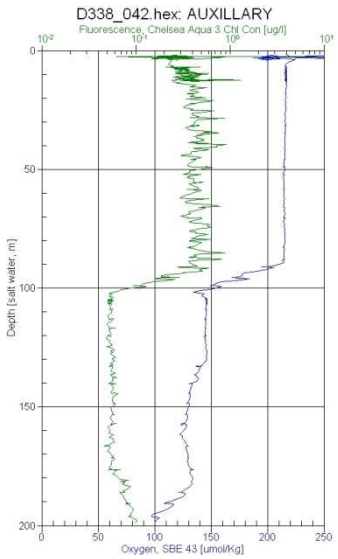
Tuesday 28 April 2009 JD 118

Arghh ! the nightmare returns. I arrived in the lab at 02:30 to find that there was no SF_6 in the immediate vicinity of the buoy, and that the patch was now so long (~ 50 km) and thin (~ 3 km) that the software used to predict the centre of the patch had insufficient data to provide a reasonable prediction. We started a search around the buoy, knowing that the scientists would be tumbling out of bed in a few minutes time expecting us to be on station and ready to deploy the CTD. We found SF_6 north to northwest of the buoy and hove to. The winds were NNE to NE 35 knots gusting 40, and after monitoring the swell and the ability to keep the ship on station, the decision was taken to cancel the CTD deployments and heave to until the winds died down. At



05:37 we were at 20° 43.90 N 018° 09.15 W, the sea surface temperature was 16.9 °C, fluorescence was 0.44 fluorescence units, and the surface SF_6 concentration was approximately 40,000 magical units. By 08:00, the winds were dropping and we expected to be able to deploy the CTD for the 09:00 station. However, the surface SF_6 concentration decreased again, as if we were moving across the edge of the patch – either the front edge (i.e. the ship was drifting faster than the patch), or the back edge (i.e. the patch was drifting faster than the ship). We chose the former and moved east in search of higher SF_6 concentrations, only to realise we had made the wrong prediction, so we moved west and were relieved to measure increasing SF_6 concentrations. We deployed a drifter in this SF_6 patch and then a CTD at 09:43. The CTD (#42) at 12:30 was deployed in a water depth of 1566m with sea surface temperature of 17.5 °C, salinity 36.27 and fluorescence of 0.25 fluorescence units. Chlorophyll and oxygen (green and blue lines respectively on figure 1) were constant down to almost 100m. SF_6 concentrations in the surface waters at the 12:30 CTD station were 18,000 to 19,000 magical units, and the data derived from the optics rig deployed at the same time, gave an estimated 1% light depth of 39 to 41m. Atmospheric sampling occurred as usual between 17:00 and 19:00, after which we resumed the SF_6 mapping. There was an emergency muster station at 16:15.

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

Wednesday 29 April 2009 JD 119

We spent an hour before the pre-dawn CTDs mapping around the buoy and assessing the direction of drift of the ship. We decided to position the ship about 0.9 nautical miles from the buoy on a bearing of 258 °T in water with an SF_6 concentration of 18,000 units. The first CTD was at 03:31 at 20° 39.10N 018° 27.3 W in a water depth of 1530m. The sea surface temperature was 17.5 °C, salinity was 36.27, and the chlorophyll fluorescence was 0.25 fluorescence units (1.9 $\mu g l^{-1}$ using the preliminary calibration, and a four fold decrease

since the beginning of the experiment). The second CTD of the morning (#44) was overboard at 04:25. We also completed deployments of a CTD at 08:58, a turbulence probe at 10:40, a CTD at 12:25, an optics rig (#009) at 12:38, a turbulence probe at 14:35, Apstein, Bongo and 700 µm nets at 15:48, and a turbulence probe at 16:57. The surface layer was mixed to a depth of 60m, and the oxygen minimum occurred between a depth of 300 and 500m.

With the cancellation of the pre-dawn productivity casts yesterday, Vas and Pablo had 100 fewer oxygen titrations to do today and so were able to put their feet up and catch up with bottle washing (photos 1 and 2). The 09:00 CTD is when we focus on collecting samples to measure how gases produced by plankton efflux from the seawater into the atmosphere (and therefore affect climate). By measuring the ratio of the concentrations of helium and sulphur hexafluoride (the two gases we added to the seawater) Phil Nightingale's team can determine the rate of loss of the gases into the air. The helium samples are collected in copper tubes which have to be tapped with a rubber hammer to remove any air bubbles before the tubes are crimped closed at each end. Helium samples are collected from the CTD bottles first and the sample collection and bubble removal process has to be done slowly and carefully, as demonstrated by John Stephens and Ian Brown in photo 3. While everyone else waited patiently to siphon water after the helium samples had been collected, we were amused to see that one female scientist (who shall remain nameless) was wearing very appropriate underwear (photo 4).

At 16:30, Carol, Phil, Andy, Gavin and Riqui met to discuss the implications of the spreading of the patch and what to do next. The options are 1) to try to stay with the patch despite it becoming increasingly difficult to find and to continue following only the buoys if necessary, 2) to 're-seed' the patch with the remaining SF_6 left in the tank or 3) to end this experiment, review what we've learnt and plan the next one. From the underway measurements collected during the SF_6 deployment, we know that the 3 km x 3 km area to which we initially added the SF_6 included waters with a temperature range from 16.65 to 16.95 ^{o}C and a range in chlorophyll from 0.7 to 1.1 fluorescence units (5.6 to 8.9 µg chlorophyll l^{-1} using the preliminary calibration). We also know that the buoys and the SF_6 had become aligned with a frontal feature along the northern edge of the major filament. The spatial variability in all of the chemical and biological parameters caused by these frontal features, mean that it is becoming increasingly difficult to interpret the data in a Lagrangian (i.e. temporal) way, and so it would be better to stop now and utilise the remaining time to undertake a longer Lagrangian study starting in an area away from the frontal region (if such an area exists). If we re-seed with the remaining SF_6, the likelihood is that we would add SF_6 to water that had not previously been seeded with SF_6 and so in effect begin a new experiment – there is little reason to do this for just 1 or 2 days (the length of time the SF_6 is likely to remain detectable). So we decided to stop sampling, recover the buoys and undertake a large scale MVP survey back to the shelf. However, since it is preferable to recover the buoys during daylight, we agreed to remain mapping the area overnight, complete the pre-dawn casts in the

morning and begin to recover the buoys during tomorrow. In terms of the next experiment, one suggestion would be to not repeat exactly what we had just accomplished, but if sufficient data has already been collected in the highest productivity water, to start the SF_6 deployment further offshore than last time (e.g. at the 200 m depth contour) and aim to travel with it for 10-12 days ending up further offshore than we have finished this time. After the meeting and dinner, we completed 2 hours of atmospheric sampling at 19:00, the final CTD of the day at 19:06, and resumed the SF_6 mapping at 19:43. Later, in discussions with the other scientists, we realised that there would be some benefit to delaying the recovery of the buoys until we had completed a CTD tomorrow morning at 09:00. We therefore decided to risk the possibility of not finding the patch at 09:00, and not finding all the buoys in daylight hours, and try to stay in Lagrangian mode until 10:00 tomorrow.