Weekly report no. 7 EIFEX (ANT XXI/3) RV "Polarstern" 8 March 2004

The last report conveyed a rather dreary picture of the ACC as a vast, stormy greyness and this is indeed what one sees through the bull-eyes or when one is hurrying about one´s business on deck. But there is plenty for the eye to enjoy if one takes a few minutes off and rests them on the restless sea surface. The everchanging patterns of surging swell, breaking white caps and streaking foam capture the eye the way the flames of a lively fire do. Under foggy skies the breaking waves are a deep steel-grey tinged with blue along their tips, but when the sun is shining and the ocean calm, all one sees are shades of Mediterranean blue relieved only by the shining white of clouds on the horizon (the next depression). Had the sky been clear these last few days, we would have noticed that the sea is no longer the clear blue it once was but has acquired a turquoise tinge. Our bloom has grown sufficiently to change the colour of the water. Chloro-phyll concentrations above 2.5 mg/m3 extend down to 100 m depth and even at 150 m the values in some CTD casts are as high as in the unfer-tilised surface water around the patch (0.5 mg/m3). If one were to condense the plankton in our bloom into a 10 m layer, the average depth of the summer surface layer in coastal waters, the sea around us would be a murky brown, murkier than the North Sea at the height of the spring bloom. The highest chlorophyll values recorded so far is 2.9 mg/m3.

By about the middle of last week the buoy had completed another closed oval within the eddy, almost identical to the first, and was again hovering at the southeastern corner where the eddy is open and the danger of losing it to the Polar Front is greatest. Since the time had come to service the instruments, we retrieved the buoy hoping to replace it in the westward flowing patch water within a few hours. The buoy is a yellow steel cylinder 5 m long and 50 cm in diameter to which is attached, some 10 m below, a long bag of coarse polyester mesh kept open by steel hoops. This is the drogue whose function is to "anchor" the buoy in a specific water mass of the surface layer for us to follow. During EisenEx we had used a spherical buoy which danced on top of the waves and tugged so much on the drogue that the strong rope snapped and we lost the drogue with the instruments below it. The spar buoy we are using now is more difficult to spot in the daytime (at night a flashing light renders it conspicuous) because the waves go over it, but, together with the stregthened steel frame of the drogue and the elastic rope with which it is now secured to the buoy, it has weathered the storms, so far.

Below the drogue are an ADCP to record current speeds and instruments that continuously measure oxygen and carbon doixide in the mixed-layer water. Far below, at about 200 m depth, are located two sediment traps to collect the particles sinking out of our bloom. One is of standard design and has 24 cups that rotate at intervals of 2 days under the collecting funnel, thus obtaining a time course of the particle rain. However, estimating the amount of this "rain" through the water column quantitatively is as dif---fi--cult as measuring snowfall during a blizzard because the sinking parti-cles move horizontally much faster than vertically. The other trap is specially designed to overcome this hydrodynamic problem and is expected to provide an accurate estimate of the amount of particles sinking through the water column.

All the various mappings of the patch by ship and helicopter indicate that it is fairly sharply delineated at one end but much more diffuse on the other side. The high chlorophyll values which represent the least diluted region, are concentrated in a "hot-spot" about 10 km wide close to the region of sharp demarcation of the patch. The accumulation rate of plankton in this hot-spot is the closest one can get to the true growth rates re----sulting from fertilsation so we carry out our "in stations" inside it. This hot-spot has an average drift of 2 – 3 km an hour and the station takes about 10 hrs to complete, besides, the direction of the patch is inde-pen---dent of the wind which, however, pushes the ship a few km/hr during the station. Besides, the altimeter images sent to us indicate that the eddy itself moves many tens of km, carrying its core with it, over a few days and then stays put for a while. So staying in the hot spot is quite a problem. As the Red Queen told Alice in Wonderland: You have to run to stay in the same spot. And the buoy is our only point of reference as it moves with the hot-spot or at least, as we found out during the 60-hour station carried out over the weekend, weaves around inside it. The ship has to move back to the buoy ever so often during stations.

To return to the story of mid-week, by the time the buoy had been serviced, the ship had been buffeted out of the hot spot by the steadily increasing wind so we had to steam around to find it again. Deploying the buoy is a tricky business and requires all deck hands and a crane to accomplish. Darkness was settling, the white caps were surging ever higher and we could not keep the people on standby for too long so we broke off the exercise and spent the night locating the hot-spot with the FRRF and CO2 values. The buoy was deployed in the middle of the hot-spot from the heaving ship the next morning. After that we steamed to the opposite end of the rotating core and, when FRRF values dropped and CO2 values rose, carried out our "out station". The next few days were spent mapping the region around the hot-spot simply by steaming back and forth along the same track with short CTD stations and letting the current carry it through our line of in---ter----cep-tion. The hot-spot with chlorophyll values above 2 mg/m3 was about 260 km2 but around it was a much vaster area where values were about double those recorded prior to fertilisation and still characteristic of unfer----tilised water.

The 60-hour station carried out over the weekend was devoted to studying temporal changes in the physical environment and diurnal rhythms in the plankton and chemistry of the water column. The mixed layer was generally 100 m deep (the deepest we have ever seen in the ACC) but the 100 m layer beneath it seemed to vary much more. Apparently internal waves were causing it to oscillate resulting in shear and mixing between the layers which would explain the high chlorophyll values below 100 m, sometimes as far down as 150 m which are also very unusual for the ACC. But mixing down has to be differentiated from sinking down and, although phytoplankton in growing blooms don't normally sink, mass sinking might start when the bloom enters the iron-limited phase. Vertical mixing of different layers occurs at the microscale, so a free-falling instrument that measures micro-scale structure in the water column down to 300 m is used to estimate mxing rates. Measuring the rates of transfer of wind energy to the water and its eventual dissipation by mixing is another topic of interest with one draw--back: Most unfortunately, just when the transfer is greatest during storms, the physicists have to retreat from the site of deployment at the back of the ship because of the waves which come crashing over the deck.

All the other groups were equally interested in recording daily cycles. Light directly influences the chemistry of various molecules and also iron (to which we shall return in a later report), apart from driving the pho---to-synthesis of phytoplankton which take up CO_2 and other nutrients. Their growth rates are estimated by various methods both new and conven----tional. Bacterial activity as well as grazing pressure on the algae also varies over the day/night cycle. In particular, the larger copepods (mosquito-sized crustacea of the zooplankton) which are major grazers of diatoms, spend the day at depth and come up in the night to graze. Their activity releases CO_2 and presumably litters the surface layer with bitten off spines (the gaint Chaetoceros are clearly dominating the bloom) and faecal pellets. These either sink out or are utilised by other copepods which feed on them. There are many hundreds of species of unicellular organisms: bacteria, phytoplankton and protozoa that, together with many different kinds of animals of the zooplankton (such as salps and copepods), are involved in our bloom. All these organisms live their daily lives according to a style or technique that evolved over millions of years and which we are investigating with our experiment. The sum total of these processes drives the biogeochemical cycles of the earth of which the carbon cycle, in terms of atmospheric CO_2, is linked to global climate, at least at geo--log-i-cal time scales, including the shorter scales of the ice-age cycle. To this topic we shall return later.

With warm regards from a ship reaping as rich a harvest as human endurance will allow,

Victor Smetacek