The Future of Shelf Seas

The shallow seas overlying the continental shelves around coastlines are of great economic value. From the Mascarene Plateau in the Indian Ocean to the continental shelf between Japan and the Asian continent, to the Grand Banks and the North Sea, these shallow seas are supplying huge amounts of seafood. Their ecosystems, though, are in jeopardy. Not only are the continental margins the world's biggest pollution dumps, but also climate change and global warming may change the temperatures, winds, water levels, currents, and waves around which the ecosystems have evolved.

Jürgen Sündermann, former director of the Centre of Marine and Climate Research, University of Hamburg, and a visitor during February 2004 to the International Pacific Research Center and the International Center for Climate and Society (*IPRC Climate*, Vol. 3, No. 1), is now spearheading North Sea under Global Warming (NORGLOW), a very ambitious international project that is developing a model to see how climate change and human impact may affect the physical, chemical and biological states of the North Sea over the next decades and century. Findings from this model will help to also answer questions about the future of other shallow seas, and the model, itself, should be adaptable to other shelf-sea regions.

Sündermann spoke at the IPRC on the conditions in the North Sea and changes over the last 40 to 100 years, conditions that the model must be able to reconstruct before any confidence can be placed in its predictions. In the North Sea, the wind direction and the ocean-bottom topography determine the circulation. Under the prevailing westerlies, the currents in the North Sea flow predominantly anti-clockwise around the basin. This direction is important for the fishes, which spawn near the entrance to the Atlantic and whose larvae drift with the current southeastward to the main nursery grounds, the very shallow Wadden See, also a way station for migrating birds.

Despite large interannual fluctuations in the atmosphere and ocean, some trends are noticeable. The average wind over the North Sea has become stronger in the last forty years (by about 0.6 m/s) and windy periods have become longer. Over the last 100 years, sea surface temperature has risen by ½°C, the tidal high in the North Sea has risen 25 to 30 cm, and storm surges have become more frequent and more dangerous owing to the overall sea level rise.

Marine life has also seen changes. The over-fertilization, resulting in nutrient pollution by nitrogen and phosphates, has led to changes in phytoplankton species and to algae blooms, with severe consequences for the ecosystem. Zooplankton seems to becoming earlier during the year, macro benthos species are becoming more varied, and horse mackerel, which were hardly seen before 1985, are now abundant. Marine biologists see a phase shift occurring during the 1990s.

The North Atlantic Oscillation (NAO), a large-scale atmospheric circulation in the Atlantic region, seems to be implicated in these changes. The state of the NAO is often measured by the NAO index, which is the surface pressure difference between the Azores and Iceland. When this index is large, winters in northern Europe tend to be warm, windy, and rainy; when small, cold and dry. The superposition of the NAO index on plots of the number of macro benthos species and horse mackerel over recent years reveals a close overlap between changes in the atmospheric pressure pattern and marine life.

Sündermann's group is developing a series of complex models representing the relevant physical, chemical, and biological processes and is conducting field experiments to validate the models. The process models will be combined into an aggregated model, which is to be coupled to an air-sea model. Ensembles of the aggregated model will then be run for the period 1900–2000 to see how well the model reconstructs the change described above. Once the aggregated model has been tested on past reconstructions, it will be used for experiments with various climate change scenarios to see what may lie in store for this shelf sea and, perhaps, others.

Jürgen Sündermann (left) with Lorenz Magaard (IPRC) and Wolf Dieter Grossmann (UFZ Center for Environmental Research).