Weekly report no. 5 EIFEX (ANT XXI/3) RV "Polarstern" 23 February 2004

The big picture of the eddy, the rotating core of which is slowly greening, emerged slice by slice, in the course of the last week. The physicists laid a grid of 8 north-south transects between 48° 48´S and 50° 36´S, a distance of 108 nm (about 200 km), each with 10 stations 20 km apart. Three of the middle transects, also 20 km apart, cut through the core of the eddy. The transects on either side sliced through the loop of fast currents enclosing it and maintaining its identity. We were pressed for time: first, the survey had to be carried out as fast as possible for it to represent the dynamic flow field and second, we were eager to get back to our fertilised patch as soon as possible to follow what was going on in it. So at most stations the CTD was dipped to 500 m depth without closing any bottles as this takes much extra time. However, water column sampling and zooplankton net hauls were carried out at a few selected stations. The grid was completed at its north-eastern corner by Friday midnight and we steamed immediately thereafter to the site of the buoy, now in the southern part of the core, raring to carry out our first full, post-fertilisation station. We were hit by a bout of stormy weather on the way and since turning the ship in the heaving sea was unwise, we proceeded into the south-westerly wind, past the buoy and double tracked after the storm had abated. Our meteorologist predicted calmer weather ahead with wave heights that would permit carrying out station work by Sunday morning. So Sunday would be our big day.

The transmitters on the buoy traced a smooth oval path, 30 km x 50 km in the eight days since fertilising the 15 km circular patch around it. Two of the grid transects had passed close to the position of the buoy and each time the FRRF signalled vigorously growing plankton (indicated by the Fv/Fm index) albeit for less than a km in its vicinity. Clearly the buoy was no longer in the centre of the patch. These spikes of high values contrasted strongly with the monotonously constant, low values that prevailed everywhere else in the ACC. The second FRRF mounted on the CTD indicated that one of the stations of the grid was within the fertilised patch. High values extended uniformly down through the water column to over 90 m depth. Since we had released the iron solution into rough seas at the tail-end of two severe storms in short succession, the agitated water column had actively mixed the iron with the phytoplankton in the entire surface layer. "T´is an ill wind that blows nobody any good", so the storms had served a useful purpose. But they are a regular part of life here and indeed, before the decisive role of iron emerged from the recent 3 fertilisation experiments, the bad weather characteristic of this region (clouds, fog and deep, vigorous mixing coupled with low temperature) was blamed for the low productivity in these nutrient-rich waters.

We reached the buoy on Saturday evening and had the night to find the location, shape and centre of our patch where we wanted to carry out our long station. We knew the patch was close to the buoy but were not sure in which direction it lay, nor did we know how big it had grown in the past 8

days and whether it had remained compact or been pulled apart into a bundle of streaks by the swiftly rotating currents along the periphery of the core. Low cloud cover prevented helicopter reconnaissance flights as the laser beam which measures the fluorescence signal of chlorophyll in the water below is dimmed by low cloud or foggy conditions. In any case we were not expecting significantly higher chlorophyll concentrations so shortly after fertilisation. In these cold waters, phytoplankton grow at a leisurely pace.

The night was spent searching for the patch with the FRRF. The data, displayed on the ship's monitors for all to follow, appear as dots at one minute intervals along the cruise track in a colour code ranging from dark blue (0.3, the average low values here) to red (0.6, about the maximum value we expected). Both diagonal transects that had crossed close to the buoy showed streaky 10 km long stretches of alternating high and low values. It appeared likely that the patch was located to the north of the buoy, so after proceeding northeast for some distance, watching uniformly deep blue dots on the screen, we cut due west some 15 km north of the buoy. For a while we left behind a line of dark blue dots and then suddenly a pale blue followed by a green dot blipped on the screen, the patch was indeed to the north of the buoy! The line of green dots interspersed with yellow and oranges continued for 20 km and then flipped back, again abruptly, to the deep blue of anemic plankton. We now had to find out how far north the patch extended so we continued westward for some kilometres to make sure we were well outside the patch and then cut northeast to a point 15 km north of the centre of the east-west green and yellow stretch. Only deep blue dots appeared on this diagonal but when we turned south the same abrupt transition to green and yellow dots appeared some 10 km north of the east-west transect and continued for a 20 km stretch to the south. We had fortuitously laid a cross exactly through the patch centre and by 6 am we had delineated our patch to the southwest, traced its frayed edge towards the buoy in the southeast, and returned to the centre in time for the station to commence as planned before Sunday breakfast.

The station was more or less a duplicate of the pre-fertilisation station and lasted till late Sunday night. The rest of the night was spent mapping the north-eastern corner of the patch and at 6 am on Monday morning the reference station outside the patch was carried out to its north. Chlorophyll concentrations in the patch station were a uniform 1.6 mg/m3 down to 90 m, well above the 0.7 mg/m3 recorded in the surroundings, including the reference station. Values as high as 2.1 mg/m3 measured by the chlorophyll group during the surface mapping of the patch was evidence of remarkably high growth rates in the past week. A glance through the microscope at a plankton sample from the station indicated that all the dominant species were growing faster than before but some species were growing even faster. This was evident from the number of dividing cells and the lengths of the chains. Where 4-celled chains had been the average, we now found many chains that had over 20 cells, the record being a small Chaetoceros species with up to 30 cells. The difference in size between

this small species (C. curvisetus) and the giant ones of the same genus mentioned in the previous report is equivalent to that between a small bush and a big tree. But here the analogy with land plants stops, because on land, the bigger plants overgrow the smaller ones and eventually deprive them of light. In the water, however, all the algal cells move with the medium in which they are suspended. So only fast-growing species can overshadow the others, regardless of size. Indeed, the smaller the cells, the faster they can divide.

The moving water provides both light and nutrients, so all the cells have to do is grow till their resources, meaning nutrients, are exhausted. Unlike land plants, phytoplankton do not require building material to make complex structures so about half their weight is protein, the same ratio common to animals in general. The amount of biomass the algae can accumulate depends on the amount of nutrients available. If all the nitrate and phosphate (which are the limiting nutrients in iron-rich ocean margins) present in the patch water were converted into diatom cells the chlorophyll concentrations would reach 60 mg/m3. Incoming light would be soaked up within the first few metres and the interior of the mixed layer would be darker than the floor of a dense forest. Our bloom will be much more modest but this calculation gives some impression of the productive capacity of these waters, to which we will return later.

The mood is good and one is greeted by smiles and a lot of laughter in the laboratories, canteens and meeting rooms. The sense of a common mission is strong. The regular evening meetings are attended by all. The weather report is followed by a summary of the day's doings and results and, if there are not too many of the latter, background talks are given by the scientists. Technical matters are also dealt with and rumours last only a few hours. The captain, the officers not on duty and the ship's doctor also attend the meetings and seem to be fascinated by what we are doing and how we are doing it: Guiding the ship with ADCP and then FRRF, changing locations after looking through a microscope, all the while extracting information on the life under us from chains of numbers produced by a bazaar of instruments. We are excited by our findings and grateful that luck has been on our side, so far.

With our best wishes, from a busy ship, working hard before the approaching storm hits us,

Victor Smetacek