Weekly report no. 4 EIFEX (ANT XXI/3) RV "Polarstern" 16 February 2004

The mood of excitement and suspense mingled with impatience that pervaded the first few weeks of this cruise has now given way to the relaxed antic-i-pation of things to come that cannot be pushed any further. We have shifted gears by moving from the uncertainties of the hunter, full of apprehension as to what the next bend of the front will reveal, to the fatalistic patience of the farmer, watching the crop developing in the painstakingly selected field over the course of the five weeks left to us.

It might seem strange that, in such a vast, seemingly homogeneous ocean, the areas suitable for our experiment are so vanishingly small and have to be sought with so much trouble. In fact, any patch of randomly selected water would do, because the phytoplankton is iron-limited across huge stretches of the ocean. The problem is to find a water mass which will retain its shape for the time scales of our experiment. The stretch of ACC sweeping through the Atlantic Sector is particularly dynamic and fast-flowing and even the bands of water with slower current speeds in between the frontal jets tend to be short-lived. Fertilising an undefined water mass can result in problems of which distortion of the patch into a long streak or break-up into several patches are the worst-case scenarios. Another potential problem is the local heterogeneity of plankton (patchiness), sometimes across kilometre-scales which can result in unequal development within the fertilised patch and cause difficulties in areal quantification of bulk processes. The core of a rotating, stationary eddy is the ideal container for the relatively small experimental patch we intend studying and is worth the trouble searching for, because it reduces these risks to a minimum. Another major advantage offered by an eddy core in the ACC is the coherence between surface and deeper layers. Particles sinking through the water column can hence be tracked quantitatively on their way down.

The decision to fertilise our new eddy was taken after assessing the results of several long ADCP transects that were completed by Tuesday last week. The physicists converted the diagrammes bristling with arrows pointing in various directions into smooth contour plots of stream functions which revealed a pear-shaped, closed eddy core of about 80 by 120 km extent and at least 500 m deep enclosed within a loop of strong currents. Silica concentrations measured in surface water along the transects beautifully confirmed the results of the current contours. Values inside the core were 19 micromoles/l but only 4 and 7 in the surrounding water to the north and south respectively; clearly the eddy core represented the silica-rich band of water in the south. The core centre could be surmised from the contours but had to be confirmed with a small-scale ADCP grid which was carried out through the night and into the next morning. Since this closed core had been rotating for at least a month the water inside it was expected to be homogenised by mixing. This was confirmed by measure---ments of the CO_2 and nutrient concentrations carried out during the small-scale grid. The constancy of the values over the large area covered re---

flected the superb analytical skills of the chemists on board.

The centre of the core was identified by Wednesday afternoon and the drift-ing buoy deployed in it. A long station with 6 CTD casts to fulfil the water demands of the various groups on board, interspersed with various other gear including zooplankton nets, was carried out next to the buoy through the night to record the initial conditions. The rough weather and heaving seas led to some delays so fertilisation was started at midday on Thursday and completed by Friday morning. The same procedure was used as in the fertilisation of the first eddy but this time the spiral was centred around the drifting buoy. A short station was carried out next in the centre of the fertilised patch for the physiologists to ascertain short-term responses by the organisms. This was followed by a longer station within the core but outside the iron patch which will serve as a reference station to compare the processes going on within the patch with those in outside water. The homogeneity of the core water will ensure that these reference or "control" stations will reflect what would have happened in the patch had it not been fertilised.

On Saturday we commenced mapping the hydrography of the eddy with a grid of stations 12 nautical miles (ca. 20 km) apart which will take us till the end of this week to complete. Normally, only one short CTD cast is taken at each station but when we cross the fertilised patch, more time will be invested in measuring chemical and biological processes. The transmitters on the buoy have shown that it has travelled in a curve – first southward and then westward – since its deployment. Clearly the clockwise rotating core and not the westerly winds determine its path. On Sunday night we passed close to it and were heartened by the high Fv/Fm values recorded by the FRRF – 0.45, well above levels surrounding the patch. The iron had taken effect and the algae have shifted gear but it will take about a week before the algal biomass doubles. This is because only some algal species will enter into a prolonged fast-growth phase. Some species will not react at all but most will respond favourably to fertilisation either by slow but steady growth or by short spurts of fast growth. To return to the analogy with terrestrial ecosystems: this region of the ocean can be compared with a semi-desert such as the Sahel zone. Most of the plants are adapted to desert conditions (cacti-like succulents) that will respond to the iron rain with a spurt of growth but it will be mostly the grasses that will turn the brown landscape green. And they will need some more time to make an impression. We are still guessing which species will be the "grasses" in our bloom.

The rotating core of this eddy had experienced much more biological ac-----tiv-i-ty in the recent past and hence carried a much larger stock of phyto-plank-ton than the first eddy. Chlorophyll concentrations ranged around 0.7 mg/m3 most of which is in the large-celled phytoplankton that will contribute the bulk of the biomass once the bloom gets started. The first eddy was impoverished in these large species and would have taken at least several weeks to reach the concentrations prevailing here, possibly even longer, given the nightly onslaughts of the hungry salps. These animals are also present here but the net catches indicate that they stay at the bottom of the phytoplankton rich layer which extends to about 100 m depth. Apparent-ly, they prefer not to tangle with the spiney diatoms that dominate in the eddy core.

A glance through the microscope at an enriched sample of plankton from the eddy core reveals a rich variety of shapes dominated by the sweeping, pointed spines of some 10 species of the ubiquitous diatom genus Chaeto----ceros (which means carrier of spiney horns). The cells of this genus are rectangular and carry long, bristle-like spines at each end which extend outward many times the width of the cells. Some species are solitary but the cells of most are attached to one another in chains. The silica spines are hollow and in the larger species they are barbed and contain chloro----plasts. Their function apparently is similar to that of thorns in land plants: they have evolved to keep grazers at bay but there are many grazers that have learned to cope with them. Salps do not seem to belong to the latter category. The spines also have another function in some species: at the end of the growth phase, when nutrients are exhausted, they become sticky and entangle with one another and with other cells to form snow-like flocs that sink rapidly through the water column. This behaviour is com--mon-ly observed in coastal blooms and some coastal species are present here, albeit in low numbers. There are many other species from different genera: some are needle-shaped, others resemble thick coins. We are eager to find out which species will dominate our bloom and how they manage to do so.

The weather has being trying all along, with wind speeds around 7 Beaufort during most of last week. We are grateful for the brief periods when the wind drops to 5 or 6 and the sea surface appears less frenzied. But at least we have not been hit by a storm since coming here and work and sleep are not disrupted by the constant heaving and occasional jolting that have become part of everyday life on board. Only Polarstern can offer this comfort in these seas.

With warm regards from the growling forties and wailing fifties,

Victor Smetacek