Drivers and stressors of coastal zones, research challenges and information needs for coastal management

Claudia G. Simionato

Centro de Investigaciones del Mar y la Atmósfera (CIMA/CONICET-UBA); Instituto Franco-Argentino para el Estudio del Clima y sus Impactos (UMI IFAECI/CNRS-CONICET-UBA); Departamento de Ciencias de la Atmósfera y los Océanos, FCEN, Universidad de Buenos Aires

The coastal zone is one of the most dynamic natural systems because there the hydrosphere, the lithosphere and the atmosphere meet and interact, forming interconnected systems. Coastal ecosystems are complex entities consisting of living beings, the physical environment they inhabit, and the interactions within and between these two components. Coastal zones comprise many habitats, all of which have been highly modified over millennia by human activities.

Coasts are of great ecological and socioeconomic importance. They sustain economies and provide livelihoods through fisheries, ports, tourism, and other industries. They also provide ecosystem services such as providing food, regulating atmospheric composition and cycling of nutrients and water. These areas have been centers of human settlement since the dawn of civilization, and also have cultural and aesthetic value.

Coastal ecosystems are among the most productive because they are enriched by land-based nutrients and nutrients that well up into the coastal waters from deeper levels of the ocean. As a consequence, they are repositories of biological diversity and provide a wide range of goods and services. Coastlines are among the most populated regions. Nearly half the world's major cities are located within 50 kilometers of a coast, and it has been estimated that 40% of the human population lives within 100 km to the coast. Coastal margins equate to only 8% of the planet surface area but provide 25% of global productivity. Coastal oceans are the most fished, the most modified, and the most subject to natural and industrial disasters.

Coastal systems are affected by two main types of external influences:

- Terrestrial influences, mostly anthropogenic in nature. They include land use changes and all the consequences of changing hydrological regimes and nutrient loading from sediment transport, runoff, and reduction of sediments through rivers.
- Marine influences, mostly natural phenomena such as climate variability, weather events (storms and cyclones), tsunamis, and wave patterns and coastal and ocean currents that affect the processes of nutrient, material, and heat transfer and mediate geomorphological changes.

Loss and degradation of coastal zone ecosystems are affected by direct and indirect drivers and stressors, most of them of anthropogenic origin. The main indirect drivers and stressors are: population expansion and increased demands for resources; distribution of wealth and social inequalities; policy failure; market failure and/or distortions; globalization; and poor development model. Direct drivers and stressors are: loss, fragmentation, and degradation of habitats; overexploitation of resources; pollution; introduction of alien invasive species; and climate change and variability, which interacts with the previous factors listed, in many cases reinforcing their impacts.

Both direct and indirect drivers and stressors are agents of global change. They do not operate singly but form an interacting and often synergistic complex. Some of the most dramatic observed and/or predicted consequences of their action are: changes in species distribution, organism metabolism and ecological processes such as productivity and species interactions;

changes in ocean chemistry, eutrophication, acidification, hypoxia; rising sea level; chronic erosion and contamination; shifts in weather patterns and greater spreading of exotic species.
As living systems, ecosystems often exhibit nonlinear responses brought on by crossing thresholds that alter their composition and key processes, changes that in turn affect ecosystem stability, resilience, and functions. Studies of several types of ecosystems, including coral reefs and kelp forests, show that pressures from human activities can bring about dramatic changes where functioning is severely impaired. Once some critical threshold is passed, even relatively small stresses may trigger rapid ecosystem degradation and loss of integrity.
In this context, a great challenge is to understand how we can exploit coastal resources within environmental and biological constraints, to ensure enduring access to them through informed regulation, management and utilization. The role of science in this sense is to provide information. Scientists can contribute expanding the knowledge base of coastal physical and biological resources, to better define the ecosystems and understand the effects of environmental variability and change, and human activities.
Three main ways in which science should produce information to aid improving coastal management can be identified:

1. Establishing an integrated temporal and spatial baseline of biological and physical resources, as well as human activities, as a basis for understanding the dynamics and sensitivities of ocean and coastal systems.
2. Understanding the interconnectedness between coastal ocean systems, including human activities.
3. Enhancing the evidence base to inform management and policy frameworks to optimize the sustainable use and conservation of coastal resources.

Even if science produces the best information, it is not always available to decision makers. Here, is where the role of services becomes evident and several countries are creating “Coastal Services” to bring the information to the users.
Nevertheless, to reach the goal of “having informed regulation, management and utilization”, it must be ensured that scientific information is used in decision-making effectively. A key on-going problem in relation to the nature of information required for coastal zone management lies not so much in the provision or the content of information itself, but in the way it is presented to those who formulate and implement policy and take management decisions. Data alone are not enough. Most people need help turning scientific information into information that can be used when making important decisions about coastal management. The application of science must therefore involve more than just providing information on the state of the coastal environment, identifying indicators for assessing environmental change or developing mechanisms for monitoring and predicting the effect of policy and management options. Information must also inform the analysis of issues, help the user to ask the right questions and then provide signposts to where appropriate data can be found. This has important implications for all data providers, research workers and those attempting to define indicators and develop management tools. It is one the biggest challenges when thinking about effective services transferring scientific knowledge to users.

Bibliography:

Doody, J.P., Pamplin, C.F., Gilbert, C. and Bridge, L., 1998. Information required for Integrated Coastal Zone Management. European Commission for Environment http://ec.europa.eu/environment/iczm/pdf/themf_ex.pdf

Lazarow, N., Souter, R., Fearon R. and Dovers, S. Eds., 2006. Coastal management in Australia. Key institutional and governance issues for coastal natural resource management and planning. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management. 136 pp.

Michel, D. and Pandya, A., Eds. 2010. Coastal Zones and Climate Change. The Henry L. Stimson Center ISBN: 978-0-9821935-5-6. 106 pp.

Millennium Ecosystem Assessment, Marine and Coastal Ecosystems and Human Well-Being: Synthesis (Nairobi: United Nations Environment Programme, 2006).

National Oceanic and Atmospheric Administration (NOAA). 2010. Adapting to Climate Change: A Planning Guide for State Coastal Managers. NOAA Office of Ocean and Coastal Resource Management. 138 pp. http://coastalmanagement.noaa.gov/climate/adaptation.html

National Science Challenges Panel, 2013. Report of National Science Challenges Panel. New Zealand. Ministry of Business, Innovation and Employment. 46 pp. http://www.pmcsa.org.nz/wp-content/uploads/Report-of-National-Science-Challenges.pdf

Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden and C.D. Woodroffe, 2007. Coastal systems and low-lying areas. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 315-356.

Rozum, J.S. and Carr, S.D., 2013. Tools for Coastal Climate Adaptation Planning. Coastal-Marine Ecosystem-Based Management Tools Network. NatureServe. Arlington, Va., 47 pp.

Scheltinga, D.M., Ed., 2005. Research for Coastal Management. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management. 60 pp.

United States Agency for International Development (USAID). 2009. Adapting to coastal climate change a guidebook for development planners. 146 pp. http://www.crc.uri.edu/download/CoastalAdaptationGuide.pdf