd	Starboard side of foremast platform	20 Hz	EC motion correction

Table 10. The ship's meteorological sensors.

Name	Sensor	Type	Serial no.	Sensitivity	Cal
STIR	Kipp & Zonen CM6B (335 – 2200 nm)	Pyranometer	973134	10.84µV/W/m2	9.22509225E+4
PTIR	Kipp & Zonen CM6B (335 – 2200 nm)	Pyranometer	973135	11.66µV/W/m2	8.57632933E+4
PPAR	ELE DRS-5 (400-700nm)	PAR	28561 (not checked)	1mV/100W/m2	9.708737386E+4
SPAR	ELE DRP-5 (400-700nm)	PAR	28562 (not checked)	1mV/100W/m2	9.803921568E+4
Pressure	Vaisala PTB100A	Barometric	Z4740021	800–1060 mbar	C0=4.64399E-2 C1=9.99388E-1
wind speed	Vaisala WAA151	Anemometer	P50421	0.4-75 m/s	
Wind Dir	Vaisala WAV151	Wind Vane	S21214	0-360 deg	
Air temp	Vaisala HMP44L	Temp	U 185 0014	-20-60 degC	slope 1.0228 offset: 0.02
humidity	Vaisala HMP44L	Humidity	U 185 0014	0-100%	slope 1.0189 offset: 0.15

Table 11. Mean differences between the temperature and humidity sensors.

Difference from psychrometers	Mean difference	Standard deviation
AutoFlux Vaisala humidity	1.1% Low	0.24%
Ship's Vaisala humidity	2.43% Low	0.96%
AutoFlux Vaisala temperature	0.01ºC high	0.033ºC
Ship's Vaisala temperature	0.3ºC high	0.039ºC

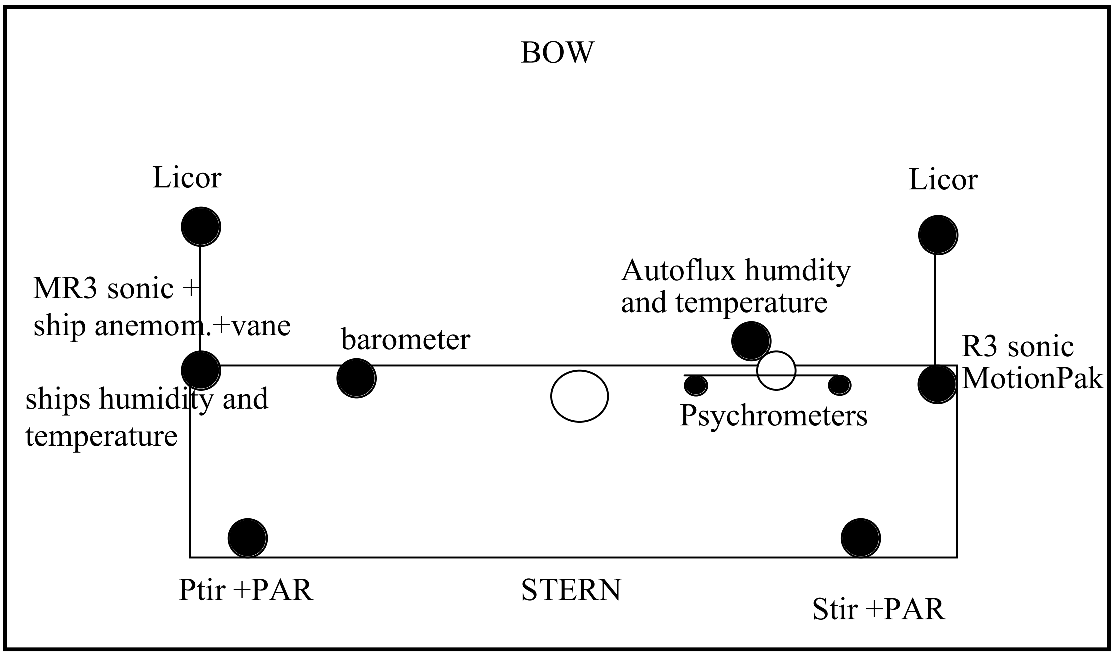

Figure 37. Schematic plan view of the foremast platform, showing the positions of the sensors.

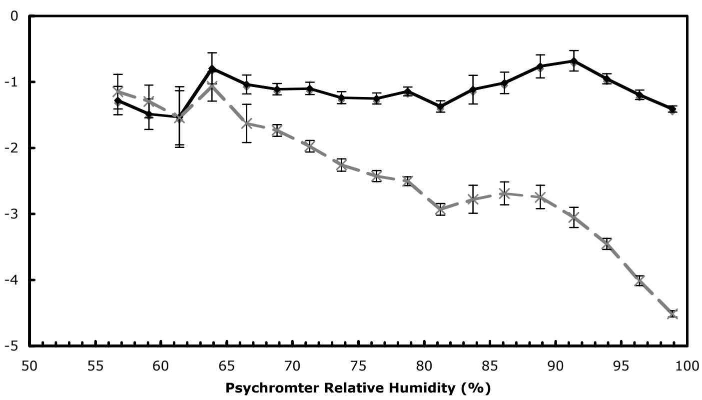

Figure 38. Showing the difference (measured – psychrometer RH) in the relative humidity as measured by the ship (grey) and Autoflux (black) Vaisala sensors. Error bars are standard deviation of the mean.

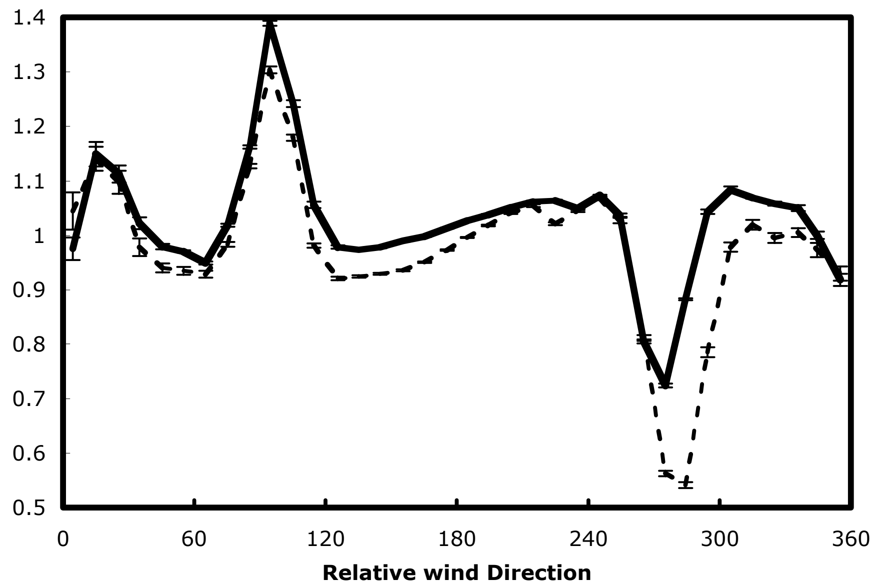

Figure 39. Measured wind speed / wind speed from the R3 sonic, for the MR3 sonic (bold line) and ship's anemometer (dashed line) each binned against relative wind direction. Only open ocean data is displayed and error bars indicate the standard deviation of the mean. A relative wind direction of 180 degrees indicates a flow directly on to the bow of the ship.

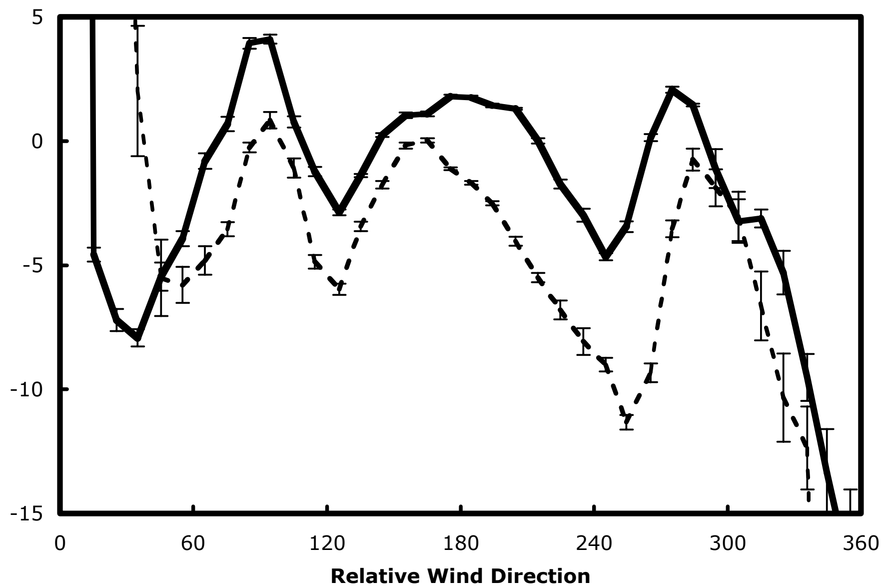

Figure 40. As Figure 38 but showing the difference (measured – R3 sonic) in the relative wind direction. Error bars are standard deviation of the mean.

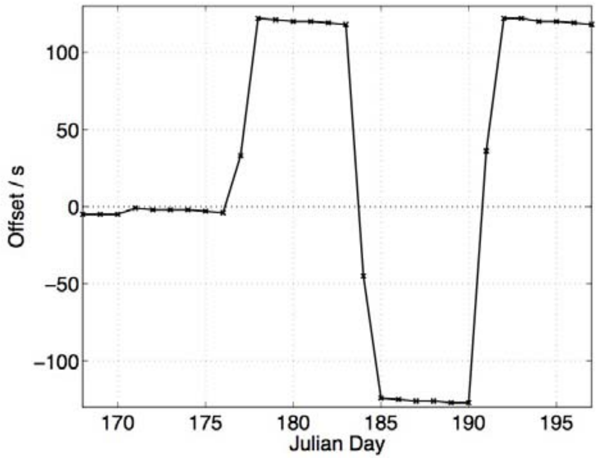

Figure 41. Time jumps of the SBWR PC in seconds.

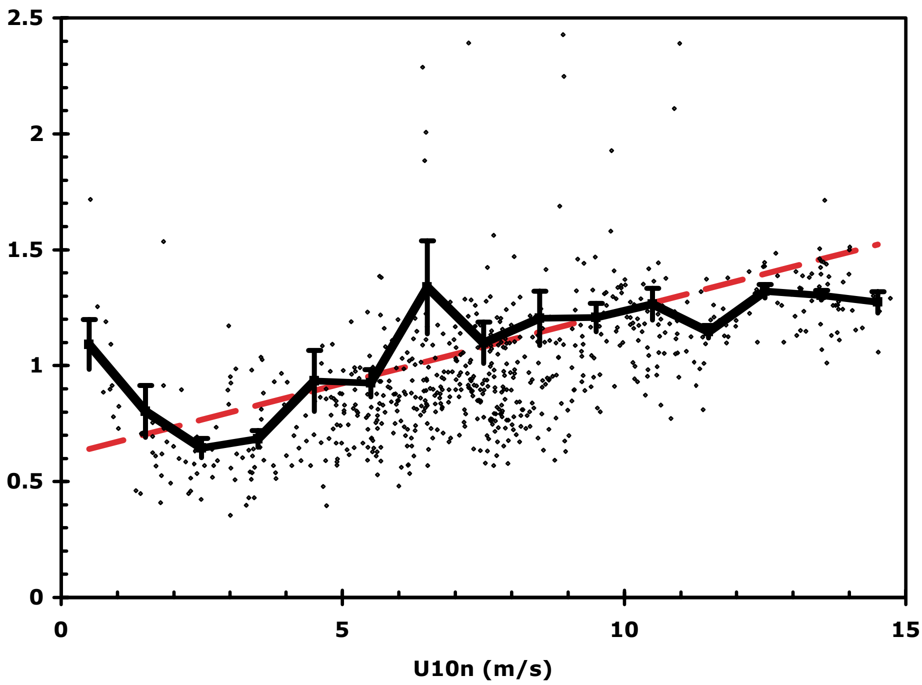

Figure 42. Fifteen minute averaged values of the measured inertial dissipation drag coefficient from the R3 sonic selected for wind directions within ±30deg of the bow, plus the mean results (solid line) binned against the 10 m neutral wind speed. The Yelland et al. (1998) relationship is shown by the dashed line.

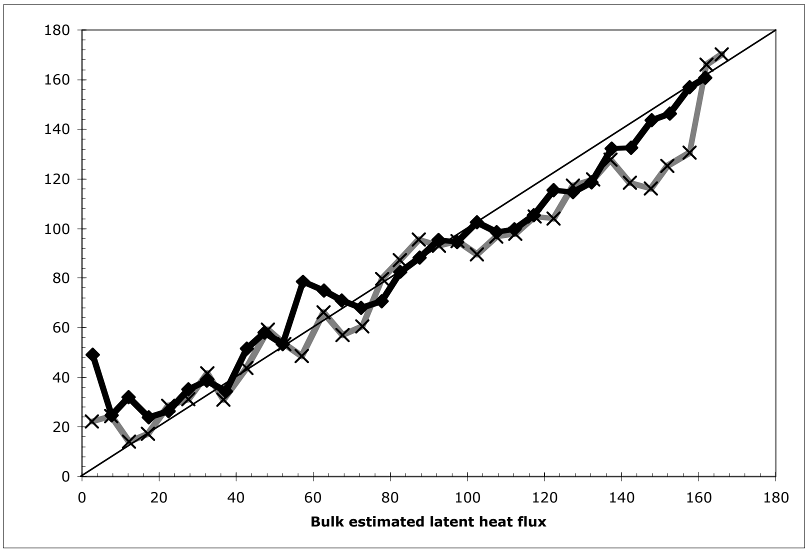

Figure 43. Inertial dissipation (ID) measurements of the kinematic latent heat flux from starboard Licor (diamonds) and the port Licor (crosses) selected for wind directions within ±30deg of the bow, binned against a flux estimated from a bulk formula (Smith, 1988).

Appendix A. List of significant events.

Day 164: Changed Licor 825 chemicals. Swapped Licor positions so 75H-0614 now port and 75H-0825 now starboard.
Day 170: Adjust bridge cameras so the horizon is at the top of frame, and ran clean supply to bridge cameras
Day 177: At 19:35 found that Surfmet had stopped working, re-booted Surfmet PC and it started OK.
Day 178: Went up foremast and re-primed starboard wet bulb, cleaned Licors and SW sensors
Day 199: Cleaned and shrouded Licors, topped up water bottles, cleaned SW sensors ready for next cruise.

Licor cleaned	TIR sensors cleaned
178 11:00	178 11:00
199 10:00	199 10:00

Table 12. Day and time when sensors were cleaned.

Appendix B. Time series of mean meteorological and air-sea flux data.

Figures 44-49 show time series of 1 minute averages of the mean meteorological data. Only basic quality control criteria have been applied to these data. Each page contains four plots showing different variables over a five-day period.

Top panel - the best wet (pwUSE) and dry (pdUSE) bulb temperatures from the two psychrometers plus sea surface temperature (SST) from the TSG.

Upper middle panel – down-welling radiation from the two shortwave TIR sensors in W/m^2.

Lower middle panel - relative wind direction (reldd = 180 degrees for a wind on the bow) and true wind direction (TRUdd) from the starboard R3 anemometer. The ship's true heading is also shown.

Bottom panel - relative (spdENV) and true wind (TRUspd) speeds in m/s from the starboard R3 anemometer. The ship's speed over the ground is also shown in m/s. When the relative wind direction was to port of the bow the significant flow distortion is apparent as steps in the true wind speed.

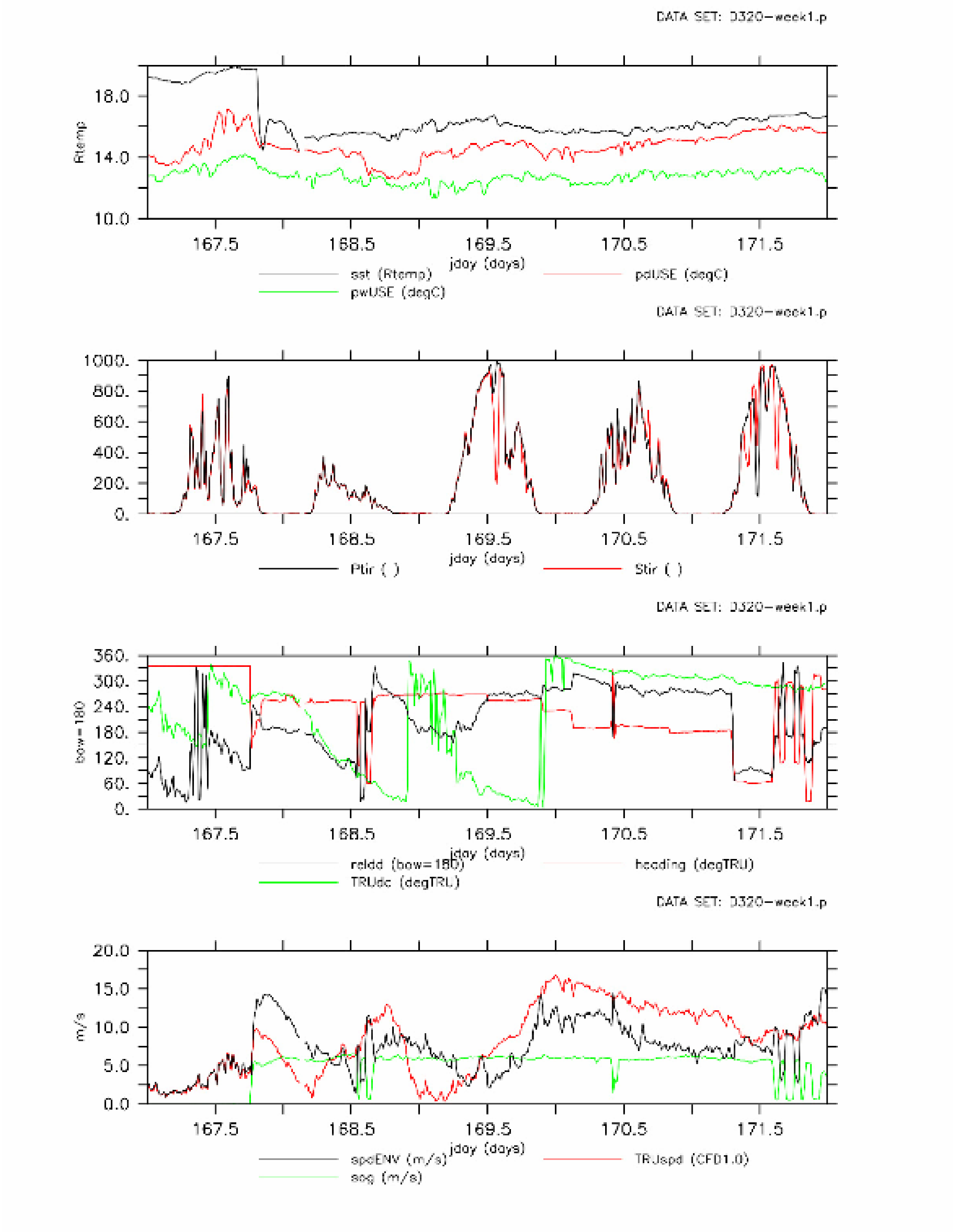

Figure 44. Mean meteorological data for days 167 to 171.

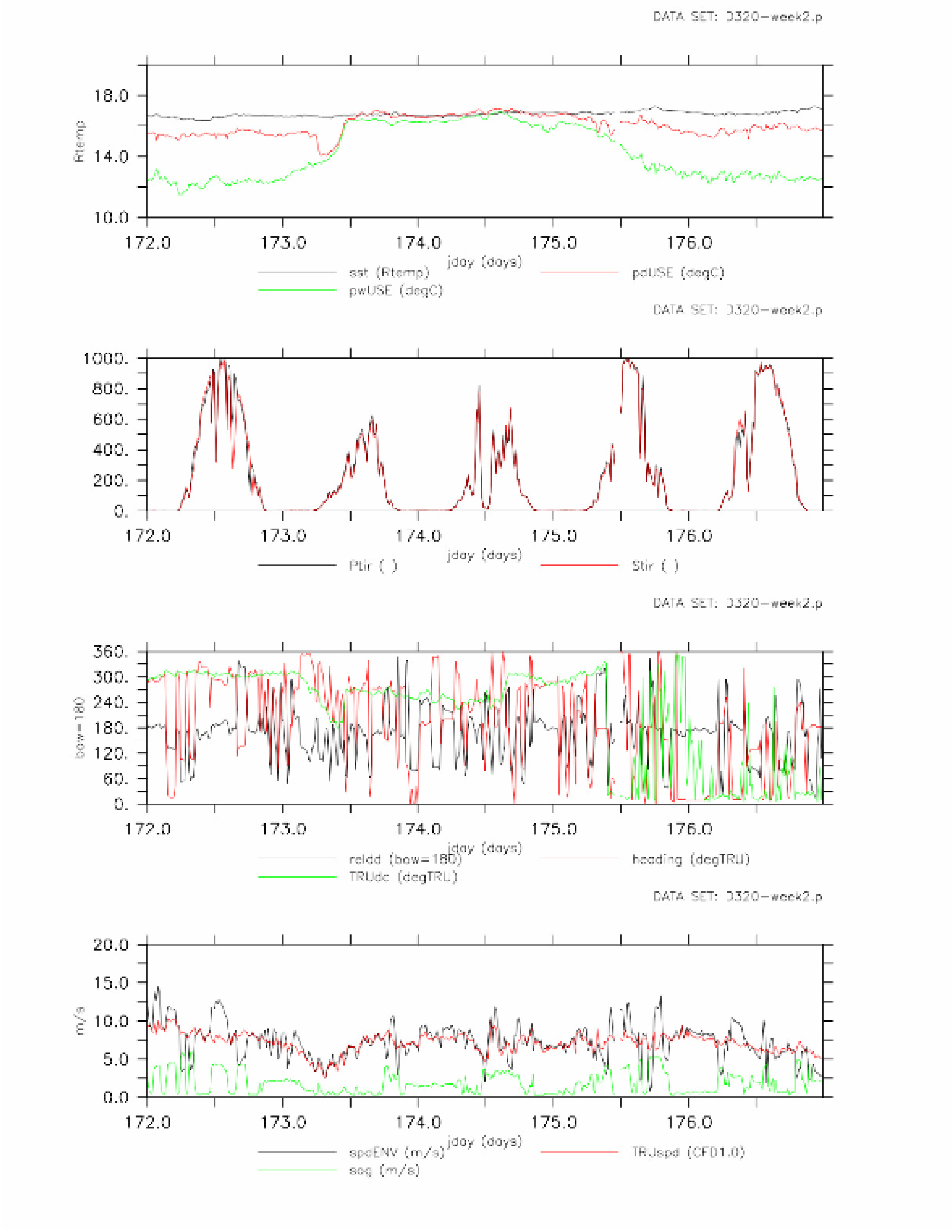

Figure 45. Mean meteorological data for days 172 to 177.

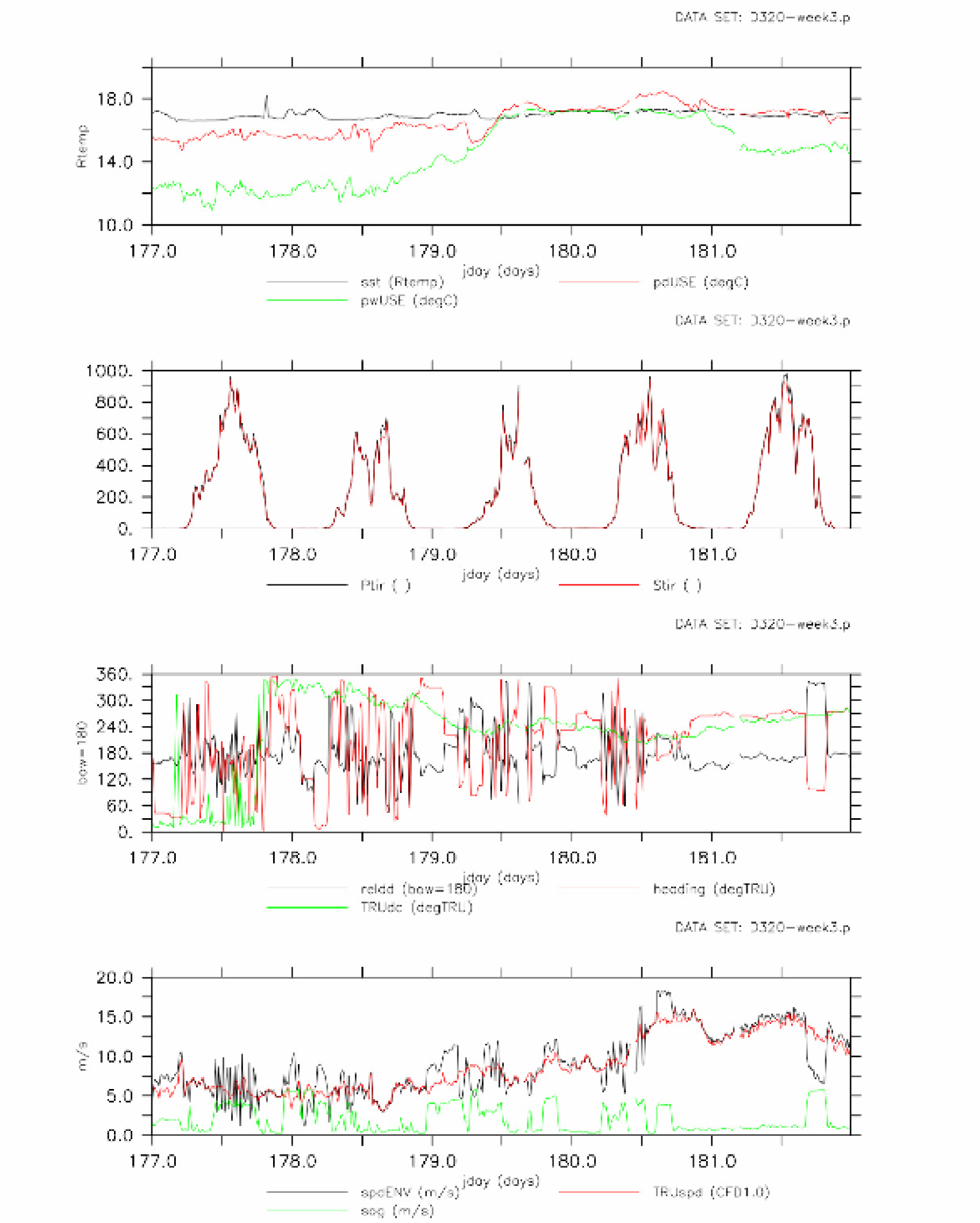

Figure 46. Mean meteorological data for days 177 to 182.

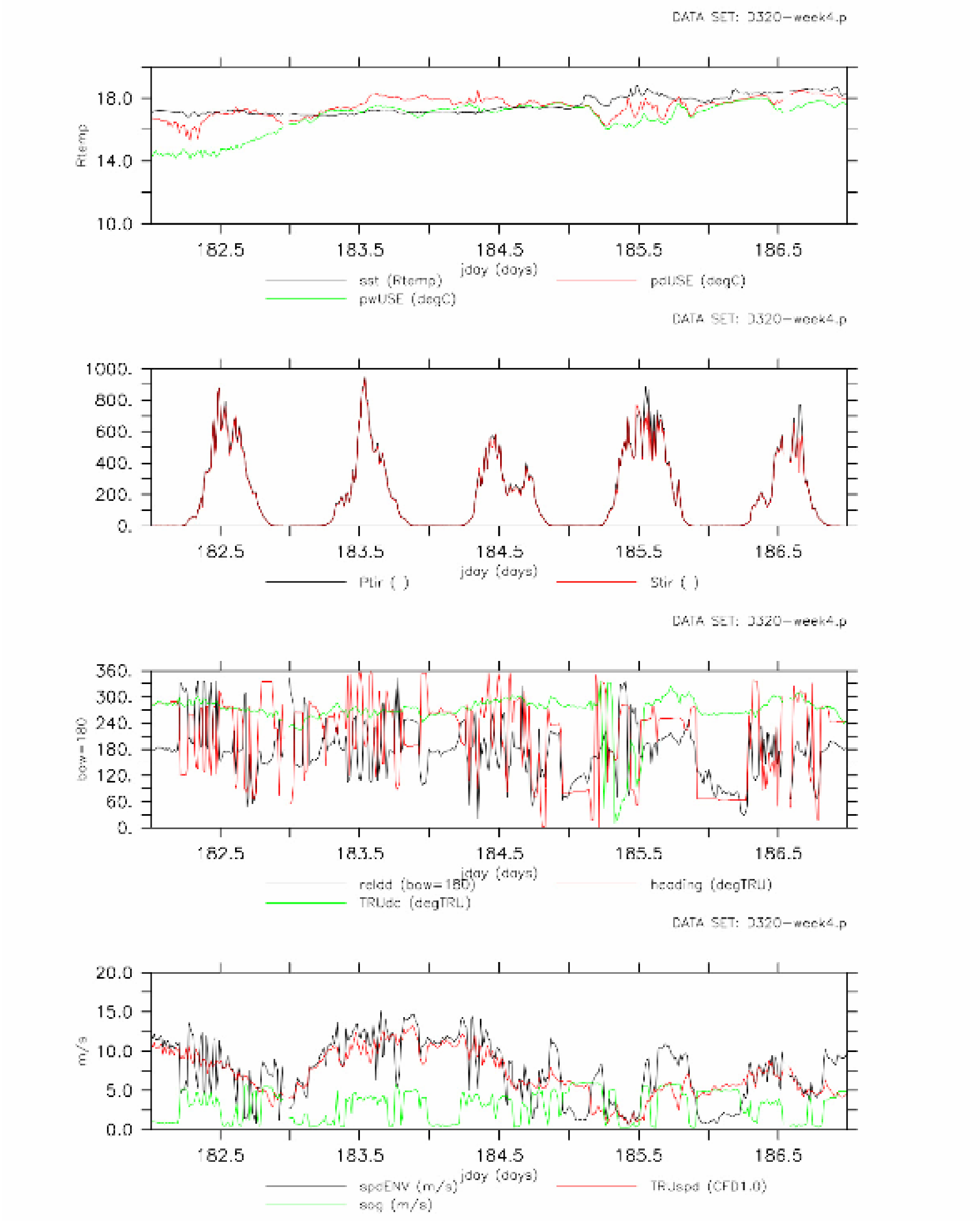

Figure 47. Mean meteorological data for days 182 to 187.

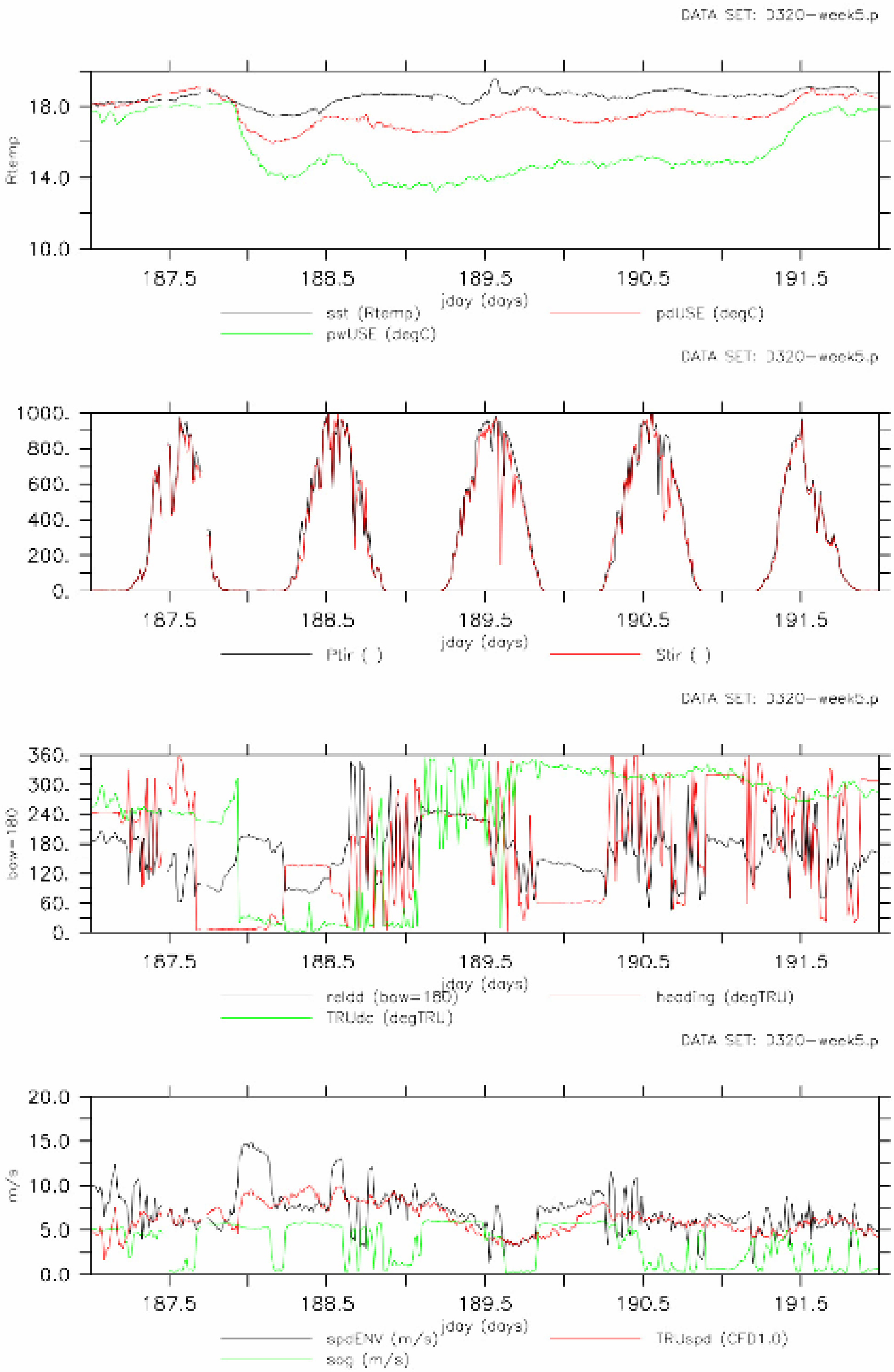

Figure 48. Mean meteorological data for days 187 to 192.

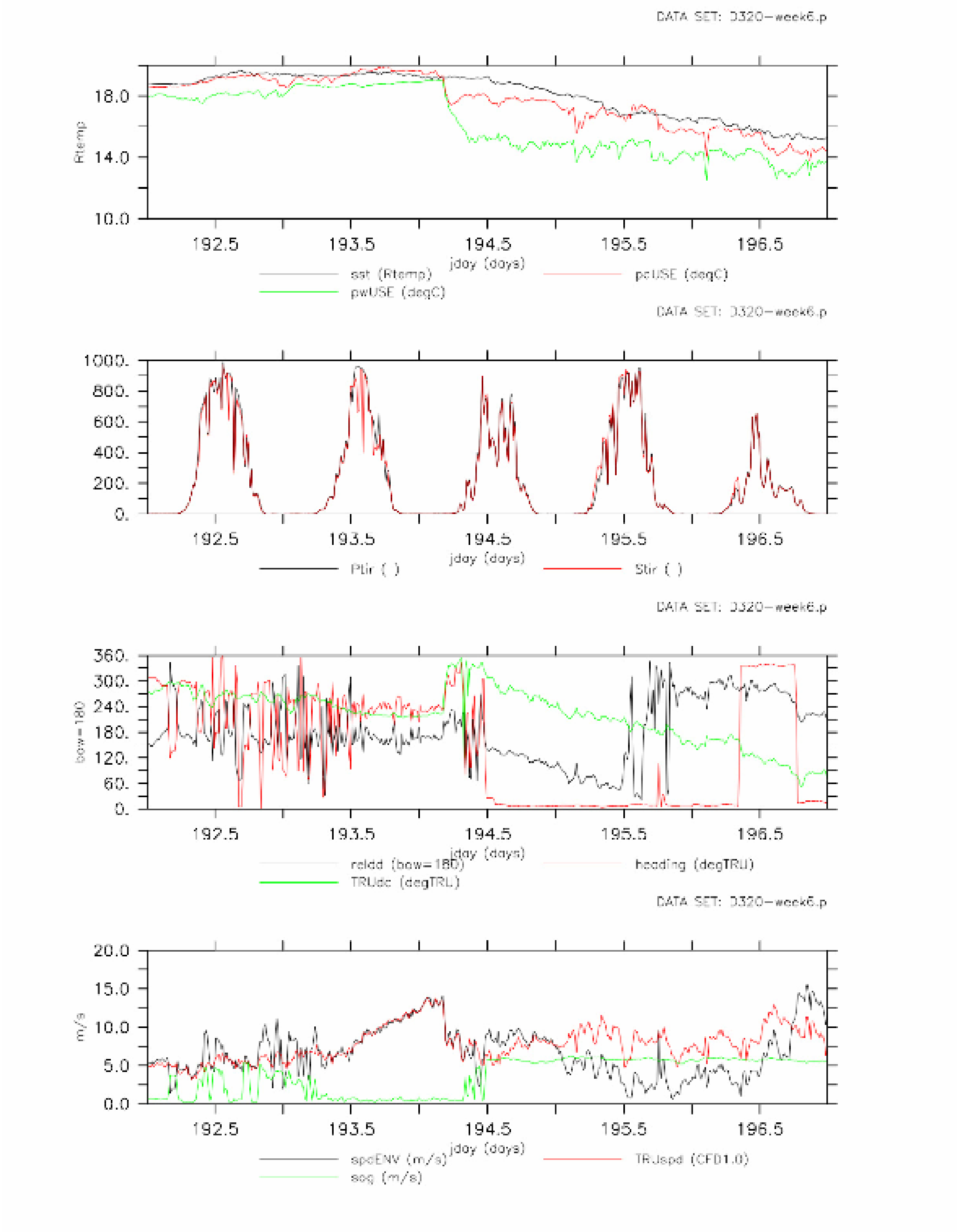

Figure 49. Mean meteorological data for days 192 to 197.

Wave Buoy

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National Oceanography Centre, Southampton and ISVR, University of Southampton

2.1 Introduction

A spar buoy has been developed and instrumented at NOC to simultaneously record (by video) and measure (by capacitance wave wires) whitecap coverage and wave breaking. In addition, the buoy has been instrumented with a system developed by ISVR to quantify the bubble populations produced by breaking waves both at the sea surface and beneath it, using acoustic methods. The aim is to develop and improve the parameterisation of wave breaking and its contribution to gas exchange. The buoy has been designed to log all data internally and be independent of the ship. Maximum deployment times are approximately 5 days, but this will be increased for future cruises. The spar buoy is a unique design and its performance and systems are evaluated in the following sections.

2.2 The spar buoy

The spar buoy is designed to make numerous measurements in oceanic conditions where breaking waves are encountered. Wave heights are measured along with a visual measurement of the waves themselves. Sub-surface bubble populations and how they evolve over time are also measured.

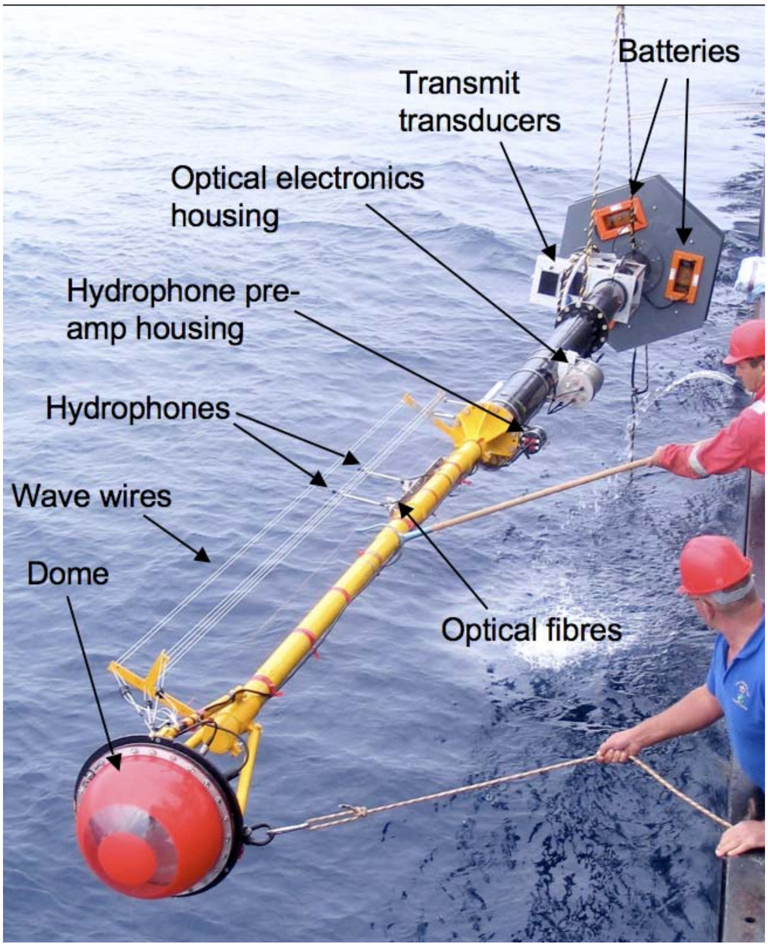

Figure 50: Recovery of the buoy off the starboard side of the ship.

The spar buoy is 11 m in length and constructed of aluminium to save weight. The buoy floats vertically in the water and is orientated into the wind by correct positioning and alignment of underwater housings as well as extra ballasting in the form of a 25 kg weight attached to one of the batteries. In addition to this, the buoy is ballasted by a 30 kg weight deployed 10 m below its base.

One 24 V and two 12 V batteries are located at the base of the buoy and are used to power the instruments and logging systems.

The buoy is deployed horizontally (**Figure 50**) using a bridle, and rights itself upon entry into the water. A second bridle, attached on the opposite side to the bridle used in deployment, is run up the length of the buoy and strapped to the very top of the buoy leaving a large hoop protruding above the dome. Upon recovery, this large hoop is then attached to a crane and used to lift the buoy from the water.

An Argos positioning system is installed inside the dome of the buoy, and this is used for radio directional finding. It also emails a GPS position approximately every hour (depending on weather conditions and satellite coverage). In addition, a strobe light was installed for visual sightings in low light conditions.

2.3 Instrumentation

2.3.1 Wave breaking system

Three 3.9 m capacitive wave wires stretch along the length of the top yellow section of the buoy and are used to measure the wave height relative to the buoy. The three wave wires are orthogonal to each other and separated by a distance of 0.14 m (**Figure 55 (b)**). The orange dome on top of the buoy contains the wave wire electronics, a digital video recorder, two digital stills cameras buoy motion sensors and the logging system for the aforementioned.

Wave heights, buoy motion and compass data are logged (using a custom designed and built logging system) to a 2 GB flash card at 45.06 Hz (waves and motion) and 8 Hz (compass). Data are written to the card in 1-hour sections. The logger system clock is checked against the ship's time before each deployment and reset to GMT if necessary. The wave wires were calibrated in Falmouth dock on Julian Day 167, before the start of the cruise.

Table 13: Calibrations applied to the wave wire data.

	Wave wire	Height = m*(register)+c	
		m	c
Falmouth (Day 167)	1	0.00007830	-0.53739125
	2	0.00007761	-0.45285766
	3	0.00007990	-0.60948069
At sea (Day 189)	1	0.00007120	-0.50628
	2	0.00007124	-0.41121
	3	0.00007202	-0.49612

The video camera and one of the stills cameras face down towards the sea surface and record images of the waves as they pass through the buoy's position (the bottom half of the dome is transparent). The second stills camera is angled slightly more towards the horizon to capture waves as they approach the buoy and to give an understanding of the wave conditions ahead of the buoy. All cameras were set to only record data during daylight hours. The JVC hard disk camcorder recorded video to an internal hard disk in MPEG 2 format, which lasts approximately 37 hours before the disk is full. The Nikon 5400 stills camera records 16 images (at 5 M Pixels) over a period of 7 seconds (2.3 images per second) with a 7 second pause in-between. The images are arranged in a 4x4 matrix at a resolution of 648x486 pixels. The images fill the 2 GB card in approximately 17 hours. The Nikon 8700 also records images at a rate of 16 images per 7 seconds but has a 9-10 second gap between each burst. It is not possible to synchronise the camera times with the logging system time (set to GMT) as the software internal to the cameras is not reliable enough. In order to overcome this, LCD displays showing the time from the logging system are stuck to the inside of the dome so as to appear in the corner of each image. By having the logger and cameras time-synchronised, it is possible to identify wave breaking events from the wave wire data and find the same breaking wave in the video and camera data.

The logging system and cameras are initialised in the lab and the dome sealed by a number of bolts. The system is taken out on deck and connected to the buoy. Water ingress into the dome was not encountered during the deployments, even though the camera data shows numerous occasions on which the buoy is completely submerged by a breaking wave.

2.3.2 Acoustic system

The acoustic system is used to measure bubble populations, caused by breaking waves, and how they evolve over time.

The system consists of a control and logging system (a MagnumX 1000 single-board computer), an NI-6110 PCI data acquisition card, custom designed and built power amplifiers (Blacknor Technology), 3 transmit transducers (2 custom built transducers for high and mid frequencies, and 1 T135 transducer for low frequencies), and 4 D140 hydrophones. The control system, data acquisition card, and power amplifiers are all located in a pressure housing positioned just above the batteries. The transmit transducers face towards sea surface and are mounted on an aluminium plate above the electronics housing. An array of three or four (depending on the configuration) hydrophones measure the transmitted pulses and the varying attenuation, which is increased by the presence of bubbles. The hydrophone pre-amplifiers are located in a small housing mounted opposite the hydrophones.

A train of 14 pulses of increasing frequency (**Table 14**) is created by the computer, output through the DAQ card, and transmitted into the water. Pulse length is 1 ms and the off-time between pulses is 20 ms (**Figure 53 (a) & (b)**). The time between pulse-trains is approximately 1 second, dictated by the processing speed of the computer. The signals received from the hydrophones are acquired at 1 MHz per channel and stored on a 2.5” hard drive.

The hydrophones can also record passively (with no signal transmitted into the water) in order to listen to breaking waves and calculate an initial bubble population from a breaking event.

A B200 hydrophone was situated on the same plate as the transmit transducers and this is used to measure surface reflections and therefore measure a profile of the sea surface.

Table 14 – Table showing the bubble radii that are possible to measure using the acoustic system and their corresponding resonant frequencies.

Frequency (kHz)	**Bubble radius resonant at corresponding frequency (mm)**
3	1107
7	474
10	332
18	184
24	138
29	115
38	87
46	72
66	50
85	39
118	28
135	25
160	21
197	17

2.3.3 Optical Fibre System

An optical fibre system is used as a secondary way of measuring bubble population and as a way of confirming bubble populations measured using the acoustic system.

Four fibres are used in total - 1 as a single sensor, and 3 in a tri-axial configuration in order to make it possible to measure global void fraction and flow velocity. The optical amplifiers, light sources and related electronics are located in a separate pressure housing below the hydrophone pre-amplifier housing.

The power for the optical electronics is taken from the main acoustics housing (which has a power distribution board inside). Optical data is also sent back to that housing where it is recorded at a sample rate of 200 kHz on to the 2.5" hard drive.

2.4 Spar buoy performance

A total of 4 full deployments and 2 test calibrations (using only the top section) were completed on Cruise D320. **Table 15** shows the positions and time of all these deployments. On the recovery from the 4th deployment, the buoy started drifting under the ship and therefore impacted the ship hull a number of times. One of the hydrophones was destroyed and one of the transmit transducers was damaged.

2.4.1 Problems Encountered – Breaking wave section

There was a recurring fault with the wave wires, which affected each deployment. The fault would cause the data stream from the wave wires to jump to full-scale within a couple of hours of deployment. Therefore, wave height data is only available for up to the first 2 hours of each deployment. Further investigations since the cruise have determined that a waveform generator in the wave wire electronics would burst in to oscillation when the 10m battery cable was connected. A minor modification to the electronics has now been applied to the electronics to cure the problem.

There was also a problem with the Nikon 8700 stills camera and its internal power management. This prevented the camera from being restarted once it had been shut down for the first time and therefore, for the first two deployments, only data from first day of each deployment was recorded from that camera. After the second deployment, a method was found to work around the problem and this resulted in data from the 1st and 3rd days (after which the memory card had become full) of the last 2 deployments.

2.4.2 Problems Encountered – Acoustics system

For the first deployment, the onboard computer was not running at full speed caused by a corrupt driver controlling the PCI and IDE buses on the motherboard. This restricted the capabilities of the system, and as a result of this only active acoustic measurements could be taken. Upon recovery, the system was completely re-installed with working drivers, which resolved the situation.

The computer had also been losing its memory of the time whenever power was unplugged. Changing the battery seemed to do nothing and after the 1st deployment it was discovered that one of the connectors on the main board was not correctly seated. Rectifying this solved the clock problem and the onboard clock functioned correctly for the 2nd, 3rd and 4th deployments. For the first deployment, the clock had been reset to 00:00 1st January 2001. It is, however, possible to work out the event times to the nearest minute, using the time the buoy entered the water.

On inspection of the data from the 3rd deployment, it was noticeable that the first hydrophone in the array was not functioning correctly, most likely due to a weak connection on the pre-amplifier board. The signal from the surface reflection hydrophone was also very weak – it was engulfed within the noise. The cause of this has yet to be discovered but it is probable that it was down to a fault with the multiplexing board for the DAQ card.

In the fourth deployment, data were only recorded for approximately 25 minutes as opposed to the usual 10 or 12 hours. Measuring the battery voltage after the buoy had been recovered showed that the battery had fully depleted, which suggests either an improper charge prior to deployment or a problem that has developed with the battery due to it being almost fully discharged 3 times before.

2.4.3 Problems Encountered – Optical Fibre system

As the ship approached the buoy for the 2nd recovery, it was clear that the buoy was floating lower than it should have, indicating a leak in one of the housings. Upon opening the optical electronics housing, it was found to be ¾ full with sea water. The electronics were cleaned with distilled water and allowed to dry. Visible inspection showed the electronics appeared to be in a good state. This was most likely because the housing sits vertically on the buoy and there is a large piece of absorbent foam at the bottom of the housing which would have drawn water away from the electronics when power was supplied. Only after power had been switched off would the housing have been turned horizontal (on recovery) and salt water touch the electronics.

After numerous tests, it was discovered that the leak was caused by over-tightening of the clamps causing a deformation of the housing and therefore destroying the integrity of the o-ring seal. For the following deployments, a second o-ring was installed and the housing sealed with silicone. This technique was successful in preventing the leak.

One of the fibre connectors had also leaked on the 2nd deployment so that was taken out and replaced with a blank. It was also apparent that one of the 4 channels on the optical amplifier board had stopped working. Therefore only 3 fibres were used for the 3rd and 4th deployments.

2.5 Initial Results

2.5.1 Breaking wave system

Figures 57-60 show the periods of each deployment for which there are data from each different piece of instrumentation. It has been possible to identify numerous breaking wave events from the video footage and also from the stills camera images. By recording the number of breaking wave events, it will be possible to calculate average number of breaking wave events for a range of sea states.

The quality of the wave wire data and basic wave statistics can be calculated using Matlab scripts. However, owing to the short time for which the wave wires were working, few breaking wave events have been found using that method.

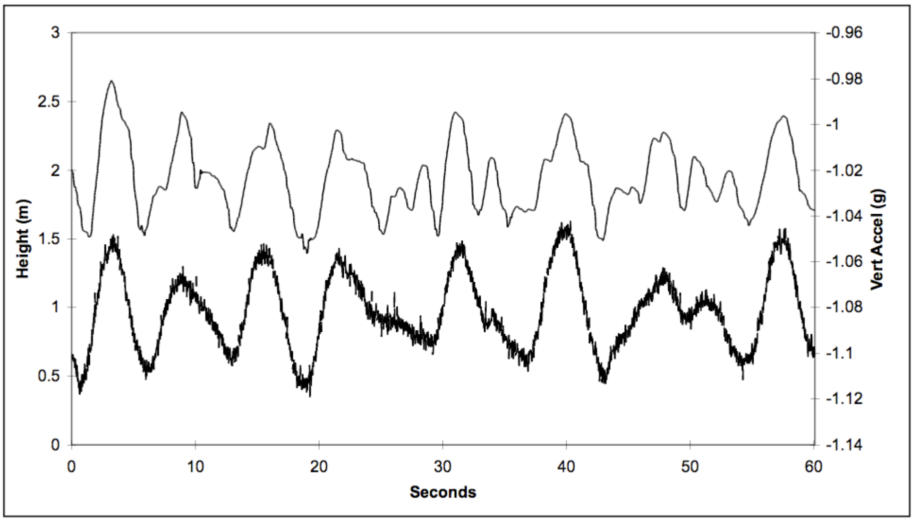

Figure 51. Data recorded by the logger over a minute. The clean line shows the wave height and the rough line shows the vertical acceleration.

2.5.2 Acoustic system

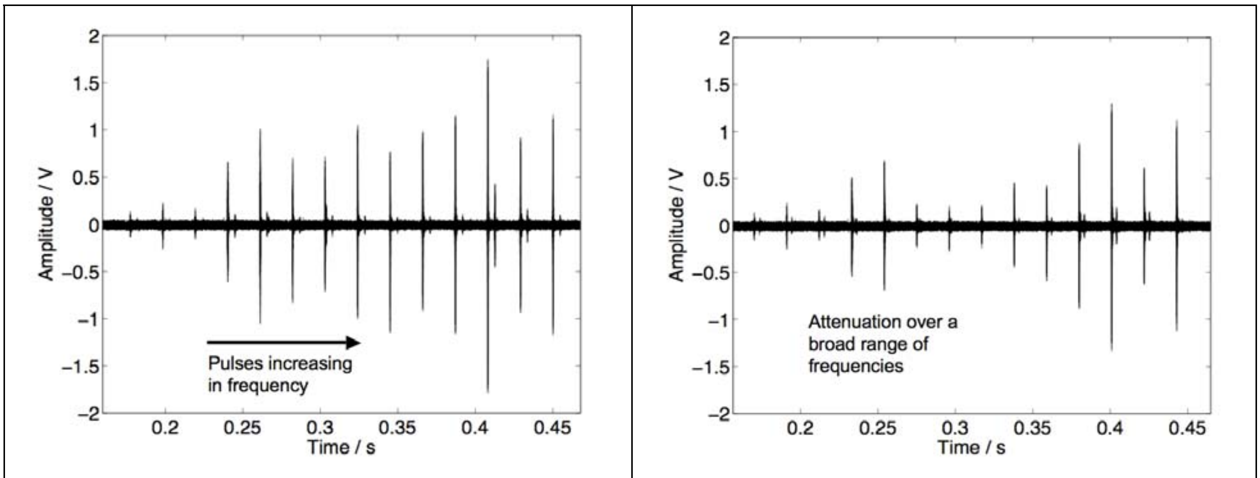

Figure 52(a): An example of the received signal at the first hydrophone in the array when there are no bubbles present, (b): The signal received at the same hydrophone when there are bubbles present in the water. Many of the frequencies are considerably attenuated.

Processing of the acoustic data is a lengthy process and has not been completed at the time of writing this report. However, initial interpretation of the data from the 2nd deployment has shown a number of events of increased attenuation in the water column - an indication of the presence of bubbles. **Figures 52(a) & (b)** show the signal at the second hydrophone, with and without the presence of bubbles. Further processing is required in order to turn these results

into bubble populations and this will be carried out after the cruise. **Figure 53** shows one of the recordings from the surface-profiling measurements.
Many of the passive recordings will require a great deal of signal processing in order to overcome the noise in the signal. The low signal to noise ratio is caused by the gain of the hydrophone pre-amplifiers being too low. The gain was set low in order to work well with the active acoustic measurements – the pulses transmitted into the water were of high amplitude and would saturate the pre-amplifiers if the gain were too high. But it is this necessity for low gain that makes passive recordings difficult. On the third and fourth deployment, some of the hydrophones were set with higher gain in order to increase the quality of the passive recordings. This technique worked but reduced the number of hydrophones that could be used in the active acoustics array.

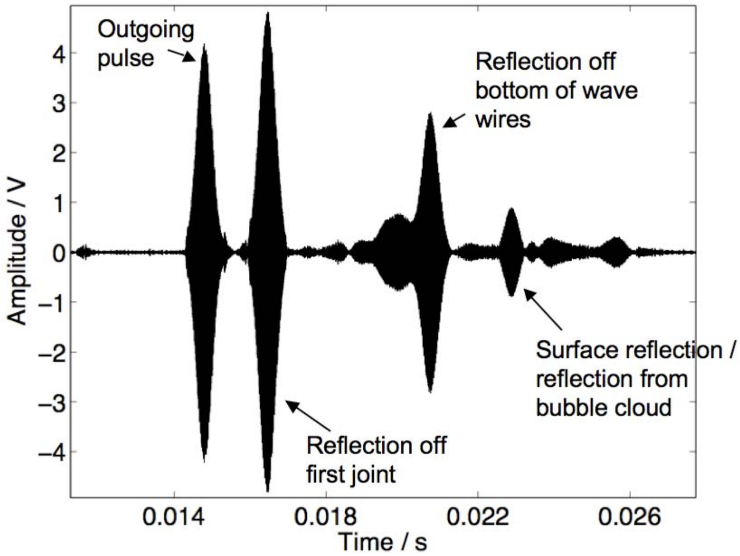

Figure 53. Pulses received by the hydrophone positioned by the transmit transducers.

2.5.3 Optical Fibre System

The optical fibre system showed that it could produce a signal in an oceanic environment. **Figure 54** shows an example of the type of signal recorded from the optical fibres. A downward peak occurs if a fibre exits the water (one of the fibres is mounted close to the surface and would therefore occasionally come out of the water as a wave passes) and an upward peak occurs when the fibre re-enters the water. The closely packed peaks are caused by bubbles, but further processing and cross-referencing with camera images will be required in order to build confidence in the integrity of the signal.

It should be noted that the Argos beacon did not work for the first deployment. This was lately discovered to be caused by a faulty connector. This was rectified and the Argos beacon worked flawlessly from that point onwards, regularly sending its position back to NOC where it was emailed to the ship.

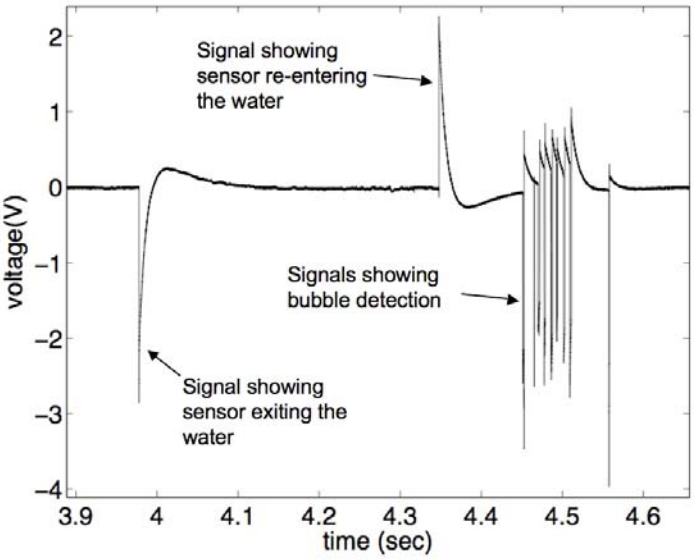

Figure 54. An excerpt from the signal recorded by the highest optical fibre, mounted just below the surface.

2.6 Future improvements

Modifications have already been made to the wave wire circuit to correct the fault that was found during the cruise. It may also be possible to change the configuration of the stills cameras in order to ensure they can run for the full length of the deployment.

The acoustic system was limited by the amount of battery power available and its inability to make measurements in more than one session. More sophisticated control of the electronics would enable the system to record for a short while on multiple days as opposed to measuring for one long time period.

The size of the tip of the optical fibre sensors limits the size of bubble that can be measured using the system. It would therefore be beneficial to use sensors with a smaller tip to allow more crossover in the bubble sizes that the acoustic system and the optical fibre system can measure. Measures need also be taken to prevent further leaking in the optical electronics housing.

2.7 Summary

The buoy and its systems are unique and significant improvements have been made since the last cruise. These included:

- Correct orientation of the buoy with respect to wind direction.
- More sophisticated control of the breaking wave system allowing for longer deployments.
- Integration of the optical fibre system.
- Passive acoustic measurements and measurements of surface profile.

Much of the equipment functioned very well and some great successes were had including:

- Deployments of the buoy lasting more than 1 day.
- Excellent physical endurance of the buoy, withstanding rough weather with maximum wave heights of over 8 metres.

- Wave heights measured successfully for a short time from all three wave wires and a large number of breaking waves identified using the cameras.
- Increases in attenuation measured by the acoustic system, strongly suggesting the presence of bubble clouds as deep as approximately 3 metres.
- At-sea signals recorded using optical fibres.

Table 15 – Deployment Log

No.	Deployment				Recovery				Comments
	Day	Time	Lat	Lon	Day	Time	Lat	Lon	
1	173	13:18	43° 42.7 N	18° 06.2 W	175	14:15	43° 36.3 N	18° 59.3 W	Buoy positioned near ASIS-1 Buoy.
2	179	17:32	43° 13.3 N	17° 44.3 W	182	18:52	42° 44.2 N	17° 20.4 W	Deployment with the most breaking waves. Leak in optical housing causing buoy to sit lower in water. Positioned near ASIS-2 Buoy.
3	185	10:47	42° 34.6 N	16° 33.7 W	188	19:15	42° 41.2 N	16° 22.6 W	Leak in optical electronics housing no longer an issue. Positioned near ASIS-1 Buoy.
4	190	19:57	43° 32.3 N	16° 06.6 W	194	11:24	42° 32.5 N	15° 49.4 W	Damage to hydrophone and transducer upon recovery. Positioned near 3rd SF6 patch.
Cal #1	167	-	Falmouth Dock		-	-	-	-	Calibration found to be unusable because of system instability.
Cal #2	189	-	At sea		-	-	-	-	Calibration strongly agrees with calibrations taken at sea on Cruise D313.

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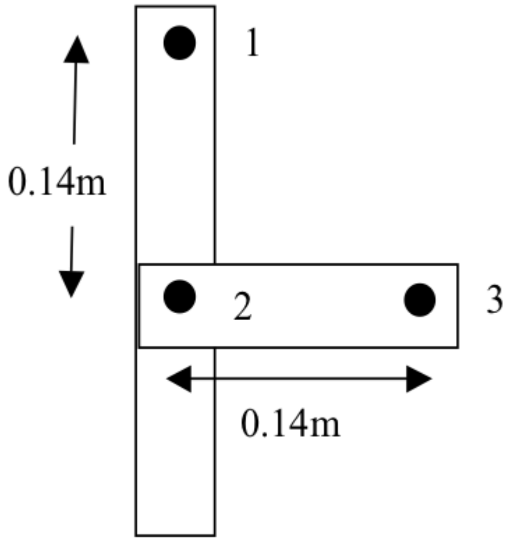

Figure 55(a): A breaking wave passing through the spar buoy, (b): The configuration of the three wave wires

Figure 56. A run of 16 images captured by the Nikon 5400 stills camera on the second deployment. A breaking wave and the white froth it leaves in its wake can clearly be seen passing through the buoy.

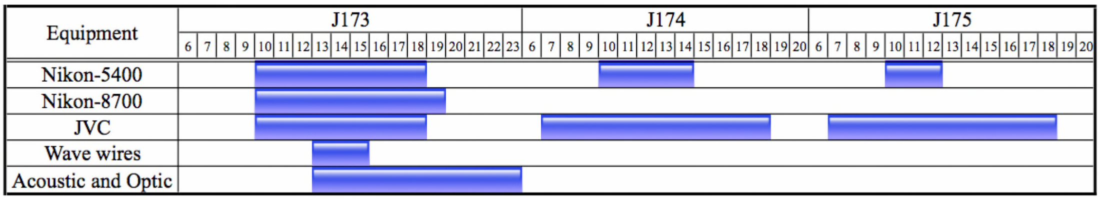

Figure 57. Timetable showing the working periods (shown in hours of the day) for each instrument during the 1st deployment. The Nikons are the stills cameras, the JVC is the video camera.

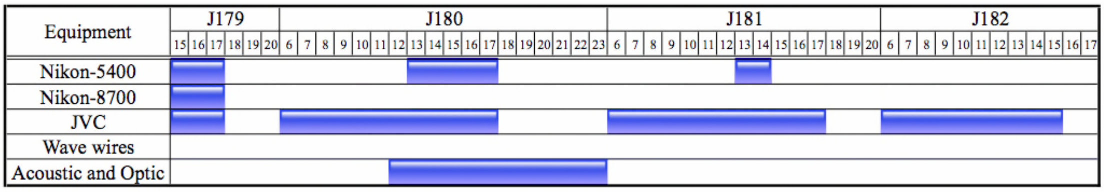

Figure 58. Timetable showing the working periods (shown in hours of the day) for each instrument during the 2nd deployment. The Nikons are the stills cameras, the JVC is the video camera.

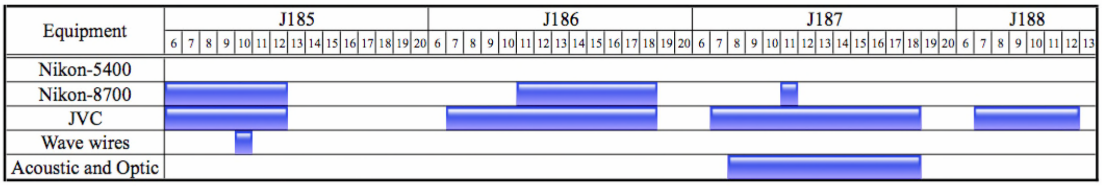

Figure 59. Timetable showing the working periods (shown in hours of the day) for each instrument during the 3rd deployment. The Nikons are the stills cameras, the JVC is the video camera.

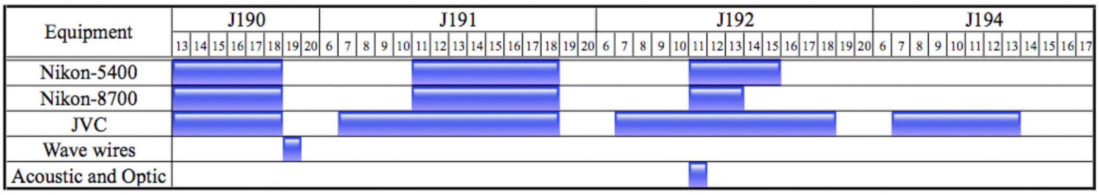

Figure 60. Timetable showing the working periods (shown in hours of the day) for ach instrument during the 4th deployment. The Nikons are the stills cameras, the JVC is the video camera.

White capping Cameras

David Coles, Ping Chang Hsueh, Robin Pascal.

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3.1 Introduction

Two Nikon Coolpix 8800 cameras were installed on the bridge to measure the whitecap fraction of breaking waves at the sea surface. The cameras were located on the port side of the bridge at a height of 13 m above the sea surface. Both cameras were initially set at an angle of 22 degrees from the horizontal, but on day 170 they were adjusted so that the horizon could just be seen at the top of the image. Each camera was fitted with a polarising filter, which were set at 90 deg to each other. Images were taken directly abeam at a resolution of 5 Mpixels every 30 seconds during daylight hours and recorded to internal 2 and 4Gb flash cards. The cameras typically generated 2.6 Gb of data per day, which was transferred to an external disk and the ship's UNIX systems daily.

3.2 Data Processing

The basic assumption is that for each image all pixels with grey levels above a certain threshold value correspond to whitecaps, and all other elements in the image having grey levels below that threshold correspond to non-whitecap areas (Figure 3.1). It is relatively straightforward to determine the threshold value by visually inspecting each image in turn using image-processing software. To achieve this automatically, Matlab code written by Dr. Moat was used calculate the whitecap fraction, although this still requires identifying sun glint manually for each image.

Matlab scripts were used to process 70,000 images, which were taken by both cameras on the bridge over a twenty-five day period. However, there are two difficult problems in this process: the ships roll, and sun glint. In order to avoid contamination of the image from sky and the ship's wake, the area of the image that is processed is limited to an area taken from the centre of the image. Next, the identification of sun glint had to be carried out manually for all images since it is difficult to automatically identify the differences between the white caps and sun glint. Sun glint data was taken only from the fore camera and images from both cameras were rejected if sun glint was present. This was done under the assumption that sun glint would be seen by both cameras at the same time, and to reduce the effort needed during the cruise.

Clearly from the results (Figure 61) it can be seen that the aft camera data are significantly higher than expected. This may be partly due to not having its own sun glint quality controls applied, but also may well be due to the polarising filter producing images less suited to the whitecap threshold used. The fore camera though produces quite reasonable results when compared to the Monahan and OMuircheartaigh, (1980) relationship especially for wind speeds above 8 m/s. Again for lower wind speeds it appears that some adjustment to the whitecap threshold is required.

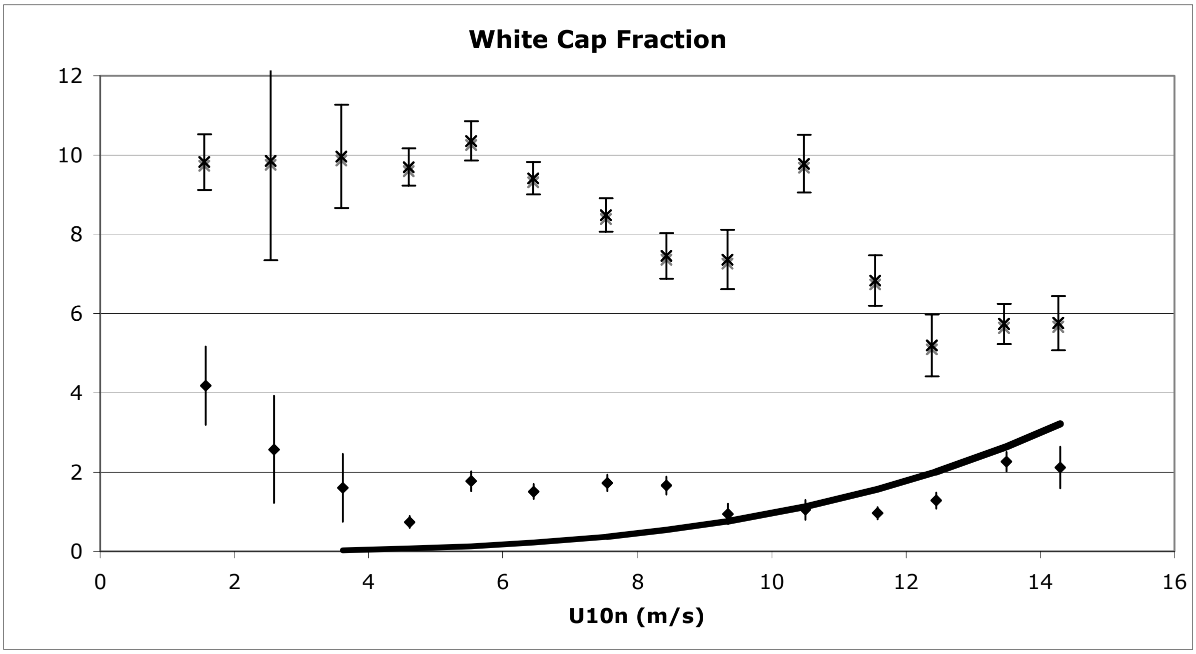

Figure 61. A plot of white cap fraction as measured by the bridge cameras, fore (dots), aft(crosses) are plotted against U10N. The Monahan and OMuircheartaigh, (1980) relationship is shown by the solid line. Only images not affected by sun glint were used.

References

Monahan , E. C. and I. G. OMuircheartaigh, 1980: Optimal power-law description of oceanic whitecap coverage dependence on wind speed, J. Physical Oceanography, 10, 2094-2099.

Measurements of Dimethylsulfide Fluxes on SOLAS/DOGEE Cruise 320

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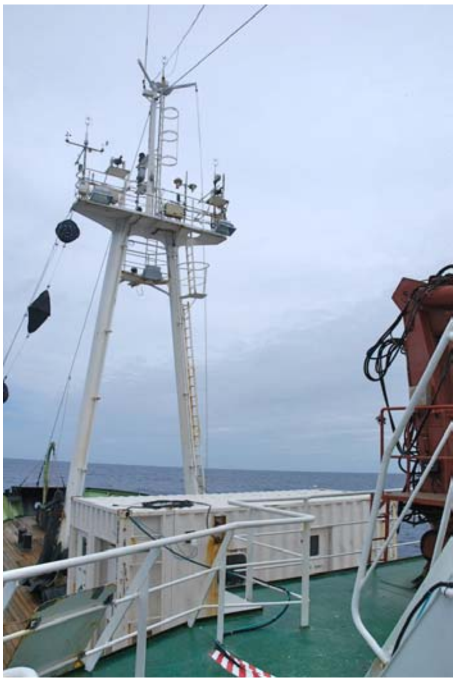
Objective: To measure the flux of dimethylsulfide (DMS) from the ocean to the atmosphere on a timescale of an hour or less, to enable the computation of the DMS transfer velocity, V_t, when combined with sea water DMS measurements (by Steve Archer). These transfer velocities should be affected by (and will be compared with) the many flux-controlling variables measured during DOGEE: surfactants (intentional and natural), mean-square slope, whitecapping, capillary waves, bubbles, and turbulence in both media. The database of V_ts will also be intrecompared with LiCor CO_2 flux measurements and intentional tracer loss experiments.

Approach

We measured DMS rapidly using an atmospheric pressure ionization mass spectrometer with an isotopically-labeled internal standard (APIMS-ILS, **Figure 62**). With this instrument we measured the concentration of DMS and triply-deuterated DMS calibration gas 20 times a second. We also measured the three wind vectors and acceleration at the same rate. The APIMS and data system were located in an 8'x20' container laboratory, which has been reinforced and modified to the new UNOLS standards for containers in which personnel work. The container was located crosswise on the bow of Discovery, just behind the foremast (**Figure 63**).

The accelerometers mounted on the sonic anemometer allow us to correct the apparent winds for the motion of the ship. The accelerometer pack is attached directly to the base of the sonic so that there is no relative movement between the two. Then the correlation between vertical winds and our ambient DMS concentrations gives us the flux. We typically average the flux measurements over one hour to remove the natural variability of the atmosphere.

The intake tube was mounted just below the sonic anemometer on the top of the forward mast (**Figure 64**). An 1/8" Teflon tube delivered the ILS to a tee directly behind the intake tip, so that the internal standard experienced any transmission losses that the ambient DMS did. Spiked ambient air was drawn down to the container through a 5/8" id tube at 120 lpm, to keep the transport time down. The ILS saturated any adsorptive sites in the tubing so that the ambient DMS was less likely to be retained. During data analysis the concentration data and wind data will be auto-correlated to identify the time lag in the tubing. Typically it is a bit over 1 second.



During 5 minutes of each hour the ambient air flow was manually replaced by zero air, to measure the instrument blank. Our original plan was to switch the flow through a tube filled with gold-coated glass beads that adsorb DMS. This would preserve all other aspects of the ambient air (humidity, trace gases, etc) for blanking purposes. Unfortunately, the glass wool we used to hold the beads in place was friable and began breaking apart, blowing into the MS aperture and partially blocking it. We had to eliminate that system once we identified the problem, and go back to using zero air for blanks. Problems with a timing card meant that we had to manually switch to zero air every two hours, around the clock.

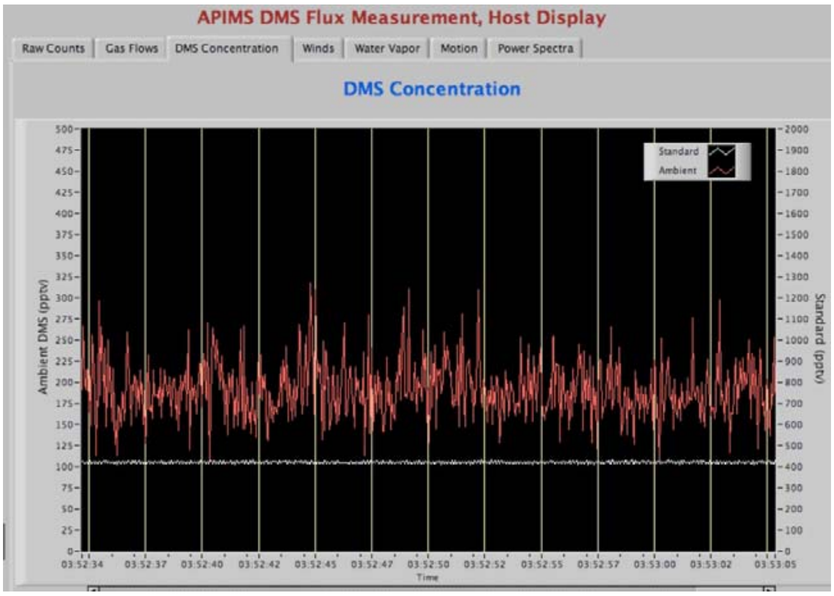
We had some power problems initially. Our air conditioner runs only on 220/60 Hz power, but 60 Hz power is only made as 110vac on the ship. Thus, we had to have a transformer (for 110 to 220) and a long line to run the 220/60 to the container on the bow. Initially the 110/60 was on a 32A breaker, so that our system kept flipping the breaker. Thus we had several days of power spikes and unexpected shutdowns. We believe one of these outages may have damaged our IRIG timing card, so that our precise times are somewhat ambiguous.

Two solutions were implemented: the transformer was put onto a 62A breaker, and we ran a 220/50 line to power our biggest pumps. Unfortunately, while the pumps are rated for 220/50, their backflow prevention valves were only rated for 110 vac. Thus, we burned our the valve's solenoids and had to operate with no protection against an inrush of oily air from the pumps to the vacuum chambers in the event of a sudden power loss. Since the A/C caused a big drop in the voltage each time it came on, we wound up not using the A/C. Fortunately the weather was such that we had that option. During most days we cracked a window to reduce the temp in the container a bit.

We expect to have DMS flux data (for all times that the wind was from a suitable direction) from 1600 CUT on 26 June to 0600 on 17 July 2007. There may be some useable data before 16 June, but that is when continuous data collection began. The APIMS was shut down (due to high seas and a concern that intense vibration on the bow might damage our turbomolecular pumps) from 1300 on 30 June to 1500 on 1 July. Throughout this time we will also have momentum and heat flux data, which we could submit if there is interest.

Results

Immediately after DOGEE we had an airborne field program on Christmas Island, so our DOGEE data processing has just begun. The rapid atmospheric DMS concentrations have been blank-corrected and cleaned up, so they are now in final form. We are working now on



the wind and motion data, but we have no flux results to show yet. From our real-time display of winds, motion, and concentrations (**Figure 65**), we believe the instruments were operating properly. We expect to have final flux data available before the end of 2007.

The ambient DMS concentration was usually quite low, because we were working in an oligotrophic (non-productive) area. (This was confirmed by the fact that even the ASIS buoy that was in the water for 3 weeks had nothing growing on it.) Steve Archer's SW DMS concentrations were often in the range of 1-2 nM, which is on the low side. Our atmospheric concentrations were generally in the 100-150 ppt range at sunrise, dropping to 25-50 ppt by sunset. We did get some concentrations above 200 ppt, during rain events and in the presence of high winds. Both factors would increase the transfer of DMS from ocean to air. **Figure 65** is an example of the ambient DMS variation typical of a large flux: concentrations jump from 125 to almost 300 ppt in a fraction of a second, as updrafts and downdrafts pass the intake tip.

These low concentrations were a bit of a disappointment to us, since we originally thought we would be working in a bloom. We understand, however, that the unfortunate experience on the first DOGEE cruise encouraged the planners (and the Captain) to seek much calmer waters, which are farther south than the most productive waters. Tradeoffs of this sort are required in all field programs. We hope, however, that the low atmospheric concentrations do not reduce our signal-to-noise ratio so much that we cannot see the impact of the surfactant patches and other flux-controlling factors. We will see when the data processing is completed.

Sensitivity was a problem early in the cruise, but improved throughout. We need to have at least 50 counts per second per ppt of DMS concentration to compute reliable fluxes. There were times early in the cruise when we were barely above this level. As the cruise wore on, however, and the MS operated for a longer time, the sensitivity improved considerably. By the time we started back toward Glasgow, the sensitivity was in the 150-250 cps/ppt range. The only exception was that during maneuvering we sometimes sampled ship's exhaust. Exhaust knocked our sensitivity almost to zero and it took a while to recover after such an exposure. Fortunately, the bow was kept into the wind as much as possible. Virtually every night the ship steamed slowly into the wind, so we should have many hours of good nighttime fluxes.

One major concern with our data is our ability to sync with the time of the ship's data, since our IRIG timing system failed early in the cruise, we think during a power outage/surge. Since we need to integrate our data with the ship's position and motion data, we have differentiated the ship's pitch and roll angles to get angular rates that we are now autocorrelating with our own angular rates, to sync the two times during each hour of observations. The ship's position, gyro, and speed-through-the-water data will then be integrated into our wind and motion record to derive winds relative to the Earth and relative to the currents.

Another concern is an apparent vibration at about 5 Hz in our y-acceleration and x-rotation data. We believe this arose because our mounting plate was affixed to the mast on its port side, but had no bracing on its starboard side. This resulted in an intermittent vibration which we will remove with a digital low-pass filter.

Since our flux data will be used with Steve Archer's SW DMS data, we intercalibrated our cylinder of ILS with Steve's permeation tube by filling GC loops of known volume with our deuterated cal gas and analyzing them with his GC. The results were very encouraging. Thus we know we will be on the same footing as we combine our data sets.

Summary

This looks like an excellent data set of DMS flux data, with negligible blanks and excellent sensitivity, to use for comparison with other fluxes and flux controlling factors. Of particular note is the period of high winds (**Figure 66**) during which we collected data in winds exceeding 15 m/s. Since high-wind data is particularly hard to come by, we are hoping that the motion correction will be adequate under these conditions so we can add some points at high wind speeds.

We are very excited about this SOLAS/DOGEE cruise, since it is the first time we have been able to compare our DMS fluxes with so many related parameters. We have every reason to believe that a tremendous amount will be learned about modeling air-sea gas exchange in the summer Eastern subtropical Atlantic.

We should not consider ourselves done, however. Without question the factors dominating ASE will differ from one region and season to another. Conducting DOGEE-like experiments in other locations is therefore necessary to learn how ASE should be modeled in various ocean regions. Similar cruises (benefiting from lessons learned on Cruise 320) should be planned for higher latitudes (not in November!), more productive regions, blooms of various kinds, coastal areas, etc.

Dimethyl sulphide concentrations in seawater (DMS_{sw})

Stephen Archer and John Stephens,
Plymouth Marine Laboratory.

Context:
This work formed the major component of Grant NE/E011489/1: A comparison of sea to air DMS flux measurements and the possible role of near-surface gradients: Nightingale & Archer; in close collaboration with Huebert et al. University of Hawaii.

The objectives of the project were (in order of importance)
1. To determine the impact of solubility on air-sea gas transfer rates
2. To inter-compare direct and indirect techniques to determine the air-sea flux of DMS
3. To investigate the role of near-surface vertical gradients on the air-sea flux of DMS
4. To investigate the possible role of the *ssm* on air-sea fluxes of DMS

In this context, we aimed to produce high temporal resolution DMS_{sw} concentration data in near surface water that was linked to the period when DMS flux could be measured using the ILS-APIMS of Huebert et al. This would enable improved estimates of K_{DMS} to be determined and compared to other approaches / gases and related to the variety of sea-surface properties being studied during DOGEE II

Method

The DMS_{sw} 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 calibration we used an off-the-shelf DMS permeation device, with the sampled volume routed through the entire purge-and-trap system. Purge efficiency was determined by repeated purging of the standard volume samples (4ml).

We also tested an automated system based around a membrane equilibrator system linked to the Varian PFPD with seawater sourced from the continuous Fish supply.

Preliminary results.

1. Continuous seawater supply:

We tested for differences in towed-fish and the ship's non-toxic supply on several occasions, generally with obvious difference in DMSsw apparent (see Table). As a result we focussed on obtaining DMSsw from the fish supply that was generally towed at < 2m depth, compared to the non-toxic supply inlet at 5-6 m.

Table 16. Comparison of fish and non-toxic supplies measured 'whilst stationary', supplies sourced alternately (n = 3): Even at the lowest DMSsw concentrations significant differences between seawater sources were apparent.

Depth	Mean	S.D.	Precision (%)
2m	0.34	0.04	11.4
5m	0.26	0.02	7.8

2. Intercomparison of DMS measurements

We used a portable gas-sample loop (PGL) to compare our permeation standard with that of the deuterated gas standard used in the ILS-APIMS. Encouragingly, our DMS concentrations were within < 10% of those of the University of Hawaii's standard (**Table 17**).

Table 17. Five estimates of the gas concentration in the University of Hawaii deuterated-DMS standard.

ng S /ml	Average	S.D.
0.97		
0.96	1.00	0.04
1.03		
0.99		
1.04		

This level of agreement gives us a sound basis from which to develop K_{DMS} estiamtes.

3. High temporal resolution DMSsw determination linked to flux measurements

Figure 67 illustrates the degree of resolution achieved for the DMSsw measurements over the head-to-wind operation period during most nights. The large variations in DMsw also illustrate why this high-resolution data, certainly on this occasion, is necessary if accurate k_{DMS} values are to be calculated.

We were able to generate DMSsw data linked to DMS flux data at wind speeds ranging from < 1m s^{-1} to > 15 m s^{-1} and a wide variety of sea-states.

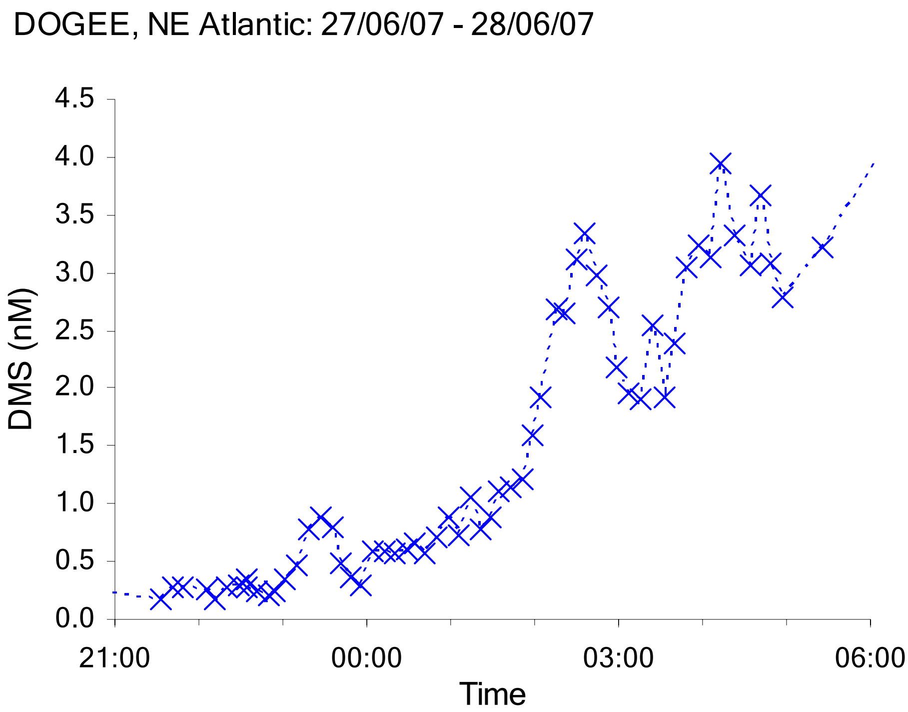


Figure 67. Plot to show the degree of resolution achieved for the DMSsw measurements over the head-to-wind operation period during most nights.

4. High DMS concentrations (and DMS flux) in an Emiliania huxleyi bloom:

Most of the crusie was conducted in relatively low DMS-producing waters. However, the transect north to Govan gave us the opportunity to measure DMS flux and determine K_{DMS} in an *E. huxleyi* bloom, with what turned out to be high (> 20 nM) DMSsw concentrations.

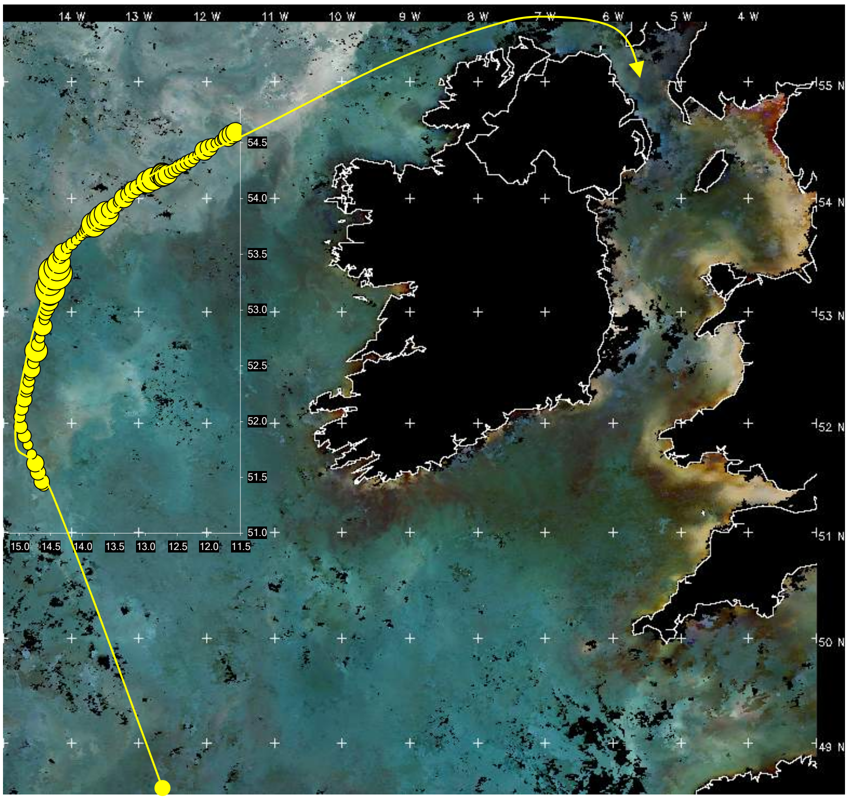


Figure 68. DMSsw concentrations on the cruise track through the *E. huxleyi* bloom off the West Coast of Ireland. Maximum DMSsw was ~ 20 nM.

5. Near surface gradients of DMSsw.

We looked for vertical gradients in DMSsw at a variety of resolutions: CTD casts (100 to 2m), Fish (< 2m) vs Non-toxic (5-6 m) seawater supplies and using the PML Near surface sampling device.

Future:

Processing of both flux data and DMSsw data are currently underway and are expected to yield exciting results, especially when compared to other approaches / gases and the sea-state measurements.

Biochemical gradients near the sea surface

H.J. Zemmelink[1)], J. Cluderay[1)], H.A. Slagter[2)]

[1)] Royal Netherlands Institute for Sea Research, 1790 AB Den Burg, The Netherlands
[2)] University of Groningen, Laboratory of Marine Biology, 9750 AA, Haren, The Netherlands

In order to gain insight into the biochemistry of the near surface water column we have sampled the sea surface microlayer during DOGEE II. We have conducted a series of short, 1 hr, sampling cruises to get a measure of the variability of the biochemistry of the near surface water column. Samples were taken from the surface microlayer by a rotating glass cylinder that is supported by a remotely controlled catamaran (**Figure 69**). This setup collects, with each rotation, a film of 50 µm by adherence to the cylinder. The collection speed can be adjusted but the cylinder allowed collection of sea water up to 200 ml min^{-1}. The system incorporates three additional sampling lines, mounted near the glass cylinder, that supply subsurface water through inlets at 0.1 m, 1 m and 2 m depth. Collected water was stored in 500 ml gas tight bottles from which subsamples were taken for analysis of biochemical compounds. During each deployment the water was sampled for dissolved inorganic carbon (DIC), alkalinity, dissolved organic carbon (DOC), dissolved organic nitrogen (DON), nitrate/nitrite (NO_3/NO_2), ammonium (NH_4), phosphate (PO_4), silicate (SiO_4), surfactants, chlorophyll *a* (Chl. a), dimethylsulfide (DMS), dimethylsulphoniopropionate (DMSP), dimethylsulfoxide (DMSO), bacterioplankton, phytoplankton and viral particles.

DMS profiles varied and showed both enrichment and depletion of DMS at the surface microlayer in comparison to subsurface water. Analysis of other compounds will be conducted in the laboratory at the NIOZ.

Alternative methods for sampling of the surface microlayer are to manually submerge and withdraw a glass plate or a metal screen into the water column. However, a potential artifact introduced by the three sampling techniques is the loss of volatile compounds to the atmosphere. This systematic error was assessed in collaboration with Plymouth Marine Laboratories and the University of Southampton. We have prepared a solution of DMS and SF6 in a 200 L tank (**Figure 70**). The solution was thoroughly mixed by an electrical outboard propeller, creating an upwelling flow from the bottom of the tank to the surface in order to inhibit the formation of a gas depleted surface layer. The surface was sampled by the glass cylinder, by the glass plate and by the metal screen. A second sample was collected from 0.05 m depth through tubing at 0.03 m distance from the cylinder. By creating the upwelling flow and taking water from approximately the same location in the tank, it was assumed that any difference between the microlayer samplers and the subsurface inlet would be due to a loss of volatiles to the atmosphere. Testing the glass plate and metal screen showed a significant loss of 75% of DMS and SF_6 the sampling artifact introduced by the glass cylinder was a loss of 30% of DMS and SF_6.

Figure 69. Ventral view of the remote controlled catamaran and skimmer holding the glass drum (between the floaters).

Figure 70. Detail of the glass cylinder and the outboard in the blue tank containing a solution of DMS and SF_6 in order to study the loss of volatiles on the cylinder.

Oxygenated volatile organic compounds

Joanna Dixon, Rachael Beale & Phil Nightingale, PML

Aims

1) To determine the biological uptake rates of methanol in seawater, and assess the spatial and temporal variability during the cruise
2) To investigate the fine scale variability in biological methanol uptake in the top 2 m of the water column (using the PML Near Surface Profiler, NSSD)
3) To assess the relationship between heterotrophic bacterial production and rates of methanol uptake in a) the euphotic zone, b) the near surface 2m and c) the micro-layer
4) To compare heterotrophic bacterial production and biological methanol uptake in the surface micro-layer in samples collected by the Garret Screen and NIOZ skimmer
5) To continue with developing a GC-FID method for the determination of OVOC compound in seawater

Methods

Water was collected from the CTD casts, NSSD & NIOZ skimmer deployments, and from Garrett screen & pipette samples (c. 10 cm depth) obtained from rib deployments, thus allowing fine scale resolution in the top 2 m of the water column, including the surface micro-layer, and from the euphotic zone. On one occasion, deep samples were obtained from the CTD (to 1000 m) to assess methanol uptake rates at depth.

Methanol Uptake: Cellular methanol incorporation rates were determined by incubating 1.7-100 ml seawater with $^{14}CH_3OH$ for between 5 mins – 48 hrs (depending on experiment). Final concentration of $^{14}CH_3OH$ added varied between 10-100 nM (final concentration) also depending on experiment. Samples were terminated by either filtration onto 47 mm diameter polycarbonate filters (0.2 and sometimes 2.0 µm pore size) or by addition of TCA (5% final concentration) to 1.8 ml samples and extraction by centrifugation. Total $^{14}CH_3OH$ respiration to $^{14}CO_2$ was determined by addition of 10-100 nM $^{14}CH_3OH$ to 1 ml seawater samples, incubation at in situ temperature in the dark for between 5 mins – 48 hrs (depending on experiment) and termination by the addition of 20 µl of 1M NaOH, 0.5 ml of 1M $SrCl_2.6H_2O$, and 100 µl of 1M Na_2CO_3 (to ensure adequate pellet formation).

Bacterial production (BP): 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] 1.7 ml seawater samples were inoculated with 25 nM ^{3}H Leucine (10 µl) (as determined by a Vmax experiment carried out on 01/05/04) and incubated in the dark at in situ temperature for 1 hr. Samples were terminated with 100% TCA (5% final concentration), and incorporated ^{3}H extracted following procedures outlined in Smith & Azam 1992 before being measured by liquid scintillation counting.

Samples for Flow Cytometry analysis: Duplicate 1.8 ml seawater samples were fixed with paraformaldehyde, flash frozen in liquid nitrogen and stored at -80°C for later analysis by flow cytometry back in the laboratory. Table 18 shows a full list of samples collected.

[1] Smith, D.C and Azam, F. 1992 Marine Microbial Food webs 6(2): 107-114.

Table 18. OVOC samples collected during D320:

Date	Time	Station	Samples collected
Sun 17 June 07	~16:00	CTD 01 (Stn 2) 49°02.50 N 9°52.85 W	V_{max} experiment for ^{3}H leucine uptake (BP) Time course incubation experiment for cellular $^{14}CH_3OH$ uptake and $^{14}CO_2$ respired on total & 2 µm filtered water (from 10m)
Wed 20 June 07	~14:41	CTD 02 (Stn 3)	BP & AFC samples from 5 & 50m V_{max} kinetic size fractionation expt for $^{14}CH_3OH$ uptake
Thur 21 June 07	08:28	CTD 10 (Stn 11)	Time course cascade filtration expt for BP & $^{14}CH_3OH$ uptake
Fri 22 June 07	12:00	CTD 11 (Stn 14)	Small volume $^{14}CH_3OH$ isotope dilution expt on surface water Large volume $^{14}CH_3OH$ uptake, BP & AFC samples at 5, 50 & 100m.
		NIOZ skimmer	Large volume $^{14}CH_3OH$ uptake, BP & AFC samples on µ layer & 10 cm depth samples
Sun 24 June 07	~11:00	RIB	Large & small volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer & 10 cm depth samples
	~16:08	CTD 15 (Stn 25)	Large & small volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on 2, 50 & 100 m depth samples
Mon 25 June 07	~18:30	RIB	Large & small volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer & 10 cm depth samples BP & AFC from surfactant slick Surfactant/ 10 cm water mixing expt for BP only
Tue 26 June 07	~18:48	CTD 18 (Stn 34)	Large & small volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on 5, 40 & 100 m depth samples
Wed 27 June 07	~11:30	RIB	Large & small volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer & 10 cm depth samples which were in the surfactant slick.
	13:54	CTD 19	Large & small volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on surface, 50 & 100 m depth samples
Thur 28 June 07	13:15	RIB	Large & small volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer & 10 cm depth samples
Sun 1 July 07	~10:15	FISH	$^{14}CH_3OH$ uptake experiments varying concentration of spike added & sequentially filtering through 2 & 0.2 µm filters

Date	Time	Station	Samples collected
Tue 3 July 07	~10:30 – 10:40	FISH	$^{14}CH_3OH$ isotope dilution expt
	14:35	CTD 29 Stn 60	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on 5, 20, 40, 50, 75 & 100 m depth samples
Wed 4 July 07	10:00	CTD 31 (deep CTD)	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on 10, 25, 50, 100, 700 & 1000 m depth samples
	~11:30	NIOZ skimmer	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer, 10, 100 & 200 cm depth samples
	~14:10	RIB	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer by Garrett Screen & Glass Plate and 10 cm from pipette samples
	~14:10	NSSD (Bottle 3 didn't fire)	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on 25, 44.5, 84, 105, 151, 182.5, 217 cm depth samples
Thu 5 July 07	~13:30	RIB	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer by Garrett Screen and 10 cm from pipette samples, 3 replicates both IN and OUT of second slick deployment
Fri 6 July 07	11:32	CTD 33 (Stn 75)	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on 2, 5. 10, 20, 50 & 100 m depth samples
	~14:00	NIOZ skimmer	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer, 10, 100 & 200 cm depth samples
Sun 8 July 07	~09:00	FISH	Large volume $^{14}CH_3OH$ isotope dilution experiment
	~17:00	NSSD (Stn 89)	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on 25, 44.5, 64, 84, 105, 217 cm depth samples
	~17:00	RIB	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer by Garrett Screen & Glass Plate and 10 cm from pipette samples,
	~20:20	NIOZ skimmer	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer, 10, 100 & 200 cm depth samples

Date	Time	Station	Samples collected
Mon 9 July 07	~08:00	FISH	Large volume $^{14}CH_3OH$ uptake & small volume $^{14}CH_3OH$ respiration time course expt
	~13:30		Stated large volume $^{14}CH_3OH$ Vmax expt from water collected on 8/7
	~18:30	RIB	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer by Garrett Screen & Glass Plate and 10 cm from pipette samples,
Tue 10 July 07			Filtered V_{max} & time course expts.
	~15:00	NIOZ skimmer	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer, 10, 100 & 200 cm depth samples
		RIB	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on µ layer by Garrett Screen and 10 cm from pipette samples,
	~19:30	NSSD	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples on 25, 44.5, 64, 84, 105, 217 cm depth samples
Thu 12 July 07	DIEL Started at 07:0(	FISH	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples taken every hour over 24 hrs with concurrent SF6 measurements.
Commence steam home & take FISH samples through Chl gradient.			
Sat 14 July 07	09:00	46° 17'43.3N 14° 53'15.3 W	Large volume $^{14}CH_3OH$ uptake, $^{14}CH_3OH$ respiration, BP & AFC samples from ~5m
	11:00	46° 38'50 N 14° 48'22.5 W	
	13:15	47° 02'18.6 N 14° 42'51.3 W	
	15:00	47° 21'36.7 N 14° 38'13.9 W	
Mon 16 July 07	~12:00	54° 12'33 N 12° 41'34.5 W	
	~14:00	54° 12'10.8 N 12° 46'06 W	
	~17:00	54° 10'09.7 N 12° 44'28.7 W	

Method development of analytical technique for the extraction of OVOCs from sea water: Several different variables tested during the course of D320, including a packed column and Reduction Gas detector (RGD) and PLOT column and Flame Ionisation Detector (FID).
Also investigated was an equilibrator system that incorporates a sample pump, 10-port valve and the FID. This showed promising results, particularly with methanol, isopropanol and acetone. No sea water samples were collected, instead sea water from the non-toxic ship supply was used to 'spike' samples and produce appropriate standards.
Peltier plates were tested for cooling a sorbent trap on which to isolate OVOCs from a gas stream. Ethanol and acetone responded well to these conditions.
No measurements were made on this cruise for the concentration of OVOCs in sea water. Method development continues.

Measuring Atmospheric Concentrations of Oxygenated Volatile Organic Compounds during DOGEE II

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Introduction: A Modified Adsorption/Desorption System (MADS) is currently being developed to monitor oxygenated volatile organic compounds (OVOCs) in the atmosphere. Using gas chromatography coupled with mass spectrometry (GCMS) as the detection method, the atmospheric concentrations of 15 OVOCs can be measured. The aim is to develop and improve the current system so that accurate measurements of atmospheric OVOCs can be made.

Instrumentation: The system uses two adsorbent traps to pre-concentrate the OVOCs in the sample, to reduce the water content of the sample and to refocus the concentrated sample for rapid injection onto the GC column. The standard gas used for calibration contains 15 OVOCs at concentrations of approximately 500 ppb for each compound. The standard cylinder also contains butane and benzene, as these are known to be stable within the cylinder. The standard is diluted to ambient air concentrations (ppt to low ppb) by injecting 50 µl loops into zero air (from a generator situated beside the instrument) which is then passed over the first trap. This zero air (ZAG) is also used as the blank sample. The sample is then passed through a GC column and analysed using a MS. The MS is set to run in selected ion monitoring (SIM) mode, which allows the MS to focus only on certain ions for certain lengths of time, therefore improving the signal to noise ratio and increasing the sensitivity of the instrument.

Sampling: The sampling sequence used for the majority of this cruise was:

Blank – Standard – Blank – 10x Air – Blank – Standard – Blank – 10x Air

Ideally the sequence would consist of alternating standard and air samples but due to issues with carryover it was necessary to a) include blank samples to allow estimates of background levels of compounds be calculated and b) reduce the number of standard samples used thus reducing the level of carryover from these. Initially 200 µl of standard was injected onto the trap but this was reduced to 100 µl. This reduced the concentrations of the compounds in the standard to similar levels seen in the air samples.

The total run time for all sample types (standard, air and blank samples) is 50 minutes. Sampling is carried out for 12 minutes of this. The volume of all samples in this study is 300 ml, which allows direct comparisons to be made between all sample types.

The air sampling inlet was attached to the top of the main mast approximately 24 m above sea level. The PFA line was 50 m in length, with air being continuously pumped through it. The air samples were taken directly from this, at approximately 44 m from the air inlet.

Towards the end of the cruise, the length of time that the air sampling line (leading from the main PFA line) was flushed prior to sampling was increased to 2 minutes in order to minimise the carryover from one run to the next.

Because of the issues with carryover from the standard runs, tests were also run in which a standard sample was run through the system followed by 12 blanks. This cycle was repeated up to four times. The average rate of decrease from one blank run to the next was estimated for each compound. This was then used to estimate the background levels of the compounds present in the air samples as a result of carryover from the previous standard sample. These estimated values were then subtracted from the air samples to give a more accurate result.

Preliminary Results: The compounds that were focused on for this cruise were acetone, methanol and acetaldehyde. The concentrations for these compounds were higher than those for the other OVOCs looked at. The levels of benzene seen were also quite high, but the error associated with the concentrations of benzene will be quite high as significant levels of carryover have been seen for this compound in the past.

The results shown in **Table 19** have been calculated assuming that the only carryover seen is as a result of the standard runs. However, there appears to be significant carryover from air sample to air sample for methanol, acetone and benzene. The calculations used to convert the results into concentrations need to be altered to take this into consideration.

Occasionally, the wind was blowing from the aft of the ship, meaning that fumes from the stack were sampled. This led to elevated levels of concentrations in all of the compounds. To compensate for this, the range of concentrations shown in table ? exclude any values outside the 5^{th} and 95^{th} percentiles.

1-Methyl-3-Buten-2-ol is converted to isoprene within the system due to the high desorption temperature of the bulktrap (330 °C). Both hexanal and 1-butanol show very poor peak shape and so have not been converted to concentration values.

Summary: The instrument itself worked very well throughout the entire cruise. However, the issues arising from the carryover of compounds from one run to the next have meant that the errors associated with the concentration calculations will be high. More development work needs to be carried out in order to reduce this problem. Possible improvements include the use of different adsorbents or glass beads to trap the compounds, altering the trapping and desorption temperatures and increasing the length of time that the system is cleaned for between sampling.

Table 19. Preliminary results showing the estimated range and average concentrations for the 17 compounds present in the standard.

Compounds	Range of Concentrations (ppt)	Average Concentration (ppt)
Methanol	30 - 120	67
Ethanol	1 - 30	12
1-Propanol	1 - 10	1
1-Butanol	Poor Peak Shape	–
2-Methyl 3-Buten-2-ol	Dehydrated to Isoprene	–
Acetaldehyde	90 - 280	184
Propanal	20 - 70	37
Butanal	10 - 40	25
Pentanal	10 - 40	23
Hexanal	Poor Peak Shape	–
Acrolein	20 - 140	37
Methacrolein	1 - 10	8
Acetone	260 - 810	512
Methyl Ethyl Ketone	20 - 60	37
Methyl Vinyl Ketone	10 - 70	40
Butane	1 - 10	4
Benzene	1 - 1050	158

Computing and Instrumentation Report: D320

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RVS LEVEL ABC System

The LEVEL ABC system is a system comprised of multiple components that can be adjusted and altered to suit the needs of the cruise in progress. The system is due to be retired due to its age and the difficulty in acquiring spares. The ABC system is created of 3 tiers:

- Level A - The Level A's role in the system is to acquire the data from an instrument, parse the data stream into the necessary format to be recorded by the level B and also place a timestamp on each piece of data. The instruments are connected to the Level A's via RS-232 and are also connected to the level B in the same way. This allows simple interrogation of messages when attempting to track a problem with the system.

- Level B - The level B is sent all data from the Level A's and allows you to view all the data as it is coming in. The Level B allows the backup of the data to magnetic disks which are backed up on the Level C in compressed Zip format. The Level B transmits the data to the Level C and the data is parsed directly into the RVS data files that we use now. All data, errors, comments can be viewed for each individual instrument.

- Level C - The level C system is a Sun Solaris 10 UNIX Workstation discovery1 also known as ABCGATE. The RVS software suite is available on this machine. This suite of software allows the processing, editing and viewing of all data within the RVS data files. This system also has monitors that allow us to ensure that the level C is receiving data from the level B.

The Level A's acquire their timestamp from a Radio code GPS Clock that is distributed via the RVS Master / Slave Clock System.

The ABC system still remains the main data logging format for the ship, this is being run in parallel with the new Ifremer Techsas Sensor Acquisition System. This system is currently being proven and a database of drivers being built to enable us to interface with the instruments on board.

This system will then become the primary system for data logging.

For this cruise the Level A system were used to log:

1) Ashtec ADU-2 multi antenna GPS with attitude (gps_ash)
2) Ashtec GPS G12 integral to the FUGRO Seastar DGPS receiver (gps_g12)
3) Simrad EA500 Precision Echo Sounder (ea500d1)
4) NMFD Surface-water and Meteorology instrument suite (surfmet)
5) NMFD Winch Cable Logging And Monitoring CLAM (winch)
6) Chernikeef Log – Ship's speed through water (log_chf)

The RVS level ABC system suffered no major issues during the cruise with the exception of the full loss of power to all ships systems, total loss of data was around 2 hours for most instruments, mainly due to the need to reset almost all devices that are used in the data logging process. During the power outage the computer room clean supply was turned off incase of spiking in order to protect equipment. This was successful and no further damage occurred to the ABC system or the Ifremer Techsas system.

Ifremer Techsas System

The Ifremer data logging system is the system that will inevitably replace the existing Level A + B system while for the most part the Level C will remain as the main system for outputting, viewing and editing the acquired data.

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 also backed up from the Level C using a 200GB / 400GB LTO 2 Tape Drive. 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 NMEA.

The storage method used for data storage is NetCDF (binary) and also pseudo-NMEA (ASCII). At present there are some issues on some data streams with file consistency between the local and network data sets for the ASCII files. NetCDF is used as the preferred data type as it does not suffer from this issue.

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

1) Trimble GPS 4000 DS Surveyor (converted to RVS format as gps_4000)
2) Chernikeef EM speed log (converted to RVS format as log_chf)
3) Ships Gyrocompass (converted to RVS format as gyronmea)
4) Simrad EA500 Precision Echo Sounder
5) NMFD Surface-water and Meteorology (SURFMET) instrument suite
6) ASHTECH ADU-2 Altitude Detection Unit
7) University of Rhode Island Aanderaa Desloved Oxygen Optode (coverted to RVS Format as optode)
8) University of Rhode Island Pro-Oceanus Gas Tension Sensor (converted to RVS Format as HGTD)

This system is still being trial run by the platform systems as the replacement to the aging RVS system, no major issues occurred during this cruise and no substantial data losses occurred. An attempt was made to install the most recent version of the software however this failed and attempts were made during the cruise to upgrade the software on a separate machine. No Techsas crashes occurred. Continued monitoring of the Systems Swap Space using the TOP program allowed us to remain aware of time when the system would possible become unstable. Data was lost due to resetting of the unit in the order of 2 minutes at each restart of the logger.

Techsas NetCDF to RVS Data Conversion

During this cruise there is no reliance upon the data provided by Techsas, however it has been included on the data archive in the standard rvs form using a piece of software used to make it compatible with the RVS ASCII data structure. The University of Rhode Island instruments were logged using the Techsas system and had to be converted to the RVS format in order to be able to create data logs that included multiple variables from other RVS streams.

An in house application was used to handle the conversion of NetCDF files to the RVS format. This was then parsed back to the data file and was processed as normal. These 2 new applications being ncvars and nclistit.

These new binaries require to environment variables in order to function:

$NCBASE – the base for the NetCDF binaries system, set to /rvs/def9

$NCRAWBASE – the base for the raw data files, set to /rvs/pro_data/TECHSAS/D320/NetCDF

The existing $PATH variable must also include the path to the nc binaries, the path /rvs/def9/bin was appended to the $PATH variable.

All Techsas data file names are in the format of YYYYMMDD-HHMMSS-name-type.category with the data/timestamp being the time the file was created by Techsas.

The files were each processed in the following way for this cruise:

nclistit 20060813-000001-gyro-GYRO.gyr - | sed s/head/heading > $DARAWBASE/gyro.225

At this stage the data is converted to the correct format and its header replaced by the header required by the RVS software suite.
Another issue with the conversion of the files to the RVS format is that the top timestamp is always outputted as 00 00/ 00:00:00. The file outputted with nclistit is then edited in VI in order to alter that timestamp to the correct time and day. This is done as it would not be imported into the RVS data format with this timestamp error.

The file is then passed to the titsil application which simply reads the data from the text file that was created and enters it as records in the RVS data file.

cat $DARAWBASE/gyro.225 | titsil gyronmea –

This command reads the gyro.225 file in the /rvs/raw_data directory and passes it to titsil for input in the gyronmea file. The – dictates that all variables will be included.

The TECHSAS system was set to create a new file for each day, however on days when errors occurred multiple files were created as that is normal practice for Techsas when it is restarted.

During this cruise techsas was successfully used to log 3 new sensors bought on board by the University of Rhode Island, after slight tinkering due to differences in data output (lost in translation in e-mail correspondence) the logging procedure began and there were few issues with techsas logging these instruments. Despite having checked the devices cabling and route to the system some confusion at the beginning of the cruise resulted in the 2 of the devices (both Gas Tension devices) being logged by the opposite name. The devices were swapped at the beginning of the cruise and it is now apparent that they should not have been. This is easily rectified using the RVS systems applications.

Fugro Seastar DGPS Receiver

The Fugro Seastar is the source of custom differential corrections based on its position fixed by its internal Ashtec G12 GPS module. It outputs corrections via RS-232 using the standards RTCM message. The message is distributed among all GPS receivers where they are used to compute their own DGPS positions.

The Fugro Seastar functioned correctly throughout the cruise. There have been issues with this system previously not detecting the correct satellites due to location. However in this instance it performed correctly and differential positions were calculated throughout the cruise.

This system will be removed at the end of the cruise due to a need to reprogram the EPROM chip that contains the programming inside the device. This was due to be done earlier in the cruise however time did not allow for that to happen. The overall performance of the device will not be affected however Fugro will no longer be supplying the same message to the unit and each unit must be reprogrammed to function after the end of July of this year.

Trimble 4000 DS Surveyor

The Trimble 4000DS is a single antenna survey-quality advanced GPS receiver with a main-masthead antenna. It uses differential corrections from the Fugro Seastar unit to produce high quality differential GPS (DGPS) fixes. It is the prime source of scientific navigation data aboard RRS Discovery and is used as the data source for Navigation on the ships display system (SSDS)

Ashtec ADU-2

This is a four antenna GPS system that can produce attitude data from the relative positions of each antenna and is used to correct the VMADCP for ship motion. Two antennae are on the Bridge Top and two on the boat deck.
The Ashtec system worked reliably throughout the cruise with some gaps that are quite usual with this system due to the amount of calculations necessary. No Large data gaps are present. The ADU-2 forms part of the bestnav system which is an assembly of multiple GPS signals

including the gyronmea and emlog stream in order to calculate the best possible position, speed heading pitch and roll of the ship.

Gyronmea

The Gyronmea is a file that receives its data from the Ships gyro compass located on the bridge. There are two such Gyros on the bridge and we are able to use either one of them as a source of heading. The selected Gyro is logged by the TECHSAS system and is used as part of the bestnav calculation.

Dartcom satellite imaging system.

The dartcom system is able to receive signals from satellites that take images of cloud coverage, these images can be used to see the type of atmospheric and weather conditions nearby. Some Dartcom images were logged during the cruise, however a few problems occurred during the cruise. The first being that the system was frozen at the beginning of the cruise followed by an apparent reset of the PC. The network issues on the coax system also caused many problems with the images due to not being able to access the archive from the computer room.

RDI Ocean Surveyor 75KHz Vessel Mounted ADCP (VMADCP)

Data from the RDI Ocean Surveyor was logged throughout the cruise and backed up to the /data32 shared data area. The ADCP 75 was setup to follow the settings as agreed with Ricardo Torres. They can be found in the command files on disk 3. The system was altered when we reached the area where patch deployment was to occur on 071730959 The system was reconfigured to 4 meter bins in order to achieve a better resolution through the mixed layer.

Command Files Used
071661744 D320.txt
071730959 Changed to D321.txt until end of logging 071981419

This can also be viewed in the command files that were used for both legs of the cruise that are included in the ADCP area of the data archive. The ADCP computer was time synced to the NTP server at the beginning of the cruise prior to the commencement of logging. The computer is setup to automatically sync its time with the NTP server on a daily basis.

RDI 150KHz Vessel Mounted ADCP (VMADCP)

Following several difficulties in the previous cruises with this system the transducer head was replaced prior to sailing D317. The ship was attended by a Teledyne RDI consultant who assisted in checking over the setup of the ADCP 150Khz and ADCP 75Khz systems. The transducer had been giving several errors during the cruise which would indicate that the transducer head was damaged. Problems also existed with the PC that was in use. No navigation signals were being received by the unit and the ensemble out would not function. This ensemble out allows the RVS system to grab data on a 2 minute interval from the ADCP 150Khz system. Following the visit by the RDI Consultant the system was able to handle both navigation input and ensemble output. However that seems to have now changed once more. The ADCP 150 is still receiving the GPS messages and still has the setup within its file to handle the data however it does not seem to function correctly. This appears to be a fault in the way that the VMDAS software is handling the navigation or possibly the comm ports. The system was logged without navigation to the local hard disk and also to the RVS Level C where it can be concatenated with the navigation data. This system is due for upgrade next year during the 2008 dry dock.

The ADCP computer was time synced to the clock before logging began. Due to the age of the system it is not possible to use an NTP service. The clock is synced through visual comparison to the ships GPS display. This was done before logging began at 07167210024. The ADCP then ran continuous until it was stopped in order to resync the clock due to its large gap with GPS time. Time was synced at 07180081700 and logging was resumed at 07180081715. Time drift at this point was 12 minutes 29 seconds. Between the time sync and the end of the cruise the time had drifted 7minutes 34 seconds.

The ADCP 150Khz was setup as the 75Khz as seen in the command files. The system was setup for 40 bins, 16 meters until the same time as the ADCP75Khz when it was changed to 4 meter bins.

Chernikeef EM log

The Chernikeef EM log is a 2-axis electromagnetic water speed log. It measures both longitudinal (forward-aft) and transverse (port – starboard) ships water sped.

The EM log was not calibrated prior to the cruise and was reading at -0.8 knots astern when alongside (-0.8 knots)

The system was logged by the TECHSAS logging system and also the RVS Level A system. Data loss of the log_chf occurred during the Logout of the Level C this data was recovered from the TECHSAS logging system in order to remove the gaps from the data.

Simrad EA500 Precision Echo Sounder (PES)

The PES system was used throughout the cruise, with a variation between use of the Fish and use of the hull transducer. The hull was used for the trials cruise and the PES Fish was put out during most of D318a and D318b.
The PES outputs its data to a stream called ea500d1 on the RVS System and is also logged by the TECHSAS System.

Surfmet System

This is the NMFD surface water and meteorology instrument suite. The surface water component consists of a flow through system with a pumped pickup at approx 5m depth. TSG flow is approx 25 litres per minute whilst fluorometer and transmissometer flow is approx 3 l/min. Flow to instruments is degassed using a debubbler with 40 l/min inflow and 10/l min waste flow.

The meteorology component consists of a suite of sensors mounted on the foremast at a height of approx 10m above the waterline. Parameters measured are wind speed and direction, air temperature, humidity and atmospheric pressure. There is also a pair of optical sensors mounted on gimbals on each side of the ship. These measure total irradiance (TIR) and photo-synthetically active radiation (PAR).

The Non Toxic system was enabled as soon as we were far enough away from land.

Surfmet System began receiving non toxic supply around : 07167200000
The system then ran continuously until : 07198141600

The Transmissometer and Fluorometer were cleaned at the end of the previous cruise. During which time the system was turned off. The System was then flushed with Fresh Water which remained in the system until the Non Toxic Supply was made available.

Salinity samples were taken on a daily basis while the Non toxic supply was taken, on average 2 samples a day were taken for calibration of the TSG. For Times and Salinity Values Please see the Excel Sheet in the D318/Salinities folder

The data here shows a good standard trend for all data points used. Some data points were removed due to them affecting the regression. This amounted to a small number of points and indicates a bad sample. The TSG shows that it is reading quite a bit higher salinity value than the autosal samples done.

Meteorological Instrumentation

Measurement	Wind Speed	Spec : Range 0.4-75m/s, output: 0-75 0-750Hz, Accuracy: +/-0.17m/s^2
Manufacturer	Vaisala	
Model N^o	WAA151	

Measurement	Wind Direction	Spec : Range: 0-360^o, output: 6bit p grey code
Manufacturer	Vaisala	
Model N^o	WAV151	

Measurement	PAR	Spec : Range 350-700nm output deper sensor, (see cal sheet), Accuracy: +/-5%
Manufacturer	ELE	
Model N^o	DRP-5	

Measurement	TIR	Spec : spectral Range 335-2200nm irradiance 0-1440W/m^2, Sensitivit 15uv/W/m^2
Manufacturer	Kipp & Zonen	
Model N^o	CM 6B	

Measurement	Temp & Humidity	Spec : Temp, -20 - +60^{o}C, accuracy at +/-0.4^{0}C Humidity, 0-100% RH Accuracy, +/-4%
Manufacturer	Vaisala	
Model N^o	HMP45	

Measurement	Barometric Pressure	Spec : Range 800-1060mbar, Accur 20^{o}C : +/-0.3mbar
Manufacturer	Vaisala	
Model N^o	PTB100A	

Surface Sampling

Measurement	Housing Temperature	Spec Range:-2 - +32°C, accuracy 0.003°C, res:0.0001°C Stability: +/-0.0005 °C
Manufacturer	FSI	
Model N°	OTM	

Measurement	Remote Temperature	Spec Range:-2 - +32°C, accuracy 0.003°C, res:0.0001°C Stability: +/-0.0005 °C
Manufacturer	FSI	
Model N°	OTM	

Measurement	Conductivty	Spec : Range 0.4-75m/s, output: 0-75 0-750Hz, Accuracy: +/-0.17m/s^2
Manufacturer	FSI	
Model N°	OCM	

Measurement	Turbidity	Spec : Range 0-100% or 90-100%, Output: 0-5vdc Or -5 - +5vdc Accuracy: 0.1%
Manufacturer	Seatech	
Model N°	20cm	

Measurement	Fluorescence	Spec : Output ∞ emitted light at 685nm Output: 0-+5vdc
Manufacturer	Wetlabs	
Model N°	WETStar	

Salinities

Due to time constraints at the end of the cruise and problems with the salinometer the salinities for this cruise have not been processed. This will be done during the Port call and I shall pass on the Sals to the PS.
Please contact me on cvb@sea.noc.soton.ac.uk and I shall email you them ASAP.

Plots

Plots were made using the standard bestnav system on DVD1. D320.pdf. Also included are several matlab plots from the 9 CTD survey conducted at the beginning of the cruise.

CASIX pCO_2 System

This system is an autonomous pCO2 system developed by PML and Dartcom. I am not entirely sure of the full details of this and so Im not going to pretend like I do for fear of being incorrect. I advise that you contact Nick Hardman-Muntford at PML for information. The system was run at the same time as the Surfmet system.

Network Services

The networking system was used continually throughout the cruise with connections on the monkey island being used for computers logging GPS and Drifter buoy positions. The system in general performed well, however some comments on the speed were submitted. The ships old networking system 10Base2 coax became very unstable within the last week of the cruise. This affected the PSO and the crews email system. The crew were not able to access their RYDEX system and the PSO was not able to communicate with the network at

certain times. This is believed to be due to a user connecting to the network incorrectly causing the network to loose information that is being transmitted.
The PSO cabin pc was given a temporary 100BaseT connection to the Technicians office in order to avoid the issues. The old Coax networks problems are a bigger issue and will be addressed over the following cruises

Wireless network

Previous known network issues had been addressed prior to the cruise allowing the existing system to continue to work uninterrupted. Wireless worked throughout the cruise where available.

E-mail system

The email system worked fairly well for the entire length of the cruise. Issues were expected due to the number of Argos positions that were transmitted however the server and satellite dealt well with these issues.

Data Storage

Two USB external hard drives are being use as a RAID 0 mirror hosted by Discovery3 at the /data32 export. The mirror uses the modern meta device commands available in Solaris 10. This increases storage robustness by providing another layer of redundancy at the online storage level. The maintenance and administration of the disk set is minimal and the performance more than adequate.

All cruise data except for the /rvs path were stored on this storage area. Access was given to scientists to some of the folders via Samba shares.

Level C data was logged to the discovery1 internal disk, Techsas backs its data to here under /rvs/pro_data/TECHSAS and also stores it on its own internal raided drive array.

Data Backups

Daily backups of the Level C data was done as a tar file to DLT tape. The following paths were included in the tar file:

/rvs/raw_data
/rvs/pro_data
/rvs/def7/control
/rvs/users

In addition to the redundancy provided by the RAID 0 pair, daily backups of the /data32 directory were done by a level tar of the file system to the LTO 2 tape. The whole disk was backed up not just current cruise data.

The LTO2 system was backed up on a daily basis in a rolling 2 tape system.

Data Archiving

The proposed data archive will consist of the following components.

1) All CTD data
2) All LADCP and VMADCP data
3) All TECHSAS NMEA and NetCDF data files
4) All RVS Data Streams
5) All Drifter data from miniloggers.

All data was written to DVD with 10 copies made.
1 copy for BODC (LTO)
1 copy for PSO
1 copy for PML
1 copy for URI
1 copy for UOD
1 copy for UM
1 copy for UH
1 copy for NOC
1 copy for NIOZ
1 copy for RRS DISCOVERY
1 copy for return to NOC

NMFSS Sensors & Moorings CTD Cruise Report: D320

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Introduction

D320 was part of the SOLAS – DOGEE series of cruises using different methods of measuring gas exchange. Several novel and innovative technologies were employed, some for the first time, from NOCS, NIOZ, and Miami University. These were all compared with conventional CTD and underway measurements.

1. CTD system

A total of 44 CTD casts were completed on this cruise numbered sequentially. Additionally, each over-side event was given a unique station number. The initial sensor configuration was as follows:

- Sea-Bird 9*plus* underwater unit, s/n: 09P-24680-0636
- Frequency 0 - Sea-Bird 3 Premium temperature sensor, s/n: 03P-4301
- Frequency 1 - Sea-Bird 4 conductivity sensor, s/n: 04C-2580
- Frequency 2 - Digiquartz temperature compensated pressure sensor, s/n: 83008
- Frequency 3 - Sea-Bird 3 Premium temperature sensor, s/n: 03P-4383
- Frequency 4 - Sea-Bird 4 conductivity sensor, s/n: 04C-2164
- V0 - Sea-Bird 43 dissolved oxygen sensor, s/n: 43-0619
- V2 - Benthos PSA-916T 7Hz altimeter, s/n: 1040
- V3 - Chelsea Aquatracka MKIII fluorometer, s/n: 88-2050-095
- V4 - Chelsea PAR sensor, Up-welling Irradiance, s/n: 046060
- V5 - Chelsea PAR sensor, Down-welling Irradiance, s/n: 54788005
- V6 - WETLabs Light Scattering sensor, s/n: BBRTD-168
- V7 - Chelsea Alphatracka MKII transmissometer, s/n: 161-2642-002

Ancillary instruments & components:

- Sea-Bird 11*plus* deck unit, s/n: 11P-19817-0495
- Sea-Bird 24-position Carousel, s/n: 32-37898-0518
- NOC/SBE 'Break-Out Box', s/n: BO119201
- NOC 10KHz acoustic pinger, s/n: B8
- Sonardyne HF Deep Marker Beacon, s/n: 234002-002
- RDI WorkHorse Monitor 300KHz ADCP, s/n: 5415 (Master: downward-looking)
- RDI WorkHorse Monitor 300KHz ADCP, s/n: 9191 (Slave: upward-looking)
- NOC/RDI aluminium Workhorse battery pack, s/n: WH001
- 24 x Ocean Test Equipment ES-20L water samplers, s/n: 01 to 24 inc.

1.1 CTD Analysis & changes to Configuration

The first CTD cast/station number, 1/2, was used as a shakedown cast. There was no indication of any problems and all 24 bottles closed when fired. The pressure sensor was located 10cm below the bottom of the 20L water sampling bottles. Due to the difference in wire out "depths", as measured by the winch monitoring system, and the CTD pressure sensor, both values were written on the log sheet. Paper log sheets were kept for all casts.

Sensor Failures

During subsequent CTD casts it became apparent that there was a disparity between the down and the up cast. Significant differences in temperature and conductivity were observed while the package traversed the thermocline. This was initially thought to be a fault with the pumping system. Hence, first the pump Y-cable was replaced and then, after cast 11, the primaries pump itself. Neither of these changes made any difference and as the effect was seen in both the primary and secondary systems it was deduced that the problem must be due to water entrainment. The 20 litre OTE water bottles are over 1.5m long and effectively create a barrier around the CTD frame. As this package travelled through the water column it carried within it a large volume of entrained water which was producing the error. Hence after cast 12, twelve water bottles nearest to the T and C sensors were removed from the package. This action eliminated the problem and did not cause any problems to the science as 12 discrete water samples were sufficient for most casts.

During cast 26 the data became very noisy and therefore it was thought that the taking of water samples would not prove useful. The problem originated with the primary sensors only and did not appear on the secondaries. An inspection of the connectors and cables showed a slight ingress of water in one connector. All the connectors were thoroughly cleaned, dried, re-greased and then re-fitted. The following cast, number 27, was tried as a test cast and proved that the fault had been rectified. No water samples were taken during this cast.

1.2 Water Sampling Strategy

Scientific demands (usually) only required 12 discrete samples but this could and did vary from cast to cast. This was particularly true from D320_30 onwards. Since the cruise participants were mainly concerned with the top-most surface of the ocean, most of the CTD casts were limited to a maximum depth of 100m. The exception to this was D320_31 which reached a depth of 1000m to obtain some deep ocean water for a particular experiment on board.

Casts 1 – 12 carried a full array of twenty-four 20 litre OTE bottles and hence the fire order was always in sequential order. From D320_13 onwards however, twelve bottles had to be removed. OTE bottle s/n: 7 was found to be unreliable with its lower end cap not closing properly on several occasions. Hence, from cast 20 onwards it was removed ands its place in the firing order taken by s/n: 8. A request from a scientist led to a 10 litre bottle to be fitted at position 24 for same-depth sampling from cast 22 on. For D320_31 extra depths required to be sampled and hence two more 10 litre bottles were added in positions 22 – 23.

The following table gives the serial number of the sampling bottle in the body of the table with respect to the order in which it was fired, against cast numbers. Casts 1 – 12 are omitted for brevity as the firing order was the same in each case i.e. 1 to 24.

	FIRING ORDER														
CAST NUMB	1	2	3	4	5	6	7	8	9	1	1	1	1	1	1
13-19	7	8	1	1	1	1	1	1	1	1	1	2	--	--	--
20-21	8	9	1	1	1	1	1	1	1	1	1	2	--	--	--
22-24	8	9	1	1	1	1	1	1	1	2	1	1	2	--	--
28-29	8	9	1	1	1	1	1	1	1	2	1	1	2	--	--
30	8	9	1	1	1	1	--	--	--	--	--	--	--	--	--
31	2	2	2	8	9	1	1	1	1	1	1	1	1	1	2
32	8	9	1	1	1	1	1	1	1	1	1	2	2	2	2
33	8	9	1	1	1	1	1	1	1	2	1	1	2	--	--
34	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
35-36	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--
37	8	9	1	1	1	1	1	1	2	1	1	1	2	--	--
38	8	9	1	1	1	1	1	1	2	1	1	2	--	--	--
39	8	9	1	1	1	1	1	1	2	1	1	1	--	--	--
40	8	9	1	1	1	1	1	1	1	1	2	2	1	2	2
41	8	9	1	1	1	1	1	1	2	1	1	1	--	--	--
42	8	9	1	1	1	1	1	1	--	--	--	--	--	--	--
43-44	8	9	1	1	1	1	1	1	2	1	1	1	--	--	--

1.3 Data Processing Convention and Nomenclature

Using the Seabird SBEDataProcessing-Win32 software the following data processing route was implemented (where *XX* stands for the cast number):

Step 1 - Data Conversion *(DatCnv.psa)*

Conversion to engineering units of raw data from the *D320_XX.dat* files for the whole cast using the *D320_XX.con* files for calibration coefficients and *D320_XX.hdr* files for metadata. Produces *D320_XX.cnv* converted data and *D320_XX.ros* rosette file with five second scan ranges centred on bottle firing times from *D320_XX.bl.*

The following parameters were extracted:

1) Scan Count
2) Modulo Word
3) Modulo Error Count
4) Pump Status
5) Time, Elapsed Julian Days
6) Latitude degrees
7) Longitude degrees
8) Pressure Digiquartz dbar
9) Depth Salt Water m
10) Temperature 0 ITS-90 °C (primary)
11) Conductivity 0 $mScm^{-1}$ (primary)
12) Temperature 1 ITS-90 °C (secondary)
13) Conductivity 1 $mScm^{-1}$ (secondary)

14) Oxygen Voltage SBE43 V
15) PAR/Irradiance, Biospherical/Licor
16) PAR/Irradiance, Biospherical/Licor 2
17) Salinity (PSU)
18) Salinity 2 (PSU)
19) Light scatter sensor BBRTD V
20) Transmissometer V

Step 2 – Align CTD *(AlignCTD.psa)*

Advances oxygen voltage data by five seconds to correct for the time constant of the sensor and the flow lag along the pumped flow path. Takes as input *D320_XX.cnv* and produces *D320_XX_Align.cnv*.

Step 3 – Cell Thermal Mass Correction *(CellTm.psa)*

Corrects for conductivity errors in thermal gradients. Used with parameters alpha = 0.03 and 1/beta = 7. Takes as input *D320_XX_Align.cnv* and produces *D320_XX_Align_CellTM.cnv*.

Step 4 – Bottle Summary *(BottleSum.psa)*

Creates a summary of data during each Niksin bottle closure. Uses the five second scan ranges from the rosette files. Used for salinity and oxygen calibrations etc. Produces *D320_XX.btl*.

Step 5 – Derive *(Derive.psa)*

Generates derived data from direct measurements. Computes salinities from each T-C sensor pair and oxygen concentration in ml/litre. Takes as input *D320_XX_Align_CellTM.cnv* and produces *D320_XX_Align_CellTM_Derive.cnv.*

Step 6 – ASCII Out *(ASCII_Out.psa)*

Exports data in ASCII format for use in external software packages. Outputs all parameters at 24 Hz and an associated header file. Due to the resolution of the elapsed time record in Julian Days, conversion to hh:mm:ss.ss but actually produces two samples with the same ms timestamp. For unique timestamps it is recommended to use the NMEA time in the header file as a base and integrate the sample period to get the time of each scan.

Takes as input *D320_XX_Align_CellTM_Derive.cnv*
and produces *D320_XX_Align_CellTM_Derive.cnv_asciiout.asc*
and the associated header *D320_XX_Align_CellTM_Derive.cnv_asciiout.hdr*

Step 7 – Seaplot Graphing *(SeaPlot.psa)*

Produces graphs of all casts for salinity and dissolved oxygen on a 100m scale. Takes as input *D320_XX_Align_CellTM_Derive.cnv* and exports images as metafiles as *D320_XX_Align_CellTM_Derive .wmf.*

Data Processing Comments

The dissolved oxygen advance time of five seconds was selected to produce the best fit through the thermocline. Hence the five second advance will correct for the time constant of the oxygen sensor and the position of the sensor along the pumped flow-path, but not align the up-cast and downcast. The hysteresis within water property gradients is present on all sensors of those properties, however it is not an instrument artefact but a product of package drag and entrained water within the package.

Data spiking was experienced on primary temperature during cast D320_26. This will affect the derivation of salinity from the primary sensor pair as well as oxygen concentration. Several unsuccessful attempts were made to de-spike the temperature data using the Seabird Wildedit module. Further effort is recommended to de-spike this data, but another solution would be to use the secondary temperature for oxygen concentrations *(see Seabird Application Note No.64 "SBE 43 Dissolved Oxygen Sensor" for algorithm)* and rely on the secondary pair for salinity.

2. RDI LADCP Configuration

The 300kHz LADCPs were deployed in a master/slave configuration. The master was fitted in a downward-looking orientation on the CTD frame and the slave upward-looking. Both units were aligned with beam 1 in the same orientation. The units were connected using an asterisk cable to provide deck communications, ping synchronisation and power from the NMF stainless steel BB battery pack. Battery voltage could be monitored as the cable was not diode protected.

The instruments were configured to ping alternately 0.5 s apart with a ping interval of 1 s. Both units were configured to use 16 bins, a blanking distance of 5m and a depth cell size of 10m yielding a range of approximately 165m in ideal conditions. The ambiguity velocity was set to 250 cms^{-1} and pings per ensemble to 1.

Deployment Comments

Each deployment BBtalk terminal session was logged to a file (*F3)* of the form *D320_XXm.txt* for the master and *D320_XXs.txt* for the slave, where *XX* is the CTD cast number. Downloaded files were re-named in the form *D320_XXm.000* for the master LADCP, and *D320_XXs.000* for the slave.

The real-time clocks of both units were checked prior to deployment *(TS?)* and re-synchronised with the ship's GPS clock if they were more than 5 seconds in error. The actual time was written on the log sheet.

Paper log sheets were used for all casts.

Built-in pre-deployment tests *(PA and PT200)* were run before each cast, and then the following command files sent *(F2)*:

Master command file (D320m.txt)	*Slave command file (D320s.txt)*
CR1	CR1

CF11101	CF11101
EA00000	EA00000
EB00000	EB00000
ED00000	ED00000
ES35	ES35
EX11111	EX11111
EZ0111111	EZ0111111
TE00:00:01.00	TE00:00:01.00
TP00:01.00	TP00:01.00
LD111100000	LD111100000
LF0500	LF0500
LN016	LN016
LP00001	LP00001
LS1000	LS1000
LV250	LV250
LJ1	LJ1
LW1	LW1
LZ30,220	LZ30,220
SM1	SM2
SA001	SA001
SW05000	ST600
CK	CK
CS	CS

LADCP Failures

The master LADCP (s/n: 5415) would frequently fail the *Wide Bandwidth* test during pre-deployment testing. However, this never affected the unit's performance.

During cast 35 and 36 the slave LADCP (s/n: 9191) did not begin recording for some time after the command file was sent. This was probably due to the baud rate not being set to the lower speed of 9600 at the end of the previous session of data download. Sending files at the higher rate of 115200 baud can lead to corrupted or missed commands.

Occasionally the slave LADCP would hang during the pre-deployment test *PA.* This only required power-cycling the unit and then beginning the procedure again.

3. Salinity measurement

A Guildline Autosal 8400B salinometer, s/n: 60839, was used for salinity measurements. A total of 72 salinity samples were taken during the cruise for CTD analysis. The salinometer was sited in the Constant Temperature Lab, with the bath temperature set at 24°C, the ambient temperature being 23°C. Softsal was used as the data recording program for salinity values, and results were plotted via an Excel spreadsheet.

During the initial use of the instrument, air bubbles were frequently being caught in the cell. Although eventually they were removed by constant flushing, this may have affected some of the results of the first analysis run of 24 samples. Towards the end of the cruise and before the last run of samples, one of the arms of the cell could not be flushed at all indicating a blocked tube. The cell was removed from the bath, dismantled and cleaned in hot, soapy water before rinsing. It was noticed that one of the capillary tubes had a slight kink in it and this was straightened out. Replacing the tube was not deemed necessary nor possible at the time. The cell was reassembled and refitted into the bath and allowed to equilibrate for 24 hours in the CT lab. When the instrument was used next, it was found that the problem had been eliminated.

4. Fasttracka Fast Repetition Rate Fluorimeter

The Fasttracka FRRF (s/n: 05-5335-001) was configured using the default protocol and a few basic parameters received from PML. It was bench fitted as a stand-alone instrument connected to the non-toxic water supply in the Wet Lab. The requirement was for the FRRF to operate in unattended start mode from 21.00 each night until 07.00 the following morning. The data were collected (in both ASCII and binary formats) on a non-networked portable computer using the Win 98 operating system and Hyperterminal as the communications software. This makes the large files problematic to download and record on modern media and will therefore be dealt with by Steve Archer from PML.

The protocol used is given below:

*** Boot Protocol = 0 ***

6. 100 Acquisitions
7. 1 Flash sequences per acquisition
8. 10 Saturation flashes per sequence
9. 4 Saturation flash duration (in instrument units)
A. 50 Saturation interflash delay (in instrument units)
B. ENABLED Relaxation flashes
C. 20 Relaxation flashes per sequence
D. 4 Relaxation flash duration (in instrument units)
E. 50 Relaxation interflash delay (in instrument units)
F. 1000 ms Sleeptime between acquisition pairs
G. 64 PMT Gain in Normal Mode
H. DISABLED Analog Output
I. ENABLED Desktop (verbose) Mode
J. ACTIVE Light Chamber (A)
K. ACTIVE Dark Chamber (B)
L. ENABLED Logging mode to internal flashcard
M: 90 Upper Limit Autoranging Threshold value
N: 15 Lower Limit Autoranging Threshold value

Appendix A: Sea-Bird D311 configuration file: 0636.con

Date: 07/15/2007

ASCII file: C:\Program Files\Sea-Bird\Seasave-Win32\D320\Data\0636.con

Configuration report for SBE 911/917 plus CTD

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

1) Frequency, Temperature

Serial number : 4301
Calibrated on : 1 Feb 2007
G : 4.34587204e-003
H : 6.45002586e-004
I : 2.21066853e-005
J : 1.76106646e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency, Conductivity

Serial number : 2580
Calibrated on : 26 January 2007
G : -1.03503110e+001
H : 1.52152901e+000
I : 4.08497280e-004
J : 4.85592236e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency, Pressure, Digiquartz with TC

Serial number : 83008
Calibrated on : 13 May 2005
C1 : -4.093335e+004
C2 : -1.005887e-001
C3 : 1.104120e-002
D1 : 3.017600e-002
D2 : 0.000000e+000
T1 : 2.992572e+001
T2 : -3.202788e-004
T3 : 3.724670e-006
T4 : 2.870340e-009
T5 : 0.000000e+000
Slope : 1.00001000
Offset : -0.17810
AD590M : 1.285370e-002

AD590B : -8.337660e+000

4) Frequency, Temperature, 2

Serial number : 4383
Calibrated on : 1 May 2007
G : 4.39869631e-003
H : 6.55457848e-004
I : 2.42493473e-005
J : 2.01233663e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency, Conductivity, 2

Serial number : 2164
Calibrated on : 1 May 2007
G : -9.68392592e+000
H : 1.33451849e+000
I : -2.19870201e-003
J : 2.19768663e-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 : 0619
Calibrated on : 5 October 2006
Soc : 3.5470e-001
Boc : 0.0000
Offset : -0.5018
Tcor : 0.0014
Pcor : 1.35e-004
Tau : 0.0

7) A/D voltage 1, Free

8) A/D voltage 2, Altimeter

Serial number : 1040
Calibrated on : Repaired December 2006
Scale factor : 15.000
Offset : 0.000

9) A/D voltage 3, Fluorometer, Chelsea Aqua 3

Serial number : 088095

Calibrated on : 4 January 2007
VB : 0.363700
V1 : 2.074900
Vacetone : 0.377800
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

10) A/D voltage 4, PAR/Irradiance, Biospherical/Licor

Serial number : 046060
Calibrated on : 24 May 2007
M : 0.48758073
B : 1.11440974
Calibration constant : 100000000000.00000000
Multiplier : 1.00000000
Offset : 0.00000000

11) A/D voltage 5, PAR/Irradiance, Biospherical/Licor, 2

Serial number : 054788005
Calibrated on : 23 June 2006
M : 0.48635519
B : 1.00392869
Calibration constant : 100000000000.00000000
Multiplier : 1.00000000
Offset : 0.00000000

12) A/D voltage 6, User Polynomial

Serial number : 168
Calibrated on : 9 November 2004
Sensor name : BBRTD
A0 : -0.00024110
A1 : 0.00301000
A2 : 0.00000000
A3 : 0.00000000

13) A/D voltage 7, Transmissometer, Chelsea/Seatech/Wetlab CStar

Serial number : 161/2642/002
Calibrated on : 4 September 1996
M : 22.9804
B : -0.5975
Path length : 0.250

Appendix 1: D320 Station details, activities and water samples collected

Water Samples: a = SF_6 (PML); b = ^3He (UNEW); c = surfactant analysis (UNEW); d = OVOC (PML); e = methanol (PML), f = O_2 (URI); g = Sea Surface Microlayer/ surface profiling (NIOZ); h = DMS (PML)

CTD station times in black type refer to "CTD outboard" from the ship's log. Corresponding information in red type refers to "CTD in-board" from the ship's log.

NB: There was no Station #44

Date	Time (UTC)	Station I.D. & event N^o	Latitude	Longitude	Water depth	Activity/equipment deployed	Comments	Water Samples
17/06/07	14:10	Station # 001	49.08^o N	09.60^o W		ASIS	Test deployment	
17/06/07	15:54	Station # 002	49.04^o N	09.88^o W		CTD # 01 to 100m		**c,d,e**
	16:18		49.05^o N	09.88^o W		CTD # 01 inboard		
20/06/07	14:36	Station # 003	43.38^o N	18.42^o W	2976	CTD # 02 to 200m	Background hydrography	**e,f,g**
	15:02		43.38^o N	18.42^o W		CTD # 02 inboard		
20/06/07	16:57	Station # 004	43.32^o N	18.20^o W	3276	CTD # 03 to 200m	Background hydrography	**a,b,f**
	17:22		43.32^o N	18.20^o W		CTD # 03 inboard		
20/06/07	19:19	Station # 005	43.26^o N	17.99^o W	3859	CTD # 04 to 100m	Background hydrography	**f (15m)**
	19:42		43.26^o N	17.99^o W		CTD # 04 inboard		
20/06/07	21:26	Station # 006	43.47^o N	17.89^o W	3498	CTD # 05 to 100m	Background hydrography	**f (15m)**
	21:46		43.47^o N	17.88^o W		CTD # 05 inboard		
21/06/07	00:27	Station # 007	43.53^o N	18.11^o W	3410	CTD # 06 to 100m	Background hydrography	**f (15m)**
	00:44		43.53^o N	18.11^o W		CTD # 06 inboard		
21/06/07	02:47	Station # 008	43.58^o N	18.32^o W	3810	CTD # 07 to 100m	Background hydrography	**f (15m)**
	03:03		43.58^o N	18.32^o W		CTD # 07 inboard		
21/06/07	05:18	Station # 009	43.78^o N	18.22^o W	4109	CTD # 08 to 100m	Background hydrography	**f (15m)**
	05:38		43.78^o N	18.22^o W		CTD # 08 inboard		

21/06/07	06:58	Station # 010	43.73° N	18.00° W	3949	CTD # 09 to 100m	Background hydrography	**f (15m)**
	07:14		43.73° N	18.00° W		CTD # 09 inboard		
21/06/07	08:33	Station # 011	43.67° N	17.78° W	3266	CTD # 10 to 100m	Background hydrography	**a,b,e**
	09:02		43.67° N	17.78° W		CTD # 10 inboard		
21/06/07	17:42	Station # 012	43.63° N	18.05° W		Argos Buoys x2	SF_6/^{3}He: Patch #1 release	
22/06/07	09:00	Station # 013	43.69° N	18.14° W		ASIS	ASIS #1 deployed	
22/06/07	09:55	Station # 013a	43.63° N	18.05° W		Lagrangian Float	URI float #43 deployed	
22/06/07	12:18	Station # 014	43.70° N	18.13° W	3832	CTD # 11 to 100m		**d,e,f**
	12:40		43.70° N	18.13° W		CTD # 11 inboard		
22/06/07	13:18	Station # 015	43.71° N	18.10° W		NOC Spar buoy	NOC Spar Buoy deployed	
22/06/07	13:18	Station # 016	43.71° N	18.10° W		NIOZ Catamaran	Capsized: recovered	**g**
22/06/07	16:32	Station # 017	43.70° N	18.06° W	3967	CTD # 12 to 85m	Test of CTD	
	16:45		43.70° N	18.06° W		CTD # 12 inboard		
22/06/07	17:50	Station # 018	43.69° N	18.06° W		URI CTD	Abandoned	
22/06/07	20:57	Station # 019	43.59° N	18.03° W	3488	CTD # 13 to 100m	1st CTD in Patch #1	**a,b,f**
	21:30		43.59° N	18.03° W		CTD # 13 inboard		
23/06/07	09:38	Station # 020	43.60° N	18.02° W	3502	CTD # 14 to 100m	2nd CTD in Patch #1	**a,b,f**
	10:12		43.59° N	18.01° W		CTD # 14 inboard		
23/06/07	20:48	Station # 021	43.57° N	18.02° W	3395	CTD # 15 to 100m	3rd CTD in Patch #1	**a,b,f**
	21:10		43.57° N	18.02° W		CTD # 15 inboard		
24/06/07	10:50	Station # 022	43.42° N	17.93° W		RIB	Surfactant sampling	**c**
24/06/07	14:00	Station # 023	43.61° N	18.02° W		Argos Buoys x 2	Buoys retrieved	
24/06/07	14:15	Station # 024	43.61° N	17.99° W		NOC Spar Buoy	NOC buoy retrieved	
24/06/07	16:07	Station # 025	43.54° N	18.04° W	3345	CTD # 16 to 100m	4th CTD in Patch #1	**a,b,f**
	16:31		43.55° N	18.03° W		CTD # 16 inboard		
24/06/07	16:38	Station # 026	43.55° N	18.04° W	3345	PES Fish		
24/06/07	20:52	Station # 027	43.52° N	18.01° W	3380	CTD # 17 to 100m	4th CTD in Patch #1	**a,b,f**
	21:22		43.52° N	18.01° W		CTD # 17 inboard		
24/06/07	21:30	Station # 028	43.53° N	18.01° W		Argos Buoys x 2	Buoys redeployed	

25/06/07	07:00	Station # 029	43.52° N	18.05° W		Achterberg Fish	Trial deployment	
25/06/07	13:25	Station # 030	43.64° N	17.86° W		Surfactant release	Trial release	
25/06/07	16:15	Station # 031	43.64° N	17.84° W		RIB/ASIP	ASIP trial release by RIB	
25/06/07	07:00	Station # 032	43.62° N	17.85° W		RIB	Surfactant sampling	**c**
25/06/07	07:00	Station # 033	43.52° N	18.03° W		Argos Buoy x 1	Buoy retrieved	**c**
26/06/07	06:11	Station # 033a	43.50° N	17.81° W		Argos Buoy	$SF_6/^3He$/surfact. Patch2	
26/06/07	18:47	Station # 034	43.43° N	17.85° W	3582	CTD # 18 to100m	1st CTD in Patch #2	**a,b,f**
	19:11		43.43° N	17.85° W		CTD # 18 inboard		
26/06/07	19:32	Station # 035	43.43° N	17.85° W		Argos Buoy	Deployed in patch #2	
27/06/07	01:31	Station # 036	43.38° N	18.19° W		Lagrangian Float	URI float #44 deployed	
27/06/07	01:31	Station # 037	43.36° N	17.85° W		RIB	Surfactant sampling	**c**
27/06/07	11:40	Station # 038	43.35° N	17.85° W		Argos Buoy	Retrieved: malfunction	
27/06/07	13:50	Station # 039	43.42° N	17.85° W	3689	CTD # 19 to100m	2nd CTD in Patch #2	**a,b,f**
	14:22		43.42° N	17.85° W		CTD # 19 inboard		
27/06/07	15:02	Station # 040	43.37° N	17.85° W	3689	ASIS	ASIS #1 deployed	
27/06/07	16:12	Station # 041	43.36° N	17.86° W		RIB/ASIP	ASIP trial release by RIB	
27/06/07	19:10	Station # 042	43.34° N	17.82° W		Argos Buoy x 1	Retrieved & redeployed	
27/06/07	19:10	Station # 042	43.34° N	17.82° W		Argos Buoy x 1	Retrieved & redeployed	
28/06/07	06:30	Station # 044	43.31° N	18.22° W		Lagrangian Float	URI float #44 retrieved	
28/06/07	13:14	Station # 045	43.25° N	17.83° W	3769	CTD # 20 to100m	3rd CTD in Patch #2	**a,b,f**
	13:43		43.25° N	17.83° W		CTD # 20 inboard		
28/06/07	14:45	Station # 046	43.25° N	17.83° W		RIB	Surfactant sampling	**c**
28/06/07	15:49	Station # 047	43.23° N	17.81° W	3698	CTD # 21 to100m	4th CTD in Patch #2	**a,b,f**
	16:16		43.22° N	17.81° W		CTD # 21 inboard		
28/06/07	17:32	Station # 048	43.22° N	17.81° W		NOC Spar buoy	NOC Spar Buoy deployed	
29/06/07	13:12	Station # 049	43.41° N	17.91° W		CTD # 22 to100m	6th CTD in Patch #1	**a,b,f**
	13:40		43.41° N	17.91° W		CTD # 22 inboard		
29/06/07	19:37	Station # 050	43.07° N	17.78° W	4065	CTD # 23 to100m	5th CTD in Patch #2	**a,b,f**
	20:10		43.07° N	17.88° W		CTD # 23 inboard		

30/06/07	12:17	Station # 051	42.72° N	17.71° W	4438	CTD # 24 to100m	6th CTD in Patch #2	**a,b,f**
	12:58		42.71° N	17.71° W		CTD # 24 inboard		
30/06/07	14:04	Station # 052	42.70° N	17.72° W		CTD # 25 to100m	CTD trials	**f**
	14:17		42.70° N	17.72° W		CTD # 25 inboard		
30/06/07	14:42	Station # 053	42.70° N	17.70° W		Argos Buoy x 1	Deployed @ patch centre	
30/06/07	15:09	Station # 054	42.70° N	17.70° W		CTD # 26 to100m	CTD trials	**f**
	15:22		42.69° N	17.70° W		CTD # 26 inboard		
01/07/07	17:14	Station # 055	42.69° N	17.50° W		ASIP over stern	Lost due to malfunction	
01/07/07	18:52	Station # 056	42.74° N	17.34° W		NOC Spar Buoy	NOC buoy retrieved	
02/07/07	09:11	Station # 057	42.87° N	17.59° W		CTD # 27 to100m	CTD trials	**f**
	09:37		42.87° N	17.59° W		CTD # 27 inboard		
02/07/07	17:06	Station # 058	42.90° N	17.72° W	4362	CTD # 28 to100m	7th CTD in Patch #1	**a,b,f**
	17:36		42.90° N	17.72° W		CTD # 28 inboard		
02/07/07	19:15	Station # 059	42.86° N	17.50° W		Argos Buoy x 1	Retrieved	
03/07/07	14:35	Station # 060	42.42° N	17.77° W	4826	CTD # 29 to100m	7th CTD in Patch #2	**a,b,f**
	15:02		42.42° N	17.77° W		CTD # 29 inboard		
03/07/07	17:17	Station # 061	42.36° N	17.76° W		Argos Buoy x 1	Retrieved	
03/07/07	20:15	Station # 062	42.38° N	17.49° W		Argos Buoy x 1	Retrieved	
03/07/07	22:32	Station # 063	42.32° N	17.78° W		Argos Buoy x 1	Redeployed	
04/07/07	06:12	Station # 064	42.82° N	16.65° W		CTD # 30 to 100m	ASIS # 1 CTD calibration	**f**
	06:36		42.82° N	16.65° W		CTD # 30 inboard		
04/07/07	08:39	Station # 065	42.59° N	16.56° W		CTD # 31 to 1000m	ASIS # 1 CTD calibration	**e, f**
	09:45		42.58° N	16.56° W		CTD # 31 inboard		
04/07/07	08:39	Station # 066	42.58° N	16.56° W		NOC Spar buoy	NOC Spar Buoy deployed	
04/07/07	11:15	Station # 067	42.57° N	16.55° W		NIOZ Catamaran	SSM/profiling	**g**
04/07/07	14:10	Station # 068	42.57° N	16.88° W		RIB	Surfactant sampling	**c**
04/07/07	14:25	Station # 069	42.57° N	16.88° W		PML Surf. Profiler	Top 2m profile	**c,h**
04/07/07	20:56	Station # 070	42.13° N	17.99° W	4844	CTD # 32 to100m	8th CTD in Patch #2	**a,b,f**
	21:32		42.12° N	18.00° W		CTD # 32 inboard		

05/07/07	08:42	Station # 071	42.60° N	16.46° W		Surfactant Release	Surfactant release: ASIS #1	
05/07/07	13:30	Station # 072	42.59° N	16.43° W		RIB	Surfactant sampling	**c**
05/07/07	18:00	Station # 073	42.59° N	16.39° W		NIOZ Catamaran	SSM/profiling	**c,g**
05/07/07	18:55	Station # 074	42.59° N	16.39° W		NIOZ Catamaran	SSM/profiling	**c,g**
06/07/07	11:33	Station # 075	41.88° N	18.13° W	4685	CTD # 33 to100m	9th CTD in Patch #2	**a,b,f**
	12:03		41.88° N	18.13° W		CTD # 33 inboard		
06/07/07	18:55	Station # 076	41.88° N	18.13° W		NIOZ Catamaran	SSM/profiling	**c,g**
06/07/07	13:30	Station # 077	41.88° N	18.13° W		RIB	Surfactant sampling	**c**
06/07/07	15:15	Station # 078	41.87° N	18.13° W		PML Surf. Profiler	Top 2m profile	**c,h**
07/07/07	05:10	Station # 079	43.78° N	17.77° W		Lagrangian Float	URI float #43 retrieved	
07/07/07	14:39	Station # 080	42.91° N	16.22° W		CTD # 34 to 100m	ASIS # 2 CTD calibration	**f**
	15:15		42.91° N	16.22° W		CTD # 34 inboard		
07/07/07	16:36	Station # 081	42.78° N	16.26° W		CTD # 35 to 100m	Between ASIS # 2 & NOC	**f**
	16:52		42.78° N	16.26° W		CTD # 35 inboard		
07/07/07	19:15	Station # 082	42.69° N	16.37° W		NOC Spar Buoy	NOC Spar Buoy retrieved	
07/07/07	20:44	Station # 083	42.60° N	16.18° W		CTD # 36 to 100m	SW of ASIS # 1	**f**
	21:00		42.59° N	16.17° W		CTD # 36 inboard		
07/07/07	21:22	Station # 084	42.59° N	16.17° W		Argos Buoy		
07/07/07	21:52	Station # 085	42.57° N	16.20° W		Tracer release	SF_6/^{3}He: Patch #3 release	
08/07/07	02:04	Station # 086	42.73° N	16.25° W		Lagrangian Float	URI float #43 deployed	
08/07/07	15:05	Station # 087	41.72° N	18.43° W	4697	CTD # 37 to100m	10th CTD in Patch #2	**a,b,f**
	15:40		41.73° N	18.43° W		CTD # 37 inboard		
08/07/07	16:24	Station # 088	41.72° N	18.41° W		RIB	Surfactant sampling	**c**
08/07/07	16:44	Station # 089	41.72° N	18.41° W		PML Surf. Profiler	Top 2m profile	**c,h**
08/07/07	18:35	Station # 090	41.71° N	18.40° W		NIOZ Catamaran	SSM/profiling	**c,g**
08/07/07	18:55	Station # 091	41.70° N	18.40° W		Argos Buoy	Retrieved from Patch #2	
09/07/07	15:26	Station # 092	42.60° N	16.12° W	4343	CTD # 38 to100m	1st CTD in Patch #3	**a,b,f**
	15:54		42.60° N	16.12° W		CTD # 38 inboard		
09/07/07	16:06	Station # 093	42.60° N	16.13° W		Argos Buoy	Deployed in Patch #3	

09/07/07	16:43	Station # 094	42.60° N	16.11° W		NIOZ Catamaran	SSM/profiling	**c,g**
09/07/07	18:36	Station # 095	42.58° N	16.11° W		RIB	Surfactant sampling	**c**
09/07/07	19:57	Station # 096	42.53° N	16.11° W		NOC Spar Buoy	NOC buoy deployed	
10/07/07	06:16	Station # 097	42.60° N	15.96° W		Argos Buoy	Retrieved	
10/07/07	07:22	Station # 098	42.62° N	16.08° W		Argos Buoy	Deployed at patch centre	
10/07/07	08:22	Station # 099	42.53° N	16.06° W		Surfactant Release	Surfactant release: ASIS #1	
10/07/07	11:28	Station # 100	42.59° N	16.16° W	4343	CTD # 39 to100m	2nd CTD in Patch #3	**a,b,f**
	12:00		42.60° N	16.16° W		CTD # 39 inboard		
10/07/07	14:27	Station # 101	42.61° N	16.16° W		NIOZ Catamaran	SSM/profiling	**c,g**
10/07/07	16:45	Station # 102	42.64° N	16.14° W		RIB	Surfactant sampling	**c**
10/07/07	18:35	Station # 103	42.63° N	16.13° W		PML Surf. Profiler	Top 2m profile	**c,h**
11/07/07	05:25	Station # 104	42.75° N	15.91° W		ASIS #2	ASIS #2 retrieved	
11/07/07	07:08	Station # 105	42.76° N	15.93° W		CTD # 40 to100m	ASIS #2 calibration	**f**
	08:08		42.76° N	15.94° W		CTD # 40 inboard		
11/07/07	11:18	Station # 106	42.69° N	16.12° W		Lagrangian Float	URI float #43 retrieved	
11/07/07	14:20	Station # 107	42.66° N	16.09° W	4203	CTD # 41 to100m	3rd CTD in Patch #3	**a,b,f**
	15:07		42.66° N	16.09° W		CTD # 41 inboard		
11/07/07	15:27	Station # 108	42.65° N	16.09° W		NIOZ Catamaran	SSM/profiling	**c,g**
11/07/07	18:33	Station # 109	42.48° N	16.92° W		ASIS #1	ASIS #1 retrieved	
11/07/07	18:59	Station # 110	42.48° N	15.92° W		CTD # 42 to100m	ASIS #1 calibration	**f**
	19:32		42.48° N	15.93° W		CTD # 42 inboard		
12/07/07	10:45	Station # 111	42.66° N	16.07° W	5164	CTD # 43 to100m	4th CTD in Patch #3	**a,b,f**
	11:20		42.66° N	16.07° W		CTD # 43 inboard		
13/07/07	07:08	Station # 112	42.67° N	16.04° W	4753	CTD # 44 to100m	5th CTD in Patch #3	**a,b,f**
	07:40		42.67° N	16.04° W		CTD # 44 inboard		
13/07/07	08:42	Station # 113	42.68° N	15.99° W		Argos Buoy	Retrieved	
13/07/07	09:38	Station # 114	42.66° N	15.92° W		Argos Buoy	Retrieved	
13/07/07	11:15	Station # 115	42.54° N	15.82° W		NOC Spar Buoy	NOC buoy retrieved	
16/07/07	11:15	Station # 116	54.20° N	12.72° W		Surfactant release	DMS flux experiment	

Appendix 2: D320 Master's Diary of Events, June/July 2007

Bulk of times in text are UTC (initially & latterly BST).

2007-06-15

0930	Scientific party embarked; Mobilisation continues
1400-1600	Sign-on & Safety Briefing for Sci/Tech contingent

2007-06-16

0730	Master notified of sci equipment prob that would delay sailing. Pilot etc postponed.
0915	Spares ordered – 7-hr delivery time anticipated
1800	Spares delivered
1843	Critical instrument tests completed – all satis
1845	PoB J. Willis-Richards
1908	ERSB; singling-up
1914	Last line
1926	Passing Eastern b'water
1936	Clearing river entrance
1941	Pilot away
1948	FAOP; Pendennis Pt brng 334 x 1.95nm
2106	Lizard Pt brng 276 deg x 4.7nm; A/c 254 deg (T&G)

2007-06-17

0100	49 43.6N 06 05.6W	Wind 220 deg @ 20 knots
0130	49 42.0N 06 14.0W	A/c to 270 deg (T&G) to transit TSS south of Scillies
0249	49 42.0N 06 36.9W	Clearing TSS; A/c to 252 deg (T&G)
0500	49 34.3N 07 10.4W	Wind 280 deg @ 7 knots
0900	49 22.5N 08 11.7W	Wind 170 deg @ 10 knots
1030		Musters @ Emergency & Boat stations
1300	49 08.6N 09 18.6W	Wind 130 deg @ 10 knots
1410	49 04.6N 09 35.8W	Hove-to for trial ASIS lift & deployment
1415-1417		ASIS in water
1421		ASIS on deck
1430	49 04.6N 09 36.3W	V/l resumes passage
1550	49 02.2N 09 52.8W	Hove-to for CTD trial dip
1554		CTD deployed
1618		CTD recovered
1632	49 03.0N 09 52.9W	All secure; Set co 269 degs (T&G) (Weather routing)
1700		Wind 060 @ 20 knots
2100	49 01.1N 11 04.7W	Wind 060 @ 22 knots

2007-06-18

0100	49 00.0N 12 12.1W	Adj co to 270 deg (T&G); Wind 060 @ 20 knots {Clocks retarded 1 hr to UTC}
0400	48 59.7N 13 19.3W	Winds Lt & Var.
0800	48 59.9N 14 23.3W	Wind 130 @ 6 knots
1200	49 00.1N 15 31.4W	Adj co to 255 degs (T&G); Wind 060 @ 9 knots
1600	48 48.4N 16 38.2W	Wind 060 @ 18 knots
2000	48 37.0N 17 41.9W	Wind 360 @ 25 knots
2142	48 32.0N 18 09.2W	Adj co to 230 degs (T&G)
2400	48 15.0N 18 38.0W	Wind 010 @ 26 knots

2007-06-19

0252	47 54.7N 19 14.9W	A/c to 190 degs (T&G)
0400	47 42.2N 19 18.3W	Wind 010 @ 24 knots
0800	46 59.3N 19 29.5W	Wind 340 @ 28 knots
0957	46 38.6N 19 35.2W	Hove-to for 'Achterberg fish' deployment
1013		On track; towing fish @ 6 knots
1050	46 36.5N 19 35.7W	Fish recovered; resume full speed

1200	46 24.9N 19 39.4W	Wind 330 @ 28 knots
1600	45 42.9N 19 49.6W	Wind 330 @ 27 knots
1950	45 01.6N 19 59.7W	Adj co to 180 degs (T&G); Wind 310 @ 25 knots
2400	44 13.5N 19 59.9W	Wind 310 @ 22 knots

2007-06-20

0400	43 28.8N 20 00.0W	Wind 320 @ 25 knots
0712	42 54.3N 20 00.0W	A/c 068 deg – searching for higher chlorophyll & diff CO2 rdngs
0800	42 55.0N 19 46.0W	Wind 310 @ 18 knots
1200	43 11.8N 18 56.8W	Wind 310 @ 18 knots
1430	43 22.5N 18 24.8W	Hove-to on station
1436	43 22.6N 18 25.1W	Grid site #1; CTD deployed
1502		CTD recovered
1524		V/l repositioning; Wind 300 @ 20 knots
1657	43 19.1N 18 12.1W	Grid site #2; CTD deployed
1722		CTD recovered
1759		V/l repositioning
1924	43 15.8N 17 59.2W	Grid site #3; CTD deployed
1942		CTD recovered
1946		V/l repositioning; Wind 290 @ 20 knots
2126	43 27.9N 17 53.0W	Grid site #4; CTD deployed
2146		CTD recovered
2203	42 28.3N 17 52.6W	Trial URI dips off port aft davit
2231		URIs recovered; v/l repositioning for next grid CTD
2400		Wind 310 @ 22 knots

2007-06-21

0027	43 31.4N 18 06.2W	Grid site #5; CTD deployed
0044		CTD recovered
0100		V/l repositioning
0238	43 34.8N 18 19.1W	Aborted deployment
0247	43 34.7N 18 19.2W	Grid site #6; CTD deployed
0305		CTD recovered
0318		V/l repositioning
0400		Wind 310 @ 17 knots
0518	43 47.0N 18 12.9W	Grid site #7; CTD deployed
0538		CTD recovered
0541		V/l repositioning
0658	43 43.6N 17 59.9W	Grid site #8; CTD deployed
0714		CTD recovered
0716		V/l repositioning
0800		Wind 320 @ 18 knots
0833	43 40.2N 17 46.9W	Grid site #9; CTD deployed
0902		CTD recovered
1000	43 40.0N 17 47.3W	V/l remains hove-to – data processing
1124		Proceeding towards ASIS deployment site
1200	43 42.1N 17 54.7W	Wind 320 @ 18 knots
1424	43 47.6N 18 16.8W	Hove-to for ASIS deployment; buoy preparations
1530		Deployment postponed due swell conditions V/l repositioning for Patch #1 release
1600		Wind 320 @ 20 knots
1742	43 37.5N 18 03.0W	Hove-to on station; scientific preparations
1930	43 37.5N 18 03.1W	Patch reference buoys released
1940		Depressor weight for release hose deployed; sorting navigation
2000		Wind 310 @ 18 knots
2046	43 37.2N 18 02.8W	Close pass of Patch buoys; commence pumping SF6; v/l following Expanding Square pattern referenced on buoys.
2400	43 36.2N 18 02.5W	Wind 310 @ 16 knots

2007-06-22		
0220	43 35.4N 18 04.2W	Pumping completed
0230		Depressor weight recovered; v/l slow-steaming towards revised ASIS deployment site for 0800hrs
0400		Wind 290 @ 12 knots
0500	43 39.6N 18 07.3W	
0800		Wind 270 @ 5 knots
0845	43 41.7N 18 08.5W	Deck preparations for ASIS deployment
0900	43 41.5N 18 08.6W	ASIS #1 released, starboard quarter
0955	43 41.5N 18 08.5W	URI undulating data recorder released
1107		URI resurfaced for approx 1hr
1150	43 41.9N 18 08.2W	URI sighted – approx position 43 41.96N 18 08.03W
1200	43 41.9N 18 08.2W	V/l hove-to for CTD deployment vic buoy deployments
		Wind 270 @ 5 knots
1218	43 41.9N 18 07.9W	CTD deployed
1240		CTD recovered
1313		Hove-to for NOCs buoy release
1318	43 42.7N 18 06.2W	NOCs buoy released; preparing 'Skimmer'
1331	43 42.6N 18 06.0W	'Skimmer' (catamaran) released – radio-controlled from stbd side of vessel.
1415		Proposed RiB deployment aborted due to alongside swell conditns
1445		V/l manoeuvring to recover 'dead' Skimmer
1450		Skimmer capsizes 200 metres off v/l's stbd qtr.
1500	43 42.4N 18 04.5W	Skimmer grappled & lifted clear of water
1535		Skimmer righted on deck & landed on trailer
1550	43 42.1N 18 03.5W	Hove-to for CTD deployment; Wind 270 @ 12 knots
1632	43 41.9N 18 03.7W	CTD deployed
1645		CTD recovered
1750	43 41.3N 18 03.5W	Proposed deployment of mini CTD abandoned; v/l bound for Patch#1
1913	43 35.6N 18 00.7W	Patch buoys located; v/l relocating in vicinity for CTD
1945		ASIS#1 position recorded as 43 41N 18 02W
		Wind 260 @ 14 knots
2057	43 35.2N 18 01.7W	CTD deployed
2130		CTD recovered
2145	43 35.2N 18 01.8	V/l relocating 2.5nm east of Patch#1 & ASIS#1 & steering N/S guardlines at slow speed overnight
2300		ASIS#1 position recorded as 43 40.3N 18 02.5W
2400	43 40.1N 17 59.0W	Wind 260 @ 10 knots
2007-06-23		
0400	43 39.8N 17 58.4W	Wind 260 @ 11 knots
0750	43 35.4N 18 01.3W	Hove-to awaiting operational Patch buoy navigation
0800	43 36.4N 18 00.0W	CvtoSR determining patch concentrations; Wind 240 @ 14 knots
0938	43 35.8N 18 00.9W	Hove-to & CTD deployed in patch
1012	43 35.5N 18 00.6W	CTD recovered
1124		Complete sampling; v/l commences Patch#1 Survey; CvtoSR
1200	43 38.0N 17 58.7W	Wind 230 @ 12 knots
1337	43 36.3N 17 59.8W	Patch#1 buoys abeam to stbd (S'ly heading) at 0.1nm
1521	43 36.1N 18 00.3W	Buoys abeam to stbd (N'ly heading) at 0.3nm
1600		Wind 270 @ 8 knots ; survey for patch continues
2000	43 35.0N 18 00.8W	ASIS#1 position recorded as 43 39.3N 17 54.9W
2048	43 34.3N 18 01.3W	Hove-to & CTD deployed in patch
2110		CTD recovered
2130		Co var o'night – vicinity of monitoring buoys
2400	43 35.7N 18 02.3W	Wind 310 @12 knots

2007-06-24

0400	45 35.3N 18 03.1W	Wind 310 @ 12 knots
0724	43 35.7N 17 59.5W	Patch buoys sighted
0740	43 34.9N 17 59.0W	Commence Patch#1 survey heading south from buoys
0800		Wind 300 @ 12 knots
0900	43 29.3N 17 59.2W	ASIS#1 position recorded as 43 33.0N 17 51.6W
1022	43 25.6N 17 56.0W	Cease Patch#1 survey for RiB operations
1050	43 25.3N 17 55.8W	RiB launched for sampling work; 3 PoB
1128	43 25.0N 17 55.3W	RiB returned & personnel disembarked
1136		RiB restowed in cradle
1145	43 25.7N 17 56.0W	V/l back on N'ly line, resuming Patch#1 survey
1200	43 22.1N 17 56.1W	Wind 010 @ 12 knots
1300	43 31.4N 18 00.7W	Cease Patch#1 survey; v/l relocating for buoy recoveries
1400	43 36.5N 18 01.2W	Patch#1 buoys grappled
1405		All inboard; relocating to recover NOCs buoy
1445	43 36.3N 18 59.3W	NOCs buoy hooked & then recovered to starboard waist
		Repositioning south for CTD
1607	43 32.4N 18 02.2W	Hove-to & CTD deployed; Wind 010 @ 16 knots
1631		CTD recovered
1638	43 32.8N 18 02.0W	PES fish deployed
1641		V/l on southbound track, resuming Patch#1 survey
2028	43 31.9N 18 01.1W	Reducing speed – closing in on high concentration area
		Wind 010 @ 17 knots
2052	43 31.4N 18 00.7W	Hove-to & CTD deployed
2122		CTD recovered
2130	43 31.6N 18 00.5W	Drogue & thermistor buoys re-deployed to mark Patch#1
2200	43 32.1N 18 00.4W	Co var o'night monitoring buoy positions
2400		ASIS#1 position recorded as 43 27.2N 17 53.8W
		Wind 010 @ 14 knots

2007-06-25

0400	43 37.8N 17 57.6W	Wind 010 @ 14 knots
0700	43 31.0N 18 02.7W	Achterberg fish deployed, port quarter, for trials
		Co & speeds var. to MO.
0800		Wind 020 @ 15 knots
1100	43 41.9N 17 58.7W	Trials complete; V/l relocating for trial Surfactant release
		ASIS#1 position recorded as 43 40.8N 17 57.1W
1200	43 39.0N 17 54.5W	Wind 010 @ 12 knots
1325	43 38.3N 17 51.3W	Commence Surfactant streaming trial
1401	43 38.3N 17 51.1W	Complete streaming exercise; Hove-to to monitor effects
1515		Preparing ASIP float & RiB
1615	43 38.0N 17 50.7W	RiB + 3 men away; ASIP tests; Wind 010 @ 12 knots
1720	43 36.7N 17 51.5W	Tests completed; RiB recovered to bulwarks
1818	43 37.0N 17 51.1W	RiB released + 3 on board; Surface sampling in/out Surfactant
1852	43 36.4N 17 51.3W	RiB & men recovered; v/l relocating to vicinity Patch#1
2000		Wind 360 @ 15 knots
2100	43 31.4N 18 01.7W	Drogue buoy recovered @ Patch#1 – GPS malfunction
2106		Co var o'night, fixing ASIS#1 & closing Patch#2 depl. site.
2400	43 18.4N 18 03.7W	ASIS#1 position recorded as 43 17.0N 17 58.3W
		Wind 360 @ 9 knots

2007-06-26

0400	43 27.5N 17 51.3W	Wind 020 @ 11 knots
0510		Pre-Patch#2 drift check.
0611	43 29.7N 17 48.4W	Patch#2 drogue buoy deployed; v/l repositioning 2nm SW
0641	43 28.3N 17 50.1W	Depressor weight for patching hose deployed
0658	43 28.4N 17 49.6W	Commence patching SF6 in 1km square
0800		Wind 020 @ 14 knots
1006	43 27.5N 17 49.3W	Comp patching with SF6 & recover depressor weight

1010		Repositioning for overlay of surfactant
1048	43 26.4N 17 50.3W	Commence 'parallel lining' of surfactant over SF6
1200	43 25.7N 17 50.1W	Wind 020 @ 14 knots
1600		Wind 020 @ 16 knots
1732	43 25.2N 17 52.9W	Complete Patch#2 with surfactant overlay
1847	43 25.7N 17 51.0W	CTD deployed in patch centre
1911	43 25.7N 17 51.0W	CTD recovered
1932	43 25.7N 17 51.1W	Patch#2 thermistor buoy deployed; Wind 360 @ 12 knots
2015	43 26.5N 17 51.1W	Commence head-to-wind atmospheric sampling vic Patch#2
2220	43 26.2N 17 51.3W	Complete 2hr sampling period. V/l heading for URI#2 deployment
2400	43 22.7N 18 08.2W	Wind 010 @ 11 knots
2007-06-27		
0131	43 22.7N 18 08.2W	V/l hove-to & URI#2 released; v/l on co to verify ASIS#1 posn.
0326	43 11.4N 17 56.6W	ASIS#1 position recorded as 43 07.6N 17 56.8W
0356	43 11.4N 17 56.6W	V/l heading for vic Patch#2
0400		Wind 350 @ 11 knots
0648	43 22.7N 17 48.9W	Hove-to adjacent to Patch#2 – atmospheric sampling
0800	43 24.0N 17 50.4W	Co var. surveying patch; Wind 300 @ 12 knots
1102	43 21.5N 17 51.2W	Hove-to & RiB launched with 3 PoB; top layer sampling
1140	43 21.2N 17 51.2W	Malfunctioning Patch#2 thermistor buoy grappled
		Top section of flooded sub-surface Argos float lost on recovery
1150		Thermistor string inboard
1200	42 26.1N 17 51.2W	RiB recovered; Wind 300 @ 10 knots
1330	43 21.5N 17 51.0W	Positioning in patch for CTD
1353	43 21.7N 17 51.2W	CTD deployed
1422	43 21.7N 17 51.5W	CTD recovered; ASIS#2 preparations
1502	43 22.4N 17 51.3W	ASIS#2 released, starboard side
1612	43 21.8N 17 51.5W	RiB launched with 4 PoB; ASIP tests; Wind Lt & Variable
1805	43 19.7N 17 50.6W	RiB recovered
1910	43 20.1N 17 49.2W	Patch#2 drogue buoy recovered
1920	43 20.1N 17 49.3W	Patch#2 drogue i/c thermistor string re-released
1930		Commence RDF checks utilising ASIS#2
		Wind 290 @ 10 knots
2054	43 18.3N 17 50.1W	Complete RDF checks; commence atmospheric sampling
2254	43 18.4N 17 50.3W	Complete atmospheric sampling; v/l routed for URI#2 recovery
		via Patch#1 buoy verification
2400	43 24.9N 17 55.3W	Wind 290 @ 12 knots
2007-06-28		
0052	43 30.5N 17 59.3W	Patch#1 buoy sighted – approx positn 43 31.5N 17 58.0W
0400		Wind 270 @ 14 knots
0430	43 21.2N 18 22.4W	Commence approach towards URI#2 search area
0603	43 18.6N 18 13.4W	URI#2 sighted
0630	43 18.8N 18 13.5W	URI#2 float recovered; v/l sets co for Patch#2
0800	43 18.2N 17 58.4W	In vic Patch#2; comm search for high concentrations
		Wind 220 @ 14 knots
1100		Expanding square search continues
1200	43 14.8N 17 52.2W	Wind 220 @ 20 knots
1314	43 14.7N 17 49.8W	Hove-to & CTD deployed
1343	43 14.4N 17 49.9W	CTD recovered (Patch#2 buoy positn 43 15.2N 17 48.9W)
1415		Catamaran 'mission' aborted due to sea state
1445	43 14.2N 17 49.9W	RiB deployed with 3 PoB; top layer sampling
1515		RiB recovered
1549	43 13.6N 17 48.8W	CTD deployed
1616	43 13.3N 17 48.5W	CTD recovered; v/l repositioning to east of patch
		Wind 240 @ 15 knots
1704		Hove-to for NOCs buoy deployment
1732	43 13.3N 17 44.3W	NOCs buoy released, starboard side
1815		Catamaran 'mission' again aborted

1850	43 12.0N	17 43.9W	Complete initial monitoring of NOCs buoy
			V/l relocating towards Patch#1
2000			Wind 230 @ 15 knots
2150	43 28.0N	17 56.5W	Hove-to for atmospheric sampling
2400	43 25.9N	17 58.2W	Wind 230 @ 16 knots
2007-06-29			
0400	43 26.3N	18 00.3W	Wind 240 @ 17 knots
0500	43 26.3N	18 01.2W	V/l repositioning towards patch
0635	43 26.8N	17 53.6W	Commence exp. square search vic Patch#1 for high tracer
0800			Wind 230 @ 15 knots
0912-1000			V/l downtime due to hand steering tests/adjustments
1200	43 23.9N	17 55.9W	Wind 230 @ 28 knots
1312	43 24.8N	17 54.7W	Hove-to in tracer & CTD deployed
1340			CTD recovered
1428	43 24.8N	17 54.5W	V/l repositioning towards Patch#2
1600			Wind 220 @ 34 knots
1726	43 06.9N	17 47.8W	Commence surveying for tracer, vic Patch#2
1932			Hove-to for CTD; drogue buoy 3nm to NE
1937	43 04.4N	17 47.5W	CTD deployed; Wind 230 @ 35 knots
2010	43 04.1N	17 46.8W	CTD recovered; Atmospheric sampling commences
2400	43 04.8N	17 52.6W	Atm sampling continues; v/l @ 1.5 knots, 290 deg CMG
			Wind 230 @ 27 knots
2007-06-30			
0400	43 05.9N	17 59.6W	Wind 250 @ 29 knots
0800			Wind 260 @ 30 knots
1200	43 07.2N	18 14.6W	Atm sampling continues; Wind 260 @ 30 knots
1300			Equipment stopped in for'd container due to vibration
1600			Wind 270 @ 33 knots
1620	43 07.3N	18 22.9W	V/l turned & on reciprocal track towards Patch#2
1942	43 00.6N	17 37.4W	V/l round & hove-to east of Patch#2; kept comfortable overnight
2000			Wind 270 @ 30 knots
2400	42 59.4N	17 46.5W	Wind 270 @ 25 knots; v/l making good 290 @ 1.5 knots
2007-07-01			
0400			Wind 290 @ 23 knots
0456	43 01.7N	17 54.1W	V/l round & sets co. 120 towards Patch#2
0630	42 54.3N	17 37.6W	A/c to 255 deg; zig-zagging across likely patch track
0736	42 52.5N	17 45.6W	A/c to 120 deg
0806	42 47.5N	17 39.4W	A/c to 270 deg; Wind 290 @ 20 knots
0900	42 47.5N	17 44.2W	A/c to 120 deg
0930	42 45.2N	17 38.5W	A/c to 270 deg
1000	42 45.3N	17 44.5W	A/c to 120 deg
1040	42 42.6N	17 39.1W	A/c to 270 deg
1115	42 42.8N	17 43.4W	A/c to 120 deg
1200	42 42.5N	17 41.6W	Repositioning towards anticipated patch centre
1217			Hove-to for CTD; Wind 270 @ 24 knots
1227	42 43.1N	17 42.5W	CTD deployed
1258	42 42.8N	17 42.6W	CTD recovered; sampling & repositioning
1404	42 42.2N	17 43.3W	CTD deployed
1417	42 42.1N	17 43.5W	CTD recovered
1442	42 41.8N	17 42.5W	Patch#2 drogue buoy deployed
1509	42 41.6N	17 41.7W	CTD deployed
1522	42 41.5N	17 41.8W	CTD recovered
1556			CTD retermination required; v/l re-positioning eastwards
			Wind 270 @ 18 knots
1658	42 41.5N	17 28.8W	V/l hove-to @ 2 knots thro' water for ASIP release
1714	42 41.6N	17 29.7W	ASIP released .. & lost due unit malfunction
1718			V/l in transit for NOCs buoy recovery

1852	42 44.2N	17 20.4W	NOCs buoy recovered to stbd waist; set co for Patch#1
2000			Wind 280 @ 12 knots
2202	42 59.4N	17 39.0W	A/c to 070 deg; commencing search zig-zag northward
2312	43 02.0N	17 36.8W	Cease search for night; v/l hove-to air sampling
2400			Wind 270 @ 12 knots

2007-07-02

0400	43 00.3N	17 30.3W	Wind 260 @ 18 knots
0748	42 56.6N	17 31.7W	Resume Patch#1 tracer sampling; Wind 270 @ 20 knots
0827			Heave-to for test CTD
0911	42 52.2N	17 35.3W	CTD deployed
0930			CTD recovered; resume patch survey
1028-1036			Heave-to for NOCs instrument pressure test
1200	42 52.8N	17 39.5W	Patch survey continues; Wind 270 @ 22 knots
1600	42 53.0N	17 43.2W	Wind 270 @ 28 knots
1654	42 53.9N	17 43.0W	Heave-to for CTD
1706	42 53.9N	17 43.0W	CTD deployed
1736	42 53.7N	17 42.9W	CTD recovered; reviewing samples
1755			All secure; v/l repositioning for buoy recoveries
1915	42 51.7N	17 29.9W	Patch#1 Thermistor/drogue buoy grappled & recovered
1930			V/l in transit, co 182 deg, for Patch#2
2000			Wind 270 @ 27 knots
2200	42 28.9N	17 31.8W	Patch#2 buoy detected astern @ 8nm; A/c to 000 deg
2348	42 34.9N	17 31.9W	Hove-to vicinity Patch#2 drogue buoy; Wind 270 @ 26 knots

2007-07-03

0400	42 32.5N	17 34.2W	Wind 270 @ 24 knots
0600	42 25.7N	17 36.9W	Commence Patch#2 tracer sampling survey
0800			Wind 270 @ 24 knots
1118	42 21.1N	17 45.9W	Fishing buoy caught on PES fish
1120			Buoy clear; Fish inspected – no problems
1200	42 23.6N	17 46.9W	Wind 270 @ 22 knots
1426			Heaving-to for CTD in highest tracer area detected
1435	42 21.2N	17 46.3W	CTD deployed
1502			CTD recovered
1600	42 19.5N	17 44.0W	A/c to 315 deg; commencing search for lost #0 drogue buoy Wind 300 @ 12 knots
1655			Buoy sighted
1717	42 21.6N	17 45.5W	Buoy grappled & recovered; set co 090 deg for #6 buoy
1938	42 25.5N	17 28.8W	Thermistor buoy #6 detected via GPS signal; slow approach due restricted visibility
2014	42 27.6N	17 29.2W	Buoy sighted @ 1 cable; Wind 270 @ 10 knots
2025			Therm. string & drogue buoy recovered; set co for re-deployment
2233	42 18.9N	17 46.8W	Therm. string & drogue buoy redeployed 2nm S of pm CTD V/l in transit eastward to confirm position of ASES buoys
2400	42 21.6N	17 32.6W	Wind 270 @ 6 knots

2007-07-04

0400			Wind Lt & Var
0432	42 34.2N	16 35.9W	Passing ASIS#1 in position 42 34.3N 16 36.3W
0612	42 49.0N	16 39.1W	Hove-to off ASIS#2; CTD deployed
0636	42 49.3N	16 38.8W	CTD recovered; all secure & v/l returning to ASIS#1
0800			Wind Lt & Var
0839	42 35.1N	16 33.7W	Hove-to & CTD deployed
0945	42 34.9N	16 33.6W	CTD recovered; Techs completing assembly of NOCs buoy
1047	42 34.6N	16 33.7W	NOCs buoy deployed off stbd side
1115	42 36.4N	16 32.7W	'Skimmer' launched off stbd side
1200	42 34.0N	16 32.5W	'Skimmer' recovered; Wind Lt & Var; v/l in transit for Patch#2
1400	42 27.4N	16 53.0W	Suspend transit & heave-to for RiB release

1410	42 27.4N	16 52.7W	RiB launched for surface sampling work; 3 PoB
1425	42 27.3N	16 52.9W	PML surface sampler streamed from stern
1445			Surface sampler fully streamed & triggered by RiB scientist
1455	42 27.3N	16 53.1W	Surface sampler recovered
1500			RiB & personnel recovered
1510	42 27.1N	16 53.6W	RiB secure & v/l resumes transit towards Patch#2
1600			Wind 320 @ 12 knots
1945	42 12.2N	17 52.9W	Patch#2 thermistor/marker buoy sighted; comm tracer sampling
2000			Wind 300 @ 12 knots
2056	42 07.5N	17 59.5W	Hove-to & CTD deployed
2132	42 07.3N	17 59.9W	CTD recovered
2154			V/l in return transit towards ASIS#1
2400	42 13.6N	13 37.0W	Wind 290 @ 10 knots

2007-07-05

0400	42 27.8N	16 51.1W	Wind 290 @ 10 knots
0600	42 35.0N	16 30.3W	Hove-to in vic ASIS#1, tracknig it's drift via radar positions
0800			Wind 270 @ 12 knots
0842	42 36.2N	16 27.38	Commence surfactant release to leeward of ASIS#1; CVtoSR
1200			Wind 280 @ 12 knots
1236	42 35.4N	16 26.0W	Complete surfactant release of Patch#3; v/l repositioning
1330	42 35.3N	16 25.9W	RiB away for suface sampling in patch; 3 PoB
1419	42 34.7N	16 25.3W	RiB & personnel recovered; air sampling cycle underway
1600			Wind 310 @ 10 knots
1700	42 36.3N	16 26.2W	V/l repositioning
1745	42 35.5N	16 23.8W	Resume air sampling cycle
1800	42 35.5N	16 23.5W	'Skimmer' launched stbd side
1830			'Skimmer' recovered
1855	42 35.4N	16 22.7W	'Skimmer' relaunched
1911			'Skimmer' recovered
1945	42 35.1N	16 23.0W	V/l clearing patch; air sampling continues
2000			Wind 280 @ 10 knots
2040	42 35.6N	16 33.2W	Air sampling cycle completed; v/l in transit to Patch#2
2400			Wind 290 @ 10 knots

2007-07-06

0400	42 07.4N	17 50.3W	Wind 290 @ 17 knots
0507	42 00.3N	18 01.9W	Patch#2 Thermistor/drogue buoy located
0630	41 57.9N	18 08.0W	Heading SW from buoy; tracer sampling commences
0800			Wind 230 @ 12 knots
1133	41 52.9N	18 07.6W	Hove-to & CTD deployed
1200	42 51.9N	18 07.6W	Wind 260 @ 14 knots
1205			CTD recovered
1317	41 53.0N	18 07.7W	'Skimmer' deployed
1427			'Skimmer' recovered
1447	41 52.6N	18 07.9W	RiB launched – 3 PoB; surface sampling
1515	41 52.3N	18 08.0W	PML Surface Sampler streamed
1530			PML SS triggereed by RiB personnel
1542	41 51.8N	18 08.1W	PML SS recovered
1551			RiB & personnel recovered
1600	41 51.8N	18 07.9W	Set co. 007 deg for est. URI rec. posn.: Wind 250 @ 15 knots
2000	42 31.8N	18 01.5W	Wind 240 @ 11 knots
2400	43 12.3N	17 54.6W	Wind 220 @ 24 knots

2007-07-07

0350	43 46.2N	17 46.4W	URI#1 positively identified @ 1.5nm; Wind 030 @ 20 knots
0510	43 46.8N	17 46.4W	URI recovered to starboard waist
0522			All secure; set co 140 deg for NOC buoy/ASIS#2 buoy
0800	43 27.1N	17 23.7W	Wind 020 @ 16 knots
1200	42 54.7N	16 46.2W	Wind 020 @ 16 knots

1445	42 54.6N	16 12.9W	Hove-to vic ASIS#2 for background CTD ref next patch
1459			CTD deployed
1515	42 54.7N	16 12.8W	CTD recovered; v/l in transit towards NOC buoy
1600			Wind 020 @ 20 knots
1630	42 46.8N	16 15.6W	Hove-to for intermediate background CTD
1636			CTD deployed
1652	42 46.9N	16 15.6W	CTD recovered; resume transit towards NOC buoy
1848			NOC buoy sighted
1915	42 41.2N	16 22.6W	NOC buoy grappled & recovered
1920			Relocating 4nm SE of ASIS#1 for background CTD
2044	42 35.9N	16 10.4W	Hove-to & CTD deployed; Wind 010 @ 16 knots
2100	42 35.1N	16 10.1W	CTD recovered; v/l repositioning for Patch#3 release
2122	42 35.4N	16 09.9W	Patch#3 Drogue/Thermistor marker buoy deployed
2152	42 34.1N	16 11.7W	SF6 hose on depressor weight deployed
2200	42 34.2N	16 11.6W	Commence 2km square patch release
2400	42 34.6N	16 11.6W	Patch release continues; Wind 010 @ 18 knots

2007-07-08

0058	42 34.4N	16 09.6W	Patch#3 release completed; v/l repositioning for URI release
0204	42 37.0N	16 14.8W	Hove-to & URI deployed; v/l in transit towards Patch#2
0400	42 28.3N	16 38.0W	Wind 360 @ 17 knots
0800	42 08.2N	17 29.7W	Wind 340 @ 10 knots
1106	41 49.9N	18 09.9W	Adj co to 224 deg
1200	41 43.9N	18 18.6W	Tracer monitoring in progress; Wind 360 @ 10 knots
1226	41 44.2N	18 22.9W	Patch#2 marker buoy abeam to stbd @ 0.1nm; CoVtoSR
1505	41 43.5N	18 23.8W	Hove-to & CTD deployed
1540			CTD recovered
1600	41 43.5N	18 23.9W	Sectn of NOC buoy hung of o'side for test purposes Wind 350 @ 7 knots
1614	41 43.4N	18 24.1W	RiB launched for surface sampling; 3 PoB
1644	41 43.4N	18 24.3W	PML Surface Sampler streamed
1655			PML SS triggered by RiB personnel
1706	41 43.3N	18 24.4W	PML SS recovered
1714			RiB & personnel recovered
1820	41 42.7N	18 24.2W	NOC buoy sectn recovered
1835	41 42.6N	18 24.2W	'Skimmer' launched starboard side
1855	41 42.4N	18 24.2W	Patch#2 marker buoy recovered
1940	41 42.0N	18 24.5W	'Skimmer' recovered
1945			Deck secure; v/l in transit towards Patch#3; Wind 350 @ 8 knots
2400	42 02.7N	17 33.4W	Wind 360 @ 10 knots

2007-07-09

0400	42 21.5N	16 42.3W	Wind 340 @ 15 knots
0620	42 32.8N	16 10.9W	ASIS#1 buoy abeam to port @ 0.1nm; comm. tracer monitoring
0800	42 37.9N	16 04.1W	Patch#3 marker (drogue/thermistor) buoy (#7) located Wind 330 @ 14 knots
1200	42 36.8N	16 06.5W	Patch tracer survey continues; Wind 320 @ 12 knots
1526	42 35.9N	16 07.1W	Hove-to & CTD deployed
1554	42 35.8N	16 07.5W	CTD recovered
1608	42 35.9N	16 07.0W	2nd drogue marker buoy (#6) deployed; Wind 320 @ 15 knots
1643	42 35.8N	16 06.8W	'Skimmer' launched
1815	42 35.0N	16 06.7W	'Skimmer recovered
1836	42 34.8N	16 06.6W	RiB launched for surface sampling; 3 PoB; V/l relocating southwards for NOC buoy deployment
1920	42 32.1N	16 06.5W	V/l hove-to & RiB recovered
1957	42 32.3N	16 06.6W	NOC buoy deployed; Wind 340 @ 12 knots V/l repositioning for overnight head-to-wind air sampling
2130	42 25.5N	15 57.0W	V/l round on hdng 320 deg; air sampling commences
2400	42 28.1N	15 59.3W	Wind 340 @ 10 knots

2007-07-10

0400	42 35.0N 16 04.4W	Air sampling ceases as v/l a/c to east in search of #7 buoy Wind 330 @ 10 knots
0500	42 36.5N 15 58.6W	#7 located; v/l hove-to in vicinity
0616	42 36.6N 15 57.6W	#7 recovered; v/l repositioning to vicinity Patch#3
0722	42 37.1N 16 04.5W	#7 drogue/therm. buoy redeployed; tracer monitoring in progress; V/l in transit to NOC buoy for surfactant release
0820	42 31.6N 16 03.4W	V/l hove-to vicinity of NOC buoy; Wind 300 @ 10 knots
0822		Commence surfactant release; v/l circling buoy
0910 approx		'Near Miss' incident with buoy
0927	42 31.9N 16 03.6W	Complete surfactant release; v/l relocating to vic. Patch#3; Tracer monitoring continues
1128	42 35.4N 16 09.4W	Hove-to & CTD deployed
1200		CTD recovered; Wind 290 @ 10 knots; Patch mapping continues
1357	42 36.4N 16 09.8W	Hove-to for 'Skimmer' deployment
1427	42 36.4N 16 09.4W	'Skimmer' launched; v/l providing lee
1550	42 36.2N 16 08.1W	'Skimmer' recovered; v/l repositioning; Lt & Variable winds
1645	42 38.2N 16 08.1W	RiB launched for surface sampling; 3 PoB
1655		Delay to launching PML Surface Sampler
1735	42 38.1N 16 07.6W	RiB + personnel recovered
1835	42 38.0N 16 08.0W	PML Surface Sampler streamed
1840		RiB + 3 PoB launched
1850		PML SS triggered by RiB personnel
1900	42 37.9N 16 07.7W	PML SS recovered; RiB + personnel recovered
1910		V/l manoeuvring to detect marker buoy positions
1945	42 38.6N 16 02.6W	Positions of drogue & thermistor buoys #s 6&7 re-established V/l relocating to vicinity ASIS#2; Wind 315 @ 10 knots
2054	42 46.5N 15 55.8W	Hove-to vic ASIS#2; atmospheric sampling overnight
2400	42 48.5N 15 58.2W	Wind 310 @ 8 knots

2007-07-11

0200	42 50.3N 16 00.7W	
0400		Wind 300 @ 12 knots
0525	42 45.2N 15 54.7W	V/l repositioned downwind of ASIS#2 for recovery
0605		Approaching ASIS#2
0620	42 45.5N 15 55.7W	Lifting pennant grappled & hooked on for'd crane
0625		Weight transferred to direct lift on aft hangar crane Buoy manoeuvred aft, close outboard of bulwarks
0635	42 45.5N 15 55.8W	ASIS#2 landed on aft deck
0708	42 45.6N 15 55.9W	CTD deployed
0808	42 45.8N 15 56.2W	CTD recovered; v/l remains hove-to for sampling from CTD Wind 300 @ 9 knots
0850	42 45.9N 18 56.8W	V/l in transit towards URI#1 recovery area
1000		Surfacing position available; v/l course adjustment
1118	42 41.2N 16 07.0W	URI#1 grappled & recovered
1200	42 42.2N 16 05.4W	V/l monitoring tracer vicinity Patch#3; Wind 270 @ 8 knots
1426	42 39.5N 16 05.3W	Hove-to & CTD deployed
1507		CTD recovered
1527	42 39.1N 16 05.4W	'Skimmer' launched; v/l providing lee
1600		Wind 270 @ 14 knots
1640	42 38.5N 16 04.3W	'Skimmer' recovered; v/l in transit towards ASIS#1
1815	42 28.9N 16 54.8W	Heaving-to off ASIS#1
1833		Lifting pennant grappled & hooked on for'd crane
1838		Weight transferred to direct lift on aft hangar crane
1845	42 28.8N 16 55.2W	ASIS#1 landed on deck
1859	42 28.7N 16 55.3W	CTD deployed
1932		CTD recovered; all secure; v/l in transit for Patch#3
2000		Tracer monitoring in progress; Wind 280 @ 10 knots
2400	42 38.0N 16 09.3W	Tracer survey continues; Wind 270 @ 20 knots

2007-07-12

0200	42 38.8N 16 10.6W	Tracer survey of Patch#3 continues
0420	42 40.6N 16 06.3W	Break off from survey to recover & reposition drogue marker buoy Wind 270 @ 17 knots
0520	42 41.7N 16 03.0W	Buoy unlit – search cancelled; Achterberg fish recovered for repairs; v/l repositioning to Patch centre
0555	42 40.7N 16 06.2W	V/l hove-to in Patch; Achterberg fish redeployed
0700		Commence 24 hr Patch monitoring
0800	42 40.5N 16 03.7W	Wind 280 @ 12 knots
1045	42 39.4N 16 03.9W	CTD deployed
1120	42 39.1N 16 04.4W	CTD recovered; Patch monitoring continues
1200	42 38.9N 16 03.6W	Wind 270 @ 16 knots
1600	42 39.8N 16 05.5W	Wind 270 @ 20 knots
2000	42 41.5N 16 03.5W	Wind 230 @ 22 knots
2400	42 41.0N 16 02.8W	Wind 220 @ 25 knots

2007-07-13

0400	42 40.4N 16 02.7W	Wind 230 @ 30 knots
0708	42 40.3N 16 02.2W	24 hr monitoring concluded; CTD deployed
0740		CTD recovered
0759		V/l repositioning for buoy recoveries; Wind 340 @ 12 knots
0835	42 40.8N 15 59.7W	#6 Drogue buoy grappled & recovered
0845		In transit towards #7
0938	42 39.5N 15 55.2W	#7 Thermistor buoy grappled & recovered
0955	42 38.7N 15 54.6W	V/l round & in transit towards NOC buoy
1055	42 32.3N 15 49.0W	Heaving-to off buoy
1115		NOC buoy hooked
1124	42 32.5N 15 49.4W	Buoy landed on deck
1132		PES fish recovered
1136	42 32.6N 15 49.6W	Set co northward; atmospheric & Achterberg fish measurements continue
1200	42 35.8N 15 47.9W	Wind 270 @ 14 knots
1315	42 48.0N 15 40.0W	Adj co to 009 deg (T&G) for DMS sampling route W. of Ireland
1600	43 17.3N 15 33.6W	Wind 300 @ 12 knots
2000	43 58.6N 15 24.6W	Wind 290 @ 12 knots
2400	44 38.3N 15 15.8W	Wind 280 @ 12 knots

2007-07-14

0400	45 22.3N 15 05.9W	Wind 210 @ 15 knots
0800	46 06.7N 14 55.8W	Wind 220 @ 15 knots
1200	46 48.9N 14 46.0W	Wind 320 @ 16 knots
1600	47 31.7N 14 35.9W	Wind 180 @ 11 knots
2000	48 10.3N 14 22.3W	Wind 180 @ 15 knots
2400	48 50.0N 14 14.4W	Wind 220 @ 15 knots

2007-07-15

0400	49 33.4N 14 04.6W	Wind 130 @ 12 knots
0800	50 17.0N 13 54.5W	Wind 150 @ 12 knots
1000	50 36.5N 14 04.0W	A/c to 336 degs (T&G) @ scientific request
1200	50 55.7N 14 16.9W	Wind 130 @ 16 knots
1600	51 35.8N 14 43.5W	Wind 120 @ 20 knots
1830	52 00.0N 15 00.0W	A/c to 015 degs (T&G); v/l on best track for chlorophyl levels
2000	52 15.1N 14 53.4W	Wind 090 @ 15 knots
2400	52 54.6N 14 36.0W	Wind 090 @ 26 knots

2007-07-16

0100	53 04.3N 14 31.6W	Clocks advanced 1 hr to BST
0448	53 30.0N 14 20.0W	A/c to 050 degs (T&G)
1004	53 05.0N 13 10.0W	A/c to 064 degs (T&G)

1200	54 11.0N 12 47.7W	Wind 045 @ 24 knots
1225	54 12.9N 12 43.9W	V/l hove-to for atmospheric sampling
1301	54 12.9N 12 43.0W	Commence pumping surfactant; v/l on parallel line tracks across the wind
1526	54 12.2N 12 42.4W	Complete pumping surfactant
1556	54 10.1N 12 44.2W	Hove-to downwind of patch for atmospheric monitoring Wind 020 @ 27 knots
1800	54 10.8N 12 43.9W	Surfactant release completed; resume passage; Co 058 deg (T&G)
2000	54 20.2N 12 17.0W	Wind 010 @ 15 knots
2400	54 39.8N 11 20.0W	Wind 040 @ 22 knots

2007-07-17

0330	54 59.8N 10 30.5W	A/c 065 degs (T&G)
0400	55 02.1N 10 22.2W	Wind 010 @ 19 knots
0800	55 20.0N 09 14.8W	Wind 280 @ 10 knots
0930-1130		Courses & speeds various testing & adjusting hand steering
1200	55 27.1N 08 32.0W	Wind 190 @ 10 knots
1443	55 29.0N 07 39.1W	Achterberg fish recovered
1600	55 29.3N 07 16.4W	A/c 102 degs (T&G); Wind Lt & Var.
1900	55 24.3N 06 30.1W	Bull Pt brng 129 degs x 9.9nm
2020	55 21.7N 06 07.1W	A/c 145 degs (T&G); Altocarry Hd brng 195 degs x 6.03 nm Transitting TSS; Wind 120 @ 10 knots
2118		A/c 090 degs; Torr Hd brng 250 degs x 4.6 nm
2200	55 13.6N 05 40.3W	Sanda Is brg 036 degs x 4.0 nm; A/c 061 degs (T&G)
2400	55 24.9N 05 02.8W	Wind 140 @ 9 knots

2007-07-18

0010	Pillar Rock Pt. 335 degs x 5.2 nm; A/c 002 degs (T&G)
0158	Cumbrae Elbow 122 degs x 0.5 nm; A/c 011 degs (T&G)
0330	EoP; Ardcowan Pt brng 090 degs x 0.9 nm ME tested astern; BT & steering gear tested
0400-0445	V/l hove-to off Kempock Pt awaiting pilot; Wind Lt & Var
0445	PoB Mitchell; v/l commences Clyde R. transit
0522	Leven Perch abm to port
0608	#47 buoy abm to stbd
0638	Lobnitz basin abm to stbd
0700	V/l swinging into KGV dock basin
0713	First line
0724	All fast 4&2, F&A; Pilot away
0730	RFWE

P Sarjeant Master RRS *Discovery* June/July 2007

Appendix 3: Loss of Equipment Report- ASIP

RRS 'Discovery' Cruise D320

Date & Time: 01.07.07 1658 hrs to 1714 hrs UTC

Position details: N. Atlantic – approx water depth 3500m
1658hrs 42 41.5N 17 28.8W V/l @ preferred speed & hdng
1714hrs 42 41.6N 17 29.7W Instrument released

Weather: Wind W'ly @ 18 knots. Moderate sea; low/moderate swell

Ship's Hd & Spd: Head-to-wind (280 degs); 2 knots thro' water;
Propellor stopped; Bow Thruster @ half thrust ahead.

Equipment:
ASIP - Air/Sea Interaction Profiler. A float-free, 2 metre, tubular profiling instrument to be deployed from the vessel, to oscillate through the top 100m of the water column and to be periodically (36 to 48 hrs) recovered by RiB.

Overview of Deployment:
The profiler had been tested on several occasions earlier in the cruise, using the RiB for these trial deployments.
The preferred method for mission initiation - as required by Dr B. Ward (Scientist in charge of ASIP) - was to carefully hand-drop the instrument over the stern with the vessel making slight headway with the propeller stopped. No release lines were to be attached for fear of damaging sensors in the head of the instrument when slipping such lines. This deployment method had been adopted by Dr Ward on an Indian Ocean cruise (CIRENE) aboard a French research vessel 'Suroit' earlier this year.

A risk assessment and manual handling assessment were in place; all deployment personnel were properly briefed in the method of release; all wore correct PPE for 'rails down' work in the 'red zone'.

The release was as per briefing. Due to a malfunction of the instrument, however, it failed to resurface as expected and continued it's descent towards the sea floor. It would have imploded upon reaching depths greater than 300m.

Peter Sarjeant
Master, RRS 'Discovery'
03.07.07

Report sighted & approved by R. Upstill-Goddard (PS) & B. Ward (ASIP scientist)

Appendix 4: Report of D320 Cruise Debrief Meeting, July 15, 2007

Date: Sunday 15th July 2007 in Master's Cabin @ 0900 hrs

Attendees:		
	R. Upstill-Goddard	Principal Scientist
	P. Sarjeant	Master
	D. Comben	TLO
	I. Slater	Chief Engineer
	P. Reynolds	C/O
	M. Ripper	PCO
	M. Minnock	CPO(S)

Minutes:

1. Effectiveness of cruise planning procedures as perceived by all parties present and any difficulties arising, either during the cruise or the mobilisation period.

The Principal Scientist (PS, Rob Upstill-Goddard) commented that the Planning Meeting had been arranged rather late in the pre-cruise process but that, nevertheless, all matters had been properly covered. His dealings on logistical matters had been exclusively with Malcolm Woodward and had all been satisfactorily resolved.
The only real issue concerned that of numbers of berths. Consistent advice from NMF SS had been that 27 berths were available for scientists and technicians when in fact 28 is the correct number. The addition of an extra scientist would have 'spread the load' particularly in respect of patch monitoring. {The Master had already, some days previously, requested the Head of Operations to re-iterate the correct number to all relevant parties for future reference}.

At mobilisation there had, as on D319, been issues surrounding insufficient or inaccurate pre-cruise information concerning supplies (power & compressed air) to the foredeck container. These had been resolved by the excellent combined efforts of the ship's engineering staff and technicians. It was fortuitous that a compressed air generator – planned for return to NOC – was still aboard.
The Chief Engineer advised that plans had been submitted for the installation of permanent 'plug-in' supplies to the foredeck.

Sailing had been delayed on Saturday 16th June due to the failure of a small NIOZ transformer and the absence of spares. The Master requested minuting of the excellent support afforded by the ship's Falmouth Agent, Brett Moyle, in accessing the RS Components website, establishing availability and arranging same-day delivery. {Thanks had already been conveyed to the Agents from The Head of Operations, post-sailing}.

2. Factors affecting the actual conduct of the cruise and the performance of all parties represented, including the suitability of the vessel for the operations undertaken.

The PS raised two issues that impacted upon the cruise: the liquid nitrogen generator was out of action for several days until the combined efforts of engineers and technicians brought it back to life. Dan Comben (TLO) advised that a part with a life-expectancy of 10,000 hrs had failed at half that figure. He further advised that more spares would be carried in future and undertook to verify that maintenance schedules were observed when the unit was in storage at NOC.

The second issue surrounded the inadequacy of the air conditioning system at times in the Deck Lab. Whilst it was acknowledged that leaving external doors open exacerbated the problem, the Chief Engineer advised that the (old) system was working as effectively as was possible. It was acknowledged as inadequate for the demands placed on it by the heat-generating equipment increasingly packed into the laboratory spaces.

As discussed by relevant parties during the voyage, it was agreed that enhanced PML software – integrating real-time vessel and marker buoy positions with time-corrected tracer imagery – would greatly facilitate patch mapping work on future cruises of this nature. It was further noted that timely Argos positional information would be beneficial when attempting to re-establish patch position after vessel off-station periods often in excess of 24 hours.

The performance of all parties was deemed by the PS to have been excellent as reflected in AOB comments in the completed Post-Cruise Assessment Form.

When asked about the effectiveness of lines of communication, the PS commented that they had been good, facilitated by the daily management meetings. His personal opinion was that the proposed introduction of a Science Systems Manager would introduce an unnecessary layer of management into day-to-day operations.

3. Agreement of a 'record of events' that indicates the principal activities undertaken throughout the cruise.

A ‘Record of Events’ is being prepared and a final version will be appended to these de-brief minutes and submitted to the Principal Scientist in electronic format (**see Appendix 2**).

4. Effective completion of the Cruise Objectives as defined in the minutes of the Cruise Planning Meeting

Cruise objectives were deemed by the PS to have far exceeded expectations, the loss of ASIP notwithstanding. It is hoped that sufficient DMS levels will be found west of Ireland in the next 24 hrs to compensate for the low levels found in the primary work location.

5. Safety Related Incidents and Reports arising during the Cruise.

The C/E, as Safety Officer, reported one Accident (manual exertion related) and one Near Miss (conning incident involving Spar buoy). These had both been fully investigated and reported.
{Numerous scientific Risk Assessments were reviewed at the outset of the cruise and contents sighted by all Deck Officers & Crew. – Master.}

6. Any Major Customer Complaints filed during the term of the cruise, and any Minor Customer Complaints brought to the attention of the Master.

No major customer complaints had been filed with the Master and no minor customer complaints (other than those detailed in section 2) had been brought to his attention.

7. Cleanliness and state of readiness of the vessel and its facilities at commencement of Cruise.

The PS advised that the PML group had been unhappy with the cleanliness of the Labs at cruise commencement. By way of response it was noted that the D319 scientific party had been supplied with the necessary cleaning materials and requested to effect cleaning as part of their de-mob process. It is further noted that the increased incidence of de-mobilisation merging with mobilisation once the vessel arrives alongside gives the crew little opportunity to carry out a secondary clean.

8. Packaging and shipping arrangements for departing technical equipment, or any perceived problems with the de-mobilisation period.

Current ETA dependent upon science over the next 24 hrs; de-mobilisation arrangements are in hand; crane, container spreader and forklift requirements have been instructed by NMF SS Ops via the ship's Agents. The TLO advised that he had received - or was in the process of receiving - all packing list information. Malcolm Woodward has advised that all shipping arrangements are in hand via various freight agents.

The Master advised that dry ice and liquid nitrogen requests had been telephoned through to the Agents and copied to the De-mob Officer (Jason Scott) to avoid chance of double-booking. Arrangements would be put in place for collection & delivery of remaining Surfactant.

9. Cleanliness of the vessel and scientific spaces at the termination of the cruise and checks to ensure a thorough evacuation has been completed.

The PS undertook to ensure that scientific cabins & laboratories are restored to better-than joining standard as part of de-mobilisation procedures.

10. Agreement of the overall voyage statistics and record of any lost time due to:

The Master reported the following 'downtime':

Vessel downtime: 0.8 hrs (29th June) Hand steering adjustments.

Scientific equipment: Nil
Adverse weather: 12.5 hrs (30th June/1st July) Atmospheric sampling suspended due to vibration of equipment in foredeck container.
Medical problems: Nil
Other valid reasons: 9.0 hrs (16th June) Delay to sailing – awaiting delivery of spare NIOZ transformer.

11. The Principal Scientist's perception of the degree to which NMF SS has met his/her requirements.

The PS again re-iterated that his cruise expectations had been far-exceeded and paid tribute to the superb all-round co-ordination that had made that possible. Mike Rebozo (ASIS technician – RSMAS Miami) had commented on more than one occasion that – in his wide sea-going experience - this was the best crew that he'd ever sailed with.

12. Other Observations

The Master personally thanked all departments for their excellent team effort that had contributed to a successful cruise.

Peter Sarjeant
Master

Assisted with Minutes by M. Ripper (PCO)

Verification of minutes: Please sign in the appropriate box that you have read and agreed the minutes contained above.

NAME	POSITION	SIGNATURE
Rob Upstill-Goddard	Principal Scientist	
Peter Sarjeant	Master	
Peter Reynolds	C/O	
Dan Comben	Technical Liaison Officer	
Ian Slater	Chief Engineer	
Mick Minnock	Chief Petty Officer (Scientific)	
Mike Ripper	Purser Catering Officer	

Appendix 5: NERC Post-Cruise Assessment/ Debrief Agenda Form

This form is an important tool in enabling NERC to monitor the performance of its marine facilities providers, as well as providing useful feedback for improving service provision. Consequently NERC requires all PIs who are programmed in its Marine Facilities Programme (including cruises on barter ships) to complete this form. Please see attached guidance notes for details on how this form should be completed and subsequently handled.

All forms are reviewed by NERC's Marine Facilities Review Group and therefore subsequently become part of the public record. Therefore, please do NOT make reference to individuals by name; any feedback on individuals (both positive and negative) should be sent direct to the head of the appropriate service (Please see guidance notes for contact details).

Ship :	***RRS Discovery***	***Cruise no.***	***D320***	***Dates:***	***16 June – 18 July 2007***
PS name:	**Prof R.C. Upstill-Goddard**	**Institution & position:**	**Professor: Newcastle University**	**Email:**	**Rob.goddard@ncl.ac.uk**
Work type:	**Air-sea gas exchange and biogeochemistry**		**Area of operation:**	**Atlantic around 43 N, 18 W**	
Master:	**Peter Sarjeant**		**Tech Liaison Officer:**	**Dan Comben**	

		Please tick the appropriate box and add comments if required							
		Greatly Exceeded Expectation	Exceeded Expectation	Met Expectation	Below Expectation	Greatly Below Expectation	Comments	Complaint filed (Y/N)	Internal Use Only: Logged
	Science Objectives Met	✓					Virtually all objectives met in full. Only serious matter was malfunction & loss of ASIP (air-sea interaction profiler). Work area was low DMS seawater; a scientific compromise of some concern to Univ. Hawaii.		
	Downtime								
	Safety If Accidents or Near misses have been filed refer to these.			✓			Near-miss reports filed		
	Programming & SME			✓					
	Pre-Cruise Planning / Supply agreement								
Pre-Cruise	Pre Cruise Planning & Communications				✓		Process was much later than previously. Most queries answered in good time but some emails unanswered (PML). Major issue concerns available berths. At planning I was consistently told 27 scientific berths maximum. Post-departure the Master informed me of an extra berth on-board unused. I would have invited one more scientist had I known this during planning.		
	Mobilisation Support						Excellent. Of note was effort by ship's engineers to install 60 Hz power and oil-free compressed air to Univ. Hawaii container.		

Onboard Support	Communications		✓				Excellent		
	Staff								
	Scientific Facilities ▪ Functionality ▪ Performance ▪ Reliability ▪ Safety ▪ Cleanliness of labs			✓ ✓ ✓ ✓	 ✓		It was apparent that some items are not sufficiently maintained; the liquid nitrogen was out of action for several days. Without the sterling efforts of the UKORS staff and the engineers in repairing it some scientific outcomes could have been significantly compromised. Air conditioning in the deck lab was inadequate. Even with the doors closed the lab temperature frequently reached over 29°C. This will prove a problem on future cruises, e.g. to Cap Verde cruises. Labs did not seem to have been cleaned during previous demob.		
	Domestic Facilities ▪ Hotel facilities ▪ Catering service ▪ Cleanliness of ship		✓				Cabins were adequate but some cabin toilets were smelly and use of available cleaning fluids made little difference. Catering service was excellent Ship cleanliness was excellent		
	Demobilisation Support Please advise on any issues post completion								
	Any Other Business						We could not have achieved such good mapping of the tracer patch without the magnificent contribution made by the ship's Master and officers who all really engaged with this activity and accurately predicted the patch positions relative to the movement of marker buoys. This level of help far exceeded all expectations and has been a major contributor to the sucesss of this cruise. The crew and CPO's were extremely helpful during the many deployments of the tracers, marker buoys, catamaran, near-surface sampler, RIB, NOC buoy and the two ASIS. Univ. of Miami staff remarked that this was easily the most competent crew with which they have sailed. Crew were very helpful in asking about the use of chemicals/paints in advance in order to avoid contamination. The UKORS technical staff also once more made an invaluable contribution and never became impatient of our demands. We particularly appreciate their efforts along with the engineers, to repair the liquid nitrogen generator. Email was poor in PSO office but subsequently repaired by computing officer. Lack of instant downloads and		

							WWW access a large problem		

GUIDANCE NOTES FOR COMPLETING THE PS ASSESSMENT FORM

For cruises on NMF vessels it is requested that this form is completed prior to the on board Post-Cruise Debrief Meeting (see attached agenda) and so that any issues raised can be addressed at this meeting. Following this the original form (unaltered) will be sent by the Master to the Head of NMF at NOC so that any outstanding issues can be addressed by NMF shore staff. You will be advised of any further responses by letter, but all issues raised during NMF cruises are recorded and follow up action detailed on the NMF website: this can be accessed at http://www.noc.soton.ac.uk/nmf/mfp/mfp.php

For cruises on Barter vessels the form should be sent to the Head of NMF Sea Systems, Geraint West gerw@noc.soton.ac.uk When the cruise has also utilised NMF facilities (including NMEP items), the form will de dealt with as detailed above for NMF ships; for other cruises the form will be forwarded direct to NERC.

All forms will be sent to the NERC Marine Planning Office for information, and will be included with the papers provided to the next meeting of the Marine Facilities Review Group. Occasionally when a PS raises issues of a very serious nature, they will be invited to make either a personal on written submission to the group to provide fuller details.

When completing the form, please use the following bullet points to help you in your assessment of whether the service provided met your cruise needs, although it is requested that you attach more weight to any issue that has impacted on your cruise objectives. *Please feel free to make suggestions for service provision improvement in any section.*

1) Science objectives met

a) Were the objectives specified in the Supply Agreement completed?
b) Were services supplied iaw the Supply Agreement (please amplify in the appropriate section)?

2) Downtime

The Master will provide you with a detailed breakdown of cruise time including downtime with the post cruise timetable, but was there any 'loss' of science time during the cruise which you consider unreasonable or a result of procedural issues?

3) Safety

Please ensure that any Accident or Near-miss Reports filed are cross-referenced in this section

a) Was the pre-cruise safety information provided satisfactory?
b) Were the on board safety briefings and drills adequate?
c) If there were any accidents/near misses, do you think the investigation/reporting system was effective?

4) Programming & SME

a) Did you attend a PI Workshop and was this helpful to you?
b) Were respective responsibilities in the planning process clearly outlined to you?
c) Did you find the Marine Facilities Planning website helpful?
d) Did you receive appropriate advice/support in the compilation of your SME Form?
e) Did NMF and NERC Marine Planning deal with any programming issues to your satisfaction?

5) Pre-Cruise Planning & Communications

a) (For NMF cruises) Did your assigned cruise manager establish good communications with you?
b) Were you provided with all necessary information required to plan your cruise?
c) Were any late changes to the ships programme dealt with appropriately and communicated to you in good time?

6) Pre-Cruise Planning / Supply Agreement

a) Was the Supply Agreement completed in reasonable time prior the cruise?
b) Was the planning meeting attended by all appropriate staff?
c) Did the planning meeting discuss all your requirements in sufficient detail and to your satisfaction?

7) Mobilisation support

a) Did all equipment arrive as planned?
b) Was ship set up as required (bench set ups, container locations etc)?
c) Was the mobilisation completed in the planned timescale?
d) Was any scientific equipment damaged during mob?

8) Onboard communications

a) Were you clear about respective roles and responsibilities of Master, PS and TLO?
b) Were you kept informed by the TLO and Master of any changing circumstances that affected the progress of your cruise?
c) Did the interface between science team and onboard staff (including cruise progress meetings, dialogue between PS, Master, and TLO etc.) work to your satisfaction?
d) Were any issues that required the attention of shore support staff effectively communicated and in an appropriate timescale?
e) Were you properly briefed by onboard staff on operational, domestic and safety procedures?

9) Onboard support - staff

a) Were onboard staff competent and appropriately trained to support your cruise?
b) Were there sufficient technicians and (if appropriate) extra deck staff assigned to your cruise?
c) Were onboard staff helpful, friendly and flexible in response to your needs?
d) Were onboard staff fully engaged in the aims of your cruise?

10) Onboard support - scientific facilities

a) Did equipment work as specified?
b) Was equipment supplied suitable for the cruise?
c) Were there any breakdowns of equipment?
d) Were there any safety problems with any equipment?
e) Were sufficient consumables and spares supplied for your cruise?

11) Onboard support - domestic arrangements

a) Were facilities provided in cabins and (where appropriate) shared bathroom facilities, suitable?
b) Were meals of an acceptable standard and variety, and were timings suitable for your work?
c) Was duty mess out-of-hours provision suitable?
d) Were laundry facilities suitable?
e) Were leisure facilities suitable?
f) Was the cleanliness of the vessel, both internally and externally, acceptable?

12) Arrangements for Demobilisation support

a) Have you made any requests for special requirements (dry ice, hazmat etc.)?
b) Have return equipment lists been completed?