Education and Culture

Erasmus Mundus

UCA Universidad de Cádiz

LOICZ and the Erasmus Mundus Joint Master in Water and Coastal Management

As part of the Erasmus Mundus Joint Master in Water and Coastal Management, members of the LOICZ SSC and IPO taught different modules at the University of Cadiz, Spain. In March 2009, Hartwig Kremer and Juergen Weichselgartner from the IPO started with a module on "Land-Ocean Interactions in the Coastal Zone", introducing LOICZ and its structure, objectives, and current activities. The first part of the module, lectured by Senior Science Coordinator J. Weichselgartner, introduced global environmental change issues and portrayed recent demographic change processes. Using practical examples, he outlined difficulties in global change research on process, system, and practice level. The second part focused on the barriers at the science-policy-practice interface. In presenting results of a case study analysis from the knowledge domains of vulnerability and resilience, the lecture attempted to uncover what gaps and barriers in the science-policy-practice interface limit the use of research-based knowledge. A number of factors were outlined that inhibit the production of applied knowledge and provided empirical evidence for successes and failures in co-producing knowledge.

Thereafter, CEO Hartwig Kremer introduced the concept of the socio-ecological system perspective applied to regional seas and changes we observe and foresee. Based on two examples, the Baltic and the Black Sea, he outlined the multiple coastal scales and key issues of global change across the land-coast-ocean or water-continuum. In both areas socio political changes starting some two decades ago with the break down of the Soviet Union substantially influenced the forcing that affects the coastal and shelf waters. Subsequent drops in national economies and agriculture mainly translated into decreasing fluxes of nutrients and pollutants down the rivers into the coastal seas. In particular in the Black Sea which had seen three major regime shifts over the last decades due to anthropogenic pressures this has resulted in a visible improvement of the coastal water quality in recent years. Many rivers draining to the Black and Baltic Seas have also improved considerably in water quality. Based on these observations the lectures in this section also looked into the advancement of multiple scale modeling and the efforts in LOICZ and various EU projects to actually come to a true amalgamation of natural and social science parameters in integrated modeling. In the frame of human-environment interactions, i.e. the socio ecological system perspective – the role of scenarios, their boundary conditions in terms of globalization, i.e. economic developments and governance approaches, and how to address the appropriate scales were further issues addressed. Ultimately the discussions centered on the question whether or not the new EU membership of many of the bordering countries around these regional seas would enable a continued improvement or at least maintained positive status of the coastal environment and waters in future. It was obvious that this also includes major challenges for the scientists and their interdisciplinary thinking.

Following the general introduction of March, Nancy Rabalais provided a detailed module from 30 March through 3 April on "Eutrophication: Causes, Consequences, Change and Cures." The causes of eutrophication should not be confused with the process itself. Eutrophication is the increase in the rate of production of carbon or the accumulation of carbon in an aquatic ecosystem (Rabalais 1994; modified from Nixon 1995). The causes may include changes in physical characteristics of the system such as changes in hydrology, changes in biological interactions such as reduced grazing, or an increase in the input of organic and inorganic nutrients. While the series of causes may include direct natural or anthropogenic carbon enrichment, eutrophication in the coastal ocean and in the 20th and 21st centuries is more often caused by excess nutrients that would otherwise limit the growth of phytoplankton. Human influences in the form of increased loads of nitrogen and phosphorus and indirectly through climate change are increasing the occurrence of eutrophication throughout estuarine and coastal waters and also in reducing the oxygen content of many oceanic low oxygen areas, such as oxygen minimum zones (Rabalais et al. 2009; Rabalais et al. in review).

The students were taken through primary production, nutrient cycling, grazing, carbon flux, stratification, water residence time and other physical and biological processes involved. Understanding of nutrient and carbon cycles is essential to understanding eutrophication itself as well as the potential solutions. Some processes may be reversed; others cannot. Eutrophication is driven by the increase in human population and the related needs for fuel, food and fiber. Particularly since the mid 1850s, with an acceleration since the 1950s, humans have increased the reactive nitrogen and phosphorus in the environment through fertilizers, fossil fuel burning, planting of leguminous plants, while making major changes in landscapes such as conversion of forests and pastures to croplands, draining of wetlands, manipulating hydrology, channelizing and leveeing rivers – activities that diminish the landscape's ability to remove excess nutrients naturally. Eutrophication does not happen in a vacuum but within a complex of multiple stressors. Many processes, trophic interactions, ecosystem-level responses, and interactions with society, climate, global change, and a global economy remain obscure to scientists and often considered irrelevant by others. The consequences of eutrophication are real and important at ecosystem, societal and global scales, as are efforts to reduce nutrient loads from local, such as edge of field nitrogen and phosphorus losses, to global, such as corn and soybean futures.

Multiple Consequences of Eutrophication		
➢Increased primary production, accumulation of carbon, higher chlorophyll biomass	➢Increased or decreased benthos	➢Recreation, tourism, swimming, aesthetics
➢Shifts in phytoplankton community composition	➢Increased or decreased 2□ productivity	➢Changes in the structure and functioning of marine ecosystems
➢Harmful algal blooms (HABs)	➢Behavioral and adaptive responses	➢Altered biogeochemical cycles
➢Macroalgal blooms	➢Reduced habitat complexity	➢Reduced ecosystem services
➢Growth of filamentous macroalgae	➢Reduced ecosystem resiliency	➢Changes in higher trophic levels
➢Reduced water clarity, increased turbidity	➢Regime shifts	➢Increased/decreased fisheries yields
➢Loss of submerged aquatic vegetation (SAVs)	➢Decreased biodiversity	➢Regime shifts
➢Degradation of coral reefs	➢Mass mortality	➢Climate impacts
➢Hypoxia/anoxia	➢Marine mammal, birds, turtle deaths	➢Human health

During the week of 13-17 April, 2009, Dennis Swaney presented a module on "Simple Biogeochemical Models in Coastal Science: Nutrient Budgets and Nutrient Accounting for Coastal Waters." Following on from Nancy Rabalais' earlier presentation, we initially reviewed various global impacts of nutrient loads to coastal waters, including eutrophication, hypoxia, and changes in fisheries. Over the five days of lectures, readings, discussion, and hands-on modeling, we emphasized some details of calculating nutrient fluxes in coastal waters and watersheds. Several categories of nutrient load models were discussed before presentation of a more detailed introduction to nutrient accounting methods, i.e., the relationship between inputs to coastal watersheds (fertilizer, N-fixation, atmospheric deposition, and the net transfer of nutrients in food and feed across watershed boundaries) and watershed nutrient export to the coast. This "accounting approach" is formally related to other mass balance approaches used in watersheds, such as the watershed autotrophy/heterotrophy concept (Billen et al. 2007), and in coastal waters, including the LOICZ budget methodology (http://nest.su.se/mnode) which was introduced on the second day of the module. More details of the LOICZ budget methodology, including applications to layered and spatially-extensive coastal systems, were discussed on day three. The final two days of the module engaged the students in hands-on analysis of nutrient budgets of coastal systems by introducing the students to the new LOICZ budget calculator toolbox in a university computer lab. Working individually or in teams, students went through the exercise of constructing two nutrient budgets using the budget tool by entering and checking the consistency of relevant data, generating the budget flow diagrams, and summarizing the results. This exercise was the first trial-run of the budget calculator with students in a computer lab setting, and the few minor glitches encountered were able to be corrected in real time. The toolbox, with the latest revisions and documentation, is currently available for download from the LOICZ budget website: http://nest.su.se/mnode/Toolbox/LOICZ_Toolbox.htm.

During the same week of April 17-21 Stephen Olsen presented a module on the governance of coastal ecosystems. The objective of this module was to provide the students with (1) an introduction to a learning-based approach to the challenges of designing and implementing responses to accelerating change in coastal ecosystems, (2) techniques for integrating across social and natural sciences, (3) methods for designing a governance process that has the necessary public support to achieve its goals and (4) an appreciation for the need for nested systems of governance and options for how they may be constructed. The module began with a discussion of the fundamental shift in how the problems confronting a practicing coastal manager are being defined. Coastal management began as a form of “environmental protection” and has evolved into a promising vehicle for progressing towards more sustainable forms of development. The processes and outcomes of coastal governance were illustrated by case studies that included the Great Barrier Reef, the Chesapeake Bay and the Wadden Sea. The time required to design a program, implement it over a sufficient period to generate desired outcomes at a diversity of spatial scales was a major theme of this session. On the second day the benefits of documenting the long term trajectory of coastal ecosystem change and an examination of the responses – or lack of responses – by the existing governance system were examined using the Orders of Outcomes framework. Such an analysis is essential to identifying both capacity building needs and the research that is most essential to addressing priority issues. The students worked in small groups to discuss the different interests of stakeholder groups and how a common set of objectives might be negotiated that addressed issues of concern to society in a specific locale. The third session examined the implementation gap and the challenges of making the transition from issue analysis and planning to the effective implementation of a plan of action. The fourth session examined the importance of public participation and stakeholder involvement in all phases of a program. The last session addressed the importance of monitoring progress as a basis for adaptive governance and the challenges of selecting indicators that link changes in human behaviour to desired societal and environmental outcomes. The module featured class exercises designed to address the challenges of integrating across the social and natural sciences an adopting a problem solving approach to the coastal issues.

The interaction this year between LOICZ and the postgraduate students in Water and Coastal Management has been excellent. The students received lectures from the IPO who set the scene for LOICZ science and then members SSC past and present. Erasmus and Erasmus Mundus have funded more than 200 students from more than 40 countries to participate in the Water and Coastal Management course. It has also provided scholarships for past members of the SSC, Maria Snoussi, Gerardo Perillo, Liana MacManus, and current members Jozef Pacyna, Nancy Rabalais, Bill Dennison, Eric Wolanski, Stephen Olsen, Dennis Swaney, Eva Roth, Juan Restrepo, Laurence Mee and Ramachandran Ramesh. Next year we hope to host James Syvitski and Zhongyuan Chen. This makes the Water and Coastal Management master course a truly “LOICZ” product in world-wide capacity building. On behalf of the course management team Alice Newton would like to thank LOICZ and Erasmus Mundus for making this exciting international program possible.

Erasmus Mundus students attending the module “Land-Ocean Interactions in the Coastal Zone” at the University of Cadiz in March 2009 (Photo: J. Weichselgartner)

References

Billen, G.; Garnier, J.; Mouchel, J.-M. & Silvestre, M. (2007): The Seine system: Introduction to a multidisciplinary approach of the functioning of a regional river system. Science of the Total *Environment* (375):1-12.

Nixon, S.W. (1995): Coastal marine eutrophication: A definition, social causes, and future concerns. *Ophelia* (41): 199-219.

Rabalais, N.N. (2004): Eutrophication. In: Robinson, A.R.; McCarthy, J. & Rothschild, B.J. (eds.): The Global Coastal Ocean: Multiscale Interdisciplinary Processes, The Sea, Vol. 13, pp 819-865. Harvard University Press.

Rabalais, N.N.; Díaz, R.J.; Levin, L.A.; Turner, R.E.; Gilbert, D. & Zhang, J. (in review): Dynamics and distribution of natural and human-caused coastal hypoxia. *Biogeosciences Discussion* (6): 1-95.

Rabalais, N.N.; Turner, R.E.; Justić, D. & Díaz, R.J. (2009): Global change and eutrophication of coastal waters. *ICES Journal of Marine Science* (66): 1528-1537.