Weekly report no. 6 EIFEX (ANT XXI/3) RV "Polarstern" 1 March 2004

This has been our fifth week of life on the Antarctic Circumpolar Current (ACC), one of the least attractive places for human beings on earth. There are no fishing vessels and even the brand of extreme tourists seeking hardship challenges don´t think of spending two months here. The ship is always heaving in a sea churned by the steady, strong westerly winds. The air has the same temperature as the sea which has risen in our patch from 4.0° to 4.5°C in the past two weeks of this late southern summer. The sea around us and the clouds above are grey and colourful sunsets so rare that they are announced from the bridge and even the officer on watch takes pictures. So there must be good reason for so many of us to choose to work in such inhospitable surroundings. The reason is simple, the ACC is a scientific El Dorado. Its crucial role in the global heat budget has been known for some time but consensus is slowly emerging that its biota also play a key role in the global climate machinery. The issue revolves around how productive the ACC was during glacial periods. Our experiment is already providing data, to which we will return later, showing how this might have happened.

Last week was spent carrying out long stations within and outside the fertilised patch with attempts to map its extent in between. We found that it covers an area of about 20 x 30 km slightly off the core centre but including it. The patch has two regions with chlorophyll concentrations above 2 mg/m3. Values in the rest of the patch are lower but more than double those in the surrounding water. After the first mapping we picked up the buoy and replaced it, this time equipped with a range of instruments recording various parameters and two sediment traps, in the larger area of higher productivity. During the long station carried out next to the buoy, we watched it move steadily to the south and were greatly relieved a day later when it started moving to the west. It is currently on its way north within the eddy.

Because of dilution of the patch by areal extension and the fact that the phytoplankton had already consumed much of the iron, we decided to refertilise the entire patch. We did this by starting at the southern rim and zigzagging northward at intervals of 2 km. Each time we stopped fertilising when the eastern and western borders of the patch were reached. The day before fertilisation had been exceptionally calm and sunny and the values measured by the FRRF were lower than they had been before. The algae of the surface layer had evidently suffered sunburn and had not yet repaired the damage sustained by excessive UV light. Luckily we had another property – the CO2 concentration of surface water - to guide the ship as the data flow was similar to that of the FRRF. Values prior to fertilisation had been homogeneous, so the presence of the patch was now signalled by lower values due to uptake by the growing algae. We released another 7 tonnes of iron sulfate, this time over an area of about 400 km2 two weeks after the first fertilisation of the initial 150 km2 area.
To return to the rationale underlying our experiment. The ACC occupies the

same latitude as northern Europe (our patch is closer to the equator than Bremerhaven) so it receives the same amount of sunlight as the productive North Sea and coastal Norwegian waters. Indeed, where the iron-impoverished ACC waters come into contact with land masses, in particular the tip of the Antarctic Peninsula, productivity is phenomenally high. The stocks of great whales prior to their decimation by whaling are estimated to have eaten 200 Million tonnes of krill (the shrimp-like zooplankton that thrives on diatoms) annually, from an area not larger than 5 Mill. km2. For comparsion, the total annual fish catch from the entire ocean has been stagnant at 70 Mill. tonnes for decades. The krill harvest is equivalent to 1 kg of shrimps per 4 m2. Imagine that many grasshoppers on an equivalent area of meadow and you have an impression of the enormous productivity potential lurking in ACC waters. Indeed the aquatic aliens will be wondering why land ecosystems have so much more plant but so much less animal biomass than aquatic systems. This is because: phytoplankton have much the same composition as animal biomass, so the transfer efficiency is much greater than in land plants with their huge cellulose load. This also explains the phenomenal growth rates of the Blue Whales, the largest animal the world has ever seen. To grow from fertilised egg to adult whale of more than 70 tonnes takes only four years! So why are there still so few blue whales? Evidence has been accumulating over the years that the krill stock size has, paradoxically, been decreasing ever since the whale stocks were decimated. Possibly the whale-krill food chain recycled nutrients, i.e. iron more effectively than its replacement. Research carried out in the thirties at the height of the whaling, recorded enormous diatom stocks in the productive areas which appear to have been more intensive and also extensive than those reported today. Despite their intense utlilisation by zooplankton, a substantial portion of the bloom biomass settled out of the surface layer, evidenced by the high carbon content of the underlying sediments. Are we witnessing the creeping collapse of a spectacular ecosystem? The aquatic aliens´ remedy to bring the whales back from the brink of extinction would be to fertilise their former feeding grounds. A few 100,000 tonnes of iron would be required and the only costs involved would be to ship it there and release it in an adequate manner in appropriate regions. A single ice-strengthened oil tanker plying back and forth annually would do the job. This option has not been considered to date but should now be given serious attention at an international level.

The diatoms of the iron-enriched waters sustaining the whales and all the other teeming animal life are quite different to those around us here. They are more similar to coastal plankton from other parts of the world. Wild life lovers have not yet discovered plankton, but when they do, the iron-limited ACC will become a magnet for them. It boasts the largest number of endemic species (that are not found anywhere else) and some of these are the largest and with their curving spines, the most flamboyant diatoms in the world. The several thousand scientists worldwide who study phytoplankton fall into two tribes. The taxonomists go to great pains to study individual cells under the microscope and differentiate them into species but they do not study them in their natural surroundings. The biogeochemical tribe goes to sea but subjects the phytoplankton only to chemical and biophysical (e.g. FRRF) analyses to estimate their constituent molecules and elements particularly carbon, nitrogen and silica, and their growth rates. Species are not even looked at. This tribe attempts to estimate the contribution of bacteria and phytoplankton to global budgets of these elements. That such tiny organisms can be of global significance is because their individually insignificant doings, multiplied by their numbers, which put even astronomical figures in the shade (there are 1030 plankton cells in the ocean but only about 1020 stars in the entire universe), add up to Gigatonnes (109 tonnes).

On this ship are the beginnings of a new tribe of phytoplankton ecologists who are studying the individual species with loving care, counting their numbers and watching them growing and being grazed in the patch. They have found that the smaller, thin- Shelled species are growing faster than the giant ones mentioned previously that indulge in extravagant use of silica. The group is also painstakingly isolating individual chains under a microscope for later genetic analyses to find how diverse the species populations are and what traits they have to enable such fast growth. The smaller species are the same that make the blooms in the whale feeding grounds, but since they started from much fewer seeding cells, the giants are still clearly dominating. Given enough time and iron the smaller cells will take over the bloom like the grasses in the semi-desert mentioned previously. It is only the cacti-like giants that require excessive amounts of silica. The blooms on the whale feeding grounds require much less, so silica only becomes limiting along the Polar Front, the realm of the giant diatoms which are favoured because the smaller, less protected diatoms are grazed faster than they can multiply under iron-limited conditions. So our results are confirming the hypothesis posed at the end of EisenEx. Iron fertilisation in the open ocean eventually results in establishment of coastal conditions. More about this and other exciting results in the next report.

With our best wishes from a ship reaping a rich harvest of data from the growing bloom,

Victor Smetacek