2012 GEOHAB Open Science Meeting

by Suzanne Roy and Vera Pospelova

Coastal regions are environments where blooms of harmful algae (HABs) can cause great damage. These regions are submitted to increasing urban development and often support productive fisheries, aquaculture and tourism. HABs can have a negative impact on these activities, with consequent economic loss. The international Global Ecology and Oceanography of Harmful Algal Blooms program (GEOHAB), co-sponsored by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC), set up a series of Core Research Projects to develop our understanding of HABs through a comparative approach among similar sites around the world where these harmful events occur.

The Core Research Project on "HABs in Fjords and Coastal Embayments" recently held its second Open Science Meeting to highlight progress in interpreting life history and growth dynamics of HABs in such environments. This meeting took place on May 28–29, 2012, at the School of Earth and Ocean Sciences (SEOS), University of Victoria, Victoria, Canada. Twenty-four people attended from ten different countries. Co-convened by the authors of this article, the meeting hosted six keynote presentations, six contributed talks and six posters on five major themes. These comprised: (1) a review of recent research programs that have included life cycle approaches (SEED in Europe, and ECOHAB-Gulf of Maine and GOMTOX in USA), (2) particularities of HABs in tropical embayments affected by monsoons, (3) interactions associated with allelochemicals and toxins and their effects on bloom phases and growth dynamics of HABs in small-scale coastal systems, (4) genetic diversity and population heterogeneity and their relevance to HABs in small-scale systems, and (5) the role of physical forcing and scale in coastal HABs dynamics.

In their review of recent programs, Esther Garces (Institut Ciències del Mar, CSIC, Spain) and Don Anderson (Woods Hole Oceanographic Institution, USA) summarized the major findings from these studies and pointed out that unexpected complexities in the life cycle of several species, including the reversibility of the sexual stage and the production of asexual resting cysts, were found. A heteromorphic life cycle represents an advantageous survival strategy for a population since it allows the allocation of the species biomass into stages of different size ranges, morphology and ecological niche. A reproductive barrier was identified between toxic and non-toxic strains of one species (*Alexandrium tamarense*): matings between these strains produce cysts which germinate but are not viable (Brosnahan *et al*. 2010 Deep-Sea Research II 57: 175–189). Introduction of non-toxic strains in a region with toxic species could represent a mitigation strategy, leading to a reduction in the viable cyst population needed to initiate future algal blooms. In the Gulf of Maine, efforts have been devoted towards the characterization of cyst seedbeds, identification of the links between blooms and the abundance of cysts in surface sediments, and development of a numerical model of *Alexandrium fundyense* population dynamics. The mapping of cysts in fall or winter has been shown to be a good predictor of regional bloom magnitude for the following spring or summer, although some exceptions occur. Other groups (*e.g*., Cheryl Greengrove and colleagues mostly from the University of Washington, Tacoma, USA) are also testing this cyst mapping hypothesis.

Participants to the GEOHAB Open Science Meeting on "Progress in Interpreting Life History and Coastal Dynamics of Harmful Algal Blooms in Fjords and Coastal Environments". From left to right, front row: Faiza Al-Yamani, Nicky Haigh, Svetlana Esenkulova, Rhodora Azanza, Cheryl Greengrove, Suzanne Roy, Vera Pospelova, Julie Masura and Lincoln Mackenzie; back row: Marina Montresor, Paul Harrison, Drew Lucas, Allan Cembella, Manuel Bringué, Deana L. Erdner, Andrea Price, Esther Garces, Don Anderson and Arielle Kobryn.

In tropical environments, Rhodora Azanza (Marine Science Institute, University of the Philippines) presented some research undertaken by the GEOHAB-endorsed project, PhilHABs. She stressed the influence of the monsoon-related changes affecting the temperature, salinity and stratification conditions of local bays. *Pyrodinium bahamense* var. *compressum* is a toxic species that used to dominate before the year 2000, in association with the southwest monsoon (warmer waters, lower salinities and strong stratification). This dinoflagellate produces resistant cysts which have been recorded in more than 30 bays or regions of the Philippines. It has seemingly been replaced by its major predator, *Noctilucascintillans*, since that time. *Gymnodiniumcatenatum* and *Alexandrium* spp. are also present, associated with the northeast monsoon. Aside from the strong influence of the monsoons, some of the variability in incidence of these blooms may be attributed to ENSO events, but analysis is still underway.

In the last decade, a great deal of work on allelochemicals was undertaken by Allan Cembella (Alfred Wegener Institute for Polar and Marine Research, Germany) who examined their role as bioactive molecules that can change the interactions among species. Among the chemical compounds of interest with respect to HABs, trace organics and anthropogenic substances do not seem to be major driving factors affecting the dynamics of HABs. In contrast, marine natural products comprise a large number of bioactive molecules, including toxins, several of which have not been identified. More than 120 species of eukaryotic microalgae produce toxic bioactive substances. These compounds are not stress metabolites in most cases since they are found when cells are actively growing. The role of toxins is still under debate: putative roles include competition, communication, grazing, and cell recognition. Their effects on HAB dynamics can be through competitive exclusion of other microalgae, suppression of grazers or auto-stimulatory effects. Chemically-mediated reversal of predator-prey interactions can also take place (Tillmann 2003, Aquatic Microbial Ecology. 32: 73-84). Recent studies emphasize the identification of biosynthetic genes responsible for microalgal toxins and identification of the factors regulating their expression. Available results indicate a large degree of variability in toxin profiles among clones of a particular species taken from the same station. Unraveling the factors controlling this variability will be an active field of research for the next decade.

The development of molecular tools has enabled progress in obtaining information on the biodiversity of organisms responsible for HABs. Marina Montresor (Stazione Zoologica Anton Dohrn, Italy) reviewed the genetic diversity and population heterogeneity relevant to HABs in small-scale systems. She highlighted three important advancements in the last decade: (1) the development of integrated approaches helping to circumscribe species and evidence for cryptic diversity in many microalgal lineages, (2) evidence for intra-specific genetic diversity and for the organization of species into distinct populations, and (3) evidence for genotypic diversity and phenotypic variability. The capability to model population dynamics of harmful algae and predict HAB events is based on our knowledge of the temporal and spatial distribution patterns of the species. Delineation of HAB species is particularly important if cryptic species exist, and especially when toxic and non-toxic cryptic species co-occur in the same area (Touzet *et al*. 2010, Protist 161: 370–384). Cryptic species occur not only in dinoflagellates, but also in diatoms, particularly in the genus *Pseudonitzschia*. Recent studies have shown that intra-specific diversity is generally high in marine microalgae. This may reflect a winning strategy to live in an ever-changing physical, chemical and biological environment where temporal variability in selecting pressures can favour the maintenance of diversity. Coastal semi-enclosed systems can represent the ideal setting to test fine-scale population structure and diversity, offering a less complex setting amenable to small-scale investigations in time and space.

Finally, Drew Lucas (Scripps Institution of Oceanography, USA) presented a physical oceanographer's outlook of HAB patterns and persistence in coastal environments, examining the factors which affect these patterns at various spatial scales, from the mesoscale (> 100 km) to the small scale (10 cm to m). He argued that HAB patterns are difficult to predict because dynamical spatial scales are at least eight orders of magnitude, and several physical factors affect local circulation and modify the conditions favorable for retention and growth of harmful algae and for transport onshore, where shellfish intoxication can occur. Future studies pertinent to HAB events should emphasize the small horizontal scale and focus on internal waves and tidal pulsing.

A talk by Paul Harrison (University of British Columbia, Canada) was on the questionable link between N:P ratios and red tides in Tolo Harbour (Hong Kong), and one by

Dr. Suzanne Roy (suzanne_roy@uqar.ca) is a biological oceanographer at the Institut des Sciences de la Mer of the Université du Québec à Rimouski, Canada. Suzanne is interested in the fate of microalgal populations, including local harmful algae. She uses microalgal pigmentation to address changes in population structure with respect to environmental stress factors such as UV radiation or climate change and is also working in bioinvasions associated with ship transport. She is in charge of GEOHAB's Core Research Project on "HABs in Fjords and Coastal Embayments".

Dr. Vera Pospelova (vpospe@uvic.ca), is a palynologist at University of Victoria, Canada, who is interested in applications of dinoflagellate cysts for environmental and paleoenvironmental reconstructions. Her work focuses on the distribution and diversity of modern dinoflagellate cysts in temporal and subtropical waters of the Pacific and Atlantic coasts of Canada and the United States, and on the development of dinoflagellate cysts as biological indicators of environmental conditions in estuaries to the extent that cyst records can be reliably used to assess environmental change at high-resolution scales.

Hak Gyoon Kim (Pukyong National University, Korea) was on fish-killing blooms by *Cochlodinium polykrikoides* in Korea. The two co-conveners presented their own recent studies on dinoflagellates (including harmful species) in ballast water and ballast sediment from ships visiting major ports in Canada (Suzanne Roy) and on reconstruction of past environmental conditions, helping to trace past blooms, using cysts of dinoflagellates found in the sediments of B.C.'s west coast (Vera Pospelova).

Among our contributors, PICES offered the best student presentation award. Considering that we had only one oral presentation by a student, we decided to offer a "participation award" instead. Arielle Kobryn was presented with a native art ornament for her oral presentation, and Manuel Bringué and Andrea Price were awarded with the UVic logo mugs for their poster presentations.