Biogeochemistry of the Arabian Sea: Modelling and synthesis

The CSIR Centre for Mathematical Modelling and Computer Simulation (C-MMACS) hosted a 3-day International Scientific Symposium on the Biogeochemistry of the Arabian Sea (18–20 January 1999) followed by a training course on modelling and synthesis (21–29 January 1999) intended to impart state-of-the-art knowledge to young researchers. The symposium and training course were sponsored by C-MMACS, System for Analysis, Research and Training in Global Change Studies (START), Inter-governmental Oceanographic Commission (IOC), International Ocean Colour Coordinating Group (IOCGG), Joint Global Ocean Flux Study (JGOFS), the US JGOFS Project Office and the Scientific Committee for Oceanic Research (SCOR).

The past decade has seen an intense observational programme in the Arabian Sea as a part of the JGOFS programme to study the physics, biology and chemistry of the region. The western Arabian Sea, off the Arabian Coast and Somalia was covered by American, Dutch, French, German and British expeditions while the northern and eastern sectors were covered under the Pakistani and Indian JGOFS programmes, respectively. All countries covered some sections in the central Arabian Sea. The main goal of the symposium was to bring all the main researchers involved in these cruises together to exchange ideas and knowledge to broaden the scope of understanding. The symposium would evolve strategies to synthesize the data so far collected into comprehensive models which would elucidate the mechanisms of the processes on much wider temporal and spatial scales than afforded by measurements.

Eighty-seven participants from 23 countries attended the symposium. The programme began with the inaugural address by V. K. Gaur, C-MMACS, on the importance of the JGOFS programme in the Arabian Sea in answering many of the questions related to climate change. It was followed by a keynote address by S. Krishnaswami, Physical Research Laboratory, Ahmedabad, in which he gave a broad overview of the Indian JGOFS programme. The other keynote address by K. Banse, University of Washington, provided a comprehensive review of the reanalysis of the Coastal Zone Colour Scanner (CZCS) to yield a synoptic picture of primary production in the Arabian Sea. A review of the physical and biological measurements of the Indian JGOFS programme was given by S. Prasanna Kumar, National Institute of Oceanography, while a similar review of the US programme was made by Sharon Smith, University of Miami. The scientific programme comprised sessions on air–sea exchange, remote sensing, hydrography and nutrients, phytoplankton, bacteria, zooplankton, export from surface to deep waters, oxygen minimum zone, ocean colour algorithms and modelling of primary productivity and biogeochemical cycles. A total of 33 papers were presented orally and a poster session consisting of nearly 20 papers was also organized.

Peter Burkill chaired the final session on 'what was learnt at the symposium'. Several points which arose in the symposium, such as the importance of remote sensing, the level of complexity needed to model the ecosystem, inconsistencies between different kinds of measurements, etc. were debated. One issue that attracted attention was whether the Arabian Sea was a source or a sink of CO_2. Experimental measurements and modelling studies presented at the symposium seemed to indicate that the Arabian Sea was a perennial source. A final draft of this discussion will be circulated shortly by Burkill after the ideas are consolidated.

The symposium was followed by a training course attended by 51 students from 19 countries including a third from India. Keeping in view the need to synthesize several types of observations and modelling methodologies, Karl Banse of the University of Washington gave an overview of the biological aspects of the JGOFS programme including a review of recent attempts to reanalyse CZCS data. K. Denman of the Institute of Ocean Sciences, Canada provided an exposition of mixed layer modelling using advanced turbulence mixing theories. A. Oschlies from University of Kiel, Germany made a presentation of data assimilation methods in complex ocean models. J. Kindle of Naval Research Lab, USA provided a study of a coupled physical–biological model to simulate the conditions that prevailed off the Arabian and Omani coasts during the 1995 cruises. Trevor Platt provided a review of biological processes in the ocean. Shubha Satyendranath reviewed the bio-optical algorithms used in retrieving biological parameters from ocean colour measurements. V. Garcon of CNES, France reviewed her recent results from the JGOFS programme in the Atlantic where she had employed a complex three-dimensional coupling between physics and biology. A review of each term that appeared in marine ecosystem models along with its significance was provided by G. Evans of the Department of Fisheries and Oceans, Canada. Diana Ruiz-Pino of CNRS, France provided a review of box models of biology, chemistry and physics which yielded quick but reliable estimates of fluxes and standing stocks in ecosystem modelling. Alain Vezina of Institut Maurice Lamontagne, Canada gave a review of food-web models from the point of view of the application of inverse methods, especially singular value decomposition, linear and quadratic programming. K. S. Yajnik, former Head of C-MMACS and Andy Edwards of Dalhousie University gave an exposition of recent studies on the stability of marine ecosystem models.

Besides lectures, computer demonstrations of models and software, along with hands-on training of students also formed a major part of the course. Some of the demonstrations included: (a) processing of Sea Wifs data to obtain biological parameters; (b) inverse modelling and data assimilation using MATLAB; (c) complex coupled ecosystem modelling using software from Plymouth Marine Laboratory; (d) mixed layer modelling; (e) use of box models like STELLA for the marine ecosystem; and (f) a coupled physical–biological–chemical model of the Arabian Sea. In addition, Internet access was provided for the instructors and the participants.

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