

Chemistry Takes Center Stage in Marine Science

by David Turner

The enormous breadth and range of applications of modern chemistry are reflected in the wide range of activities within IUPAC. As a result, individual chemists can often feel that their own (all-important!) specialization is under represented in IUPAC's work. As a marine chemist, I am not immune to those feelings, but can at the same time point to some significant IUPAC contributions to marine science from the Analytical Chemistry Division (V) and the Chemistry and the Environment Division (VI). Much of the work of Division V on critical evaluation of stability constants and on chemical speciation modeling has been relevant to seawater systems, and in some cases specifically directed at seawater. Division VI has also contributed to marine sciences through books published in the "IUPAC Series on Analytical and Physical Chemistry of Environmental Systems."

In the late 1990s, I was given the opportunity to develop a marine initiative in IUPAC. At that time I

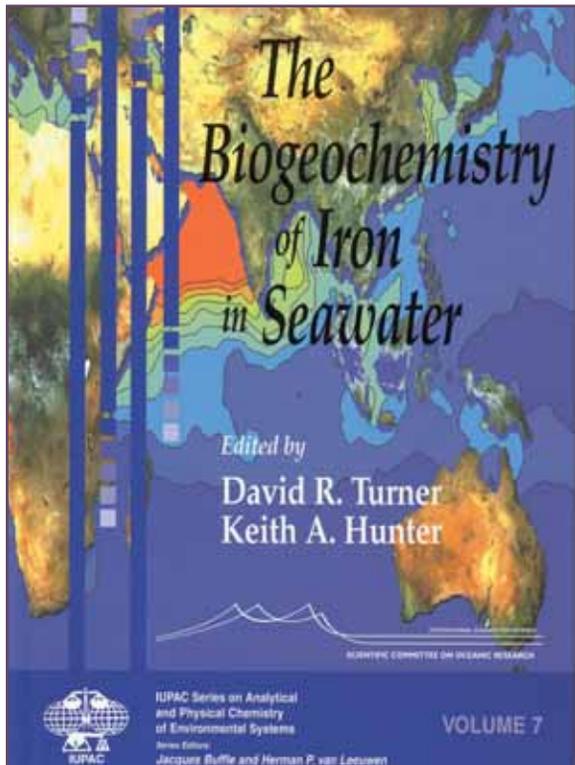
was the only chemist active in both IUPAC and in the International Council for Science's (ICSU's) Scientific Committee on Oceanic Research (SCOR). The leadership of the two organizations had agreed that collaborative projects would be a good idea, and I was given the task of turning this into reality. The result of this initiative was a joint project on iron in seawater, which resulted in the book *The Biogeochemistry of Iron in Seawater*, published in Division VI's book series in 2001 (John Wiley & Sons, 2001, ISBN 0-471-49068-7). Note the word "biogeochemistry," not just "chemistry" in the title: Chemical processes in the marine environment are intimately linked with both biology and geosciences, and it is those linkages which make marine biogeochemistry a key discipline in the science of global change.

The focus on iron in the IUPAC-SCOR collaborative project was no random choice of an interesting chemical element. It was during the 1990s that it became clear that iron is a key micronutrient in the oceans, whose bioavailability influences both the extent of primary production (photosynthesis), and also the plankton community structure. Indeed, the 1990s have been dubbed "The Iron Age of Oceanography."

Why GEOTRACES Now?

SCOR has recently launched a major new global program, GEOTRACES, in which marine biogeochemistry takes center stage. There is a clear focus on trace elements, not just because they are fascinating (which they are!), but for what they can tell us about the functioning of the ocean and its role in global change. This is the first large-scale coordinated program in this area since GEOSECS (Geochemical Ocean Sections Study) in the 1970s. So, with three decades elapsed between programs, what makes GEOTRACES timely just now? The answer to this question lies partly in developments in sampling and measurement techniques, and partly in our ability to interpret and model data on a global scale.

It was during the 1970s that much of the methodology of "trace metal clean handling" was developed and put into practice. In plain English, this means ensuring that the trace metals measured came from the sample, not from the analyst, sampling vessels, reagents, or laboratory atmosphere. Earlier studies of trace metal chemistry in seawater were bedeviled by contamination, giving rise to misleading and uninterpretable results. For example, it was recognized in the 1920s and 1930s that iron concentrations in seawater



could be so low as to limit primary production, but it was not until the advent of clean handling techniques that this could be confirmed by experiment. Even now, the accuracy of measurement of subnanomolar iron concentrations in seawater is a matter for concern (and iron concentrations are subnanomolar for the most part). Significant progress has been made through an intercalibration project within the framework of the IUPAC-SCOR project on iron (see Bowie et al., 2005. *Marine Chemistry*, 98, 81-99. doi:10.1016/j.marchem.2005.07.002).

The global oceanography programs of recent decades such as the World Ocean Circulation Experiment and the Joint Global Ocean Flux Study (JGOFS) have shown how field measurements, coordinated on a global scale, can be combined with satellite observations and modelling to develop a new understanding of the oceans' role in the Earth System. These programs have included an increasing amount of trace elements chemistry, most particularly in JGOFS during the "Iron Age of Oceanography." This has in turn stimulated the development of methods for high-density sampling and analysis, yet another methodological advance that will be important to GEOTRACES.

The GEOTRACES Program

GEOTRACES has formulated a guiding mission: "To identify processes and quantify fluxes that control the distributions of key trace elements and isotopes in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions." Within this guiding mission, GEOTRACES has identified three overriding goals, focusing on the past, present, and future.

Past: "To understand the processes that control the

concentrations of geochemical species used for proxies of the past environment, both in the water column and in the substrates that reflect the water column."

Present: "To determine global ocean distributions of selected trace elements and isotopes, including their concentration, chemical speciation, and physical form, and to evaluate the sources, sinks, and internal cycling of these species to characterize more completely the physical, chemical, and biological processes regulating their distributions."

Future: "To understand the processes involved in oceanic trace-element cycles sufficiently well that the response of these cycles to global change can be predicted, and their impact on the carbon cycle and climate understood."

I will not in this short article try to provide further details of the background and approach to these goals, but refer the interested reader to GEOTRACES's ambitious Science Plan, which can be found at its website <www.geotraces.org>. Individuals interested in becoming involved in GEOTRACES can do so by either contacting their national GEOTRACES committee or by sending an e-mail to <geotraces@ideo.columbia.edu>.

A Role for IUPAC in GEOTRACES?

Chemistry is central to the GEOTRACES program, which can only benefit from a dialogue with the international chemistry community represented by IUPAC. This could, for example, take the form of new joint IUPAC-SCOR projects. An important first step towards further development of such collaboration would be to fill the currently vacant position of IUPAC representative to SCOR. I have now relinquished this position due to the pressure of other engagements. I would be very happy to see a successor appointed. 🤝

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👉 www.geotraces.org

This clear view of chlorophyll concentrations in the northeastern Arabian Sea was collected by MODIS on the Aqua satellite on 22 February 2005.

Source: <http://oceancolor.gsfc.nasa.gov>.

