

Weekly report no. 8 EIFEX (ANT XXI/3) RV "Polarstern" 16 March 2004

Our bloom reached its peak last week and this week is witnessing the demise and sinking of several of the dominant species that had contributed to its biomass. Iron concentrations in the bloom are still fairly high, so iron limitation is not responsible. Besides, other species are continuing to grow healthily, so what is happening is a replacement of the dominant species by others. But we do not yet know what is causing this "changing of the guard". We first need to find out what is going on outside the fertilised patch. Have the same species died there as well or are they still thriving? We will be doing the last outside station tomorrow and are eagerly looking forward to it.

During the last week, chlorophyll concentrations remained at about 2.5 mg/m³ inside the hot spot although daily production rates were as high as ever at 1.7 g C per m² and day and CO₂ concentrations continued to decline. This indicated that new growth was occurring at the same rate even though diatom biomass was no longer accumulating. Silicate concentrations were reduced to half the initial values but there was still plenty for diatom growth. Nitrate and phosphate concentrations had declined only slightly, because they had been high from the start. So the bloom was growing but its size was not increasing.

The cell counts of diatom species under the microscope from 20 m depth showed a steep decline in numbers of the most abundant big species, the robust, long-spined *Chaetoceros dichchaeta*, over the previous week. Its disappearance could only be explained by selective feeding or sinking because empty cells were also missing. The several other big species of the genus were still there, so it seemed unlikely that the large numbers of copepods in the patch would feed on only a single species. Their grazing seemed to be concentrated on smaller species of *Chaetoceros*— the "grass" we had expected to overgrow the bloom — because their numbers did not increase despite high growth rates observed in culture experiments. So the big-celled, heavily defended diatoms continued to dominate. The only explanation for the disappearance of *C. dichchaeta* was that the cells had sunk out of the 100 m deep mixed layer. Analysis of the many samples collected from many depths will bring clarity later. For now data from other instruments provide a plausible picture of what actually happened.

On the CTD (conductivity (salinity), temperature and depth) are also mounted a fluorometer and a transmissometer that provide a stream of data that appear as continuous profiles together with the other parameters on the monitor while the instrument is being lowered and raised through the water column. The former provides a rough estimate of the chlorophyll concentration and the transmissometer indicates the turbidity of the water by measuring the intensity of a light beam of 25 cm length. The more particles in the water, the less light gets through. Small, evenly distributed particles leave a smooth trace, large, inhomogeneously distributed particles look noisy, whereas single very large particles, such as a large

aggregate or a copepod, leave a single blip whose length depends on the size of the particle. The profiles of these optical instruments clearly showed the development of the bloom and its dominance by large-celled phytoplankton. They also showed that the upper 100 m were generally well mixed (except in the brief periods of calm seas). The profiles below this depth did not drop off sharply but declined gradually down to 150 m, below which they were smooth all the way down to the bottom. It was in this intermediate layer that we first noticed an increasing number of blips signalling that aggregated particles were sinking out and assumed that they came from phytoplankton chains that had been mixed down below the surface layer. As these algae had been trapped in the dark for some time their buoyancy would have declined resulting in their sinking out.

But we also had other work to do. A grid was carried out across the core and the patch to assess the distribution of zooplankton in order to find out whether they were congregating within the patch. This was followed by sections across the boundaries of the core with the microstructure sonde to obtain profiles of mixing rates. Two different seals made separate visits to the ship. The first was only 1 m long and mistaken for a penguin because it jumped out of the water several times like a porpoise (penguins also do this) while approaching us. It then lay on its back to inspect the ship. It looked like a very young, still playful harbour seal and seemed to enjoy itself cavorting in the waves made by the side thrusters that are used to position the ship while at station. It swam in when the thrusters were switched on and then let itself be pushed out on its back, with flippers folded over the belly. Perhaps it was reminded of the breakers on the beach of its childhood. It entertained us for several hours and would have come on board if possible. We wondered from where such a young animal had come and where it was going all by itself and what it was feeding on in these fishless waters: It seemed happy and healthy and in an exploring mood. The other visitor was a fur seal which inspected us briefly and then swam off. It was dusk and we were completing the last profiles of the day with the free-falling sonde. The data stream was suddenly interrupted, so we hauled in the instrument and found that the plastic covered attachment cable was damaged. Closer inspection revealed clear bite marks that cut through the insulating plastic and flooded 200 m of the cable with water. The seal had evidently sampled the cable before leaving.

The in-patch station occupied on Sunday was an unforgettable experience. The station prior to it indicated that the hot spot had expanded and that the buoy had drifted to its downstream edge in the course of the one-and-a-half rounds it had completed since deployment. But now we had to search around for some time before we located the CO₂ minimum which was a bit higher than 3 days ago. We were expecting even lower values, so the growth rate had declined. The data from the FRRF were perplexing. The instrument performed well outside the patch, but values inside it jumped around with many higher than the theoretical maximum. Clearly the phytoplankton was behaving peculiarly. We finally carried out the station in the CO₂ minimum two hours later than planned. The first CTD went down to 500 m and we

watched the profiles on the screen while it was going down with bated breath. As the instrument sank below the mixed layer, the fluorescence and turbidity profiles declined as they should but in contrast to the earlier smooth lines the turbidity profile was as spiky as a hedgehog's back all the way down to 500 m. The next CTD went down to 1000 m and showed the same phenomenon all the way. The fluorescence profile was smoother but there were more blips at depth than before. Clearly, a lot of large particles were sinking out rapidly. There were too many to be just the missing *C. dictyota* chains.

We examined a live plankton sample collected with a hand net under blue light in the microscope. This light causes chlorophyll to fluoresce bright red and chloroplasts of healthy algae glow ruby-like against the black background. The sample was a jungle of giant diatoms but when we switched on the blue light expecting to see ruby spots everywhere, we were surprised to see that the cells of only a few species were fluorescing. The others, including all the remaining *Chaetoceros* species, were dark. We were looking at a bloom of dead and dying cells. Was this mass cell death programmed as in the leaves of trees before they are shed, or were we witnessing some virulent disease killing off some species and sparing others? The cells of the two species which contribute most to the diatom ooze in the underlying sediments – *Fragilariopsis* and *Thalassiothrix* – were healthy and flour---ish--ing but most of the other species were dying. None of us had witnessed anything like this before. The CTD which went down to the bottom showed that the spikes extended all the way to 3,500 m depth. The algal cells were not only dying fast but also sinking at extraordinarily high rates of more than 500 m a day. We were witnessing an event of immense geochemical significance: one of Nature's mechanisms to regulate CO₂ in the atmosphere and ultimately global climate.

We have to leave on Saturday midday so we are using the remaining time to sample as many water columns in and around the patch as possible. The weather forecast indicates no storms around the corner, just the usual wind force around 7 with occasional 8s. We are lucky.

Best wishes from an exhausted but excited ship watching its harvest sink into the deep,
Victor Smetacek