Meteor 60-5: Weekly Report #2

Since last week's report we have made good progress and have now occupied 17 stations. Eleven of these have been re-occupations of stations occupied by the Transient Tracers in the Ocean expedition of 1981. Data collection has settled down to a more-or-less routine operation and we have been continually examining and fine-tuning the analytical systems on board to ensure the highest accuracy possible. The CTD/rosette operations are going well and Christopher Smarz managed to repair our fluorometer with some ingenious 'Bastelei'. We've also had a little fun: the 'West Atlantic' leg of the table football championship was hard fought and the winners were rewarded with fantastic prizes.

Our comparison with data collected in 1981 requires chemical measurements of extremely high accuracy. The atmospheric pCO_2 has increased by about 35-36 μatm since 1981: the time of the TTO expedition. This is an ~10% increase in the carbon content of the atmosphere but the equivalent increase in the surface ocean is 25 μmol/kg: just over 1% of the background seawater carbon content. Obviously detecting anthropogenic changes of 1% or less over 23 years requires extremely accurate measurements. And the problem doesn't stop with carbon: ocean carbon is subject to natural variability associated with photosynthesis and respiration. To correct for variable amounts of carbon respired in subsurface waters we use dissolved oxygen: these data have to be accurate to about 1-2 parts in 300. To interpret any changes in oxygen we need the most accurate measurements of temperature and salinity, and so it goes on with the accuracy needs cascading down from one measurement to another. At this point of the cruise however we are confident that the required accuracy levels are being attained.

From a first look at our data from southern stations we can see a very clear signal of the post-1981 anthropogenic CO_2 increase down to depths of about 700m, or to seawater potential densities of about 1027. Further north there are indications of the signal being found in deeper and denser waters. The CO_2 measurements are being made on board by a team of 5 IfM-GEOMAR analysts who are working shifts around the clock to keep up with the samples being collected (see photo). Samples are also being collected for shore-based analyses of ^{13}C at Kiel University's Leibniz Labor für Altersbestimmung. These analyses can provide an independent estimate of anthropogenic CO_2, by detecting the progressive dilution of the heavier isotope of carbon by 'lighter' carbon released into the environment with the burning of fossil fuel.

To complement the CO_2 measurements, we have a significant transient tracer measurement program on board, including measurements of CFCs 11 and 12, CH_3CCl_3, CCl_4, and for the first time in this region, SF_6. All of these compounds are man-made and have, like CO_2, increased in the atmosphere and hence in the ocean over the past 40 (SF_6), 60 (CFC11 and 12), to 80 (CCl_4) years as a result of human emissions. Unlike CO_2, these compounds have no natural background. In addition to these 'tracer' gases, we are measuring a range of naturally-produced gases. These include the important greenhouse gas, N_2O, and a wide range of halocarbons including some 'exotic' brominated and iodinated compounds that play key roles for atmospheric chemistry. More about the results of these groups in a later report.

Our biology program has two components: one group is catching particles and 'marine snow' with a custom large-volume water sampler ('Snow Catcher') deployed on a hydro-wire. They then disappear into one of the Meteor's cold rooms for hours and hours to identify them and determine their characteristics. The larger 'Bioassay Group' has been working independently: pumping their sample water from a towed 'fish' rather than relying on the CTD/rosette. This group is conducting a series of elaborate on-board experiments to determine which nutrient(s) limit(s) biological production. Following on from work of this type initiated on Meteor 55, the results of which are soon to be published in *Nature*, the group is using our wide-ranging cruise track to sample as wide a variety of Atlantic conditions as possible. Their third experiment has just been completed: a total of 7-10 separate experiments are planned. This project is a collaboration between IfM-GEOMAR,

the University of Essex, the University of Plymouth and the Southampton Oceanography Centre.

A special feature of Meteor cruises is always the support from the crew and officers. This trip has been no exception, with the support and excellent cooperation of the deck crew having been especially important to us over the past week. Another notable feature of this cruise, has been the route-planning assistance provided by the Bordwetterwarte of the Deutscher Wetterdienst. Last week we were able to 'snatch' an extra, northern TTO station out of the jaws of two storm depressions thanks to insight into model predictions from our meteorologist, Herr Joppich.

Herr Joppich will likely have to help us again next week as we head off along a long northeasterly transect. We will retrace an old TTO cruise track and the even older GEOSECS-Atlantic track as far as 42°N 42°W, 350 miles east of the Tail of the Grand Banks. Along the way we will sample at a CLIVAR station occupied by our US colleagues last year. These stations are important to us but getting them may be a challenge: needless to say the historical cruises were not conducted in March.

Photos:
1. The CO_2 Lab. set up in the Universallabor (photo: Birgit Quack).
2. Getting ready to deploy the 'Snowcatcher' after a CTD cast (photo: Sylvia Walter).