Water masses properties, chemical signatures and biological processes in coastal marine environments

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Coastal environments are generally exposed to higher fluxes of matter, and sometimes energy, than the open ocean, generally because of the vicinity of land, which acts in different manners. In one case as a reservoir/source of matter, in two cases (tides and upwelling) as a discontinuity which forces strong acceleration of the flow field under geodynamical forcing.
The role of land as a source of matter has been enhanced by the intensification of human activity, which develops preferentially in coastal regions, but all three cases make the coastal areas, as interface between land and ocean, a key site in global biogeochemical cycles. Therefore monitoring and understanding the variations in fluxes due to climate change and/or direct human activity, become essential for responding to global change.
We may say that in the first case the coastal dynamics is land driven while in the other two cases is ocean driven. This simplifying classification is just to stress the point that in land driven systems the direct impact of human activity through land use is the dominant term. As a matter of fact while atmosphere may play an important role in mass transport, it is the fresh water runoff that rules the input of new nutrients, pollutants, etc. to coastal areas. In this case the morphology and the geodynamical forcing act as modulators of their diffusion, retention and transformation within it. All the above requires a proper quantification of fluxes to the sea, which depends on the reservoirs and processes on the land, and a proper understanding of the oceanographic processes that occur in the coastal area.
Among the different attempts to obtain a quantification of the transport to the ocean due to fresh water runoff the recent effort made by the COSCAT group (*Meybeck M., Dürr H.H., Vorosmarty C.J. Global Biogeochemical Cycles, 20(GB1S90): doi:10.1029/2005gb002540, 2006 and related papers*) is definitely the most exhaustive so far. It must be said that the analysis carried out in the COSCAT context is essentially (bio)geochemical with the parenthesis stressing the fact the biota is simply taken as a neutral transformer of energy and matter, when even considered [The specificity of biota is the topic of the another lecture]. The COSCAT approach will be therefore discussed and will be integrated with the results of studies focused on atmospheric contributions. For Cuba an essential reading is the paper by J.A. Baisre (*Biogeochemistry (2006) 79: 91–108*) who makes a quantitative assessment of nitrogen dynamics in the island.
Biogeochemical transformation in coastal regions will also be discussed with some emphasis on elemental unbalance on short and long time scales.
A brief overview of the ocean driven costal systems will be then given, especially for what human exploitation concerns.
Particular emphasis will finally be devoted to the problem of eutrophication, discussing the studies conducted in different sites, which will serve as an introduction to the response of biota.
Definitions and methods will be dealt with in a brief introduction.

Long-term observations in coastal areas: a key tool for detecting changes

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Earth is changing rapidly in response to the link between climate variations and human activities, but a proper assessment of ongoing changes, with the exclusion of a few state variables which can be easily monitored on a routine basis (e.g., temperature), is lacking and, in many cases, change is perceived and analyzed after having occurred.

Indeed, while a change in elemental or energetic fluxes can be, in theory, properly monitored, there is still a significant gap of knowledge on how biota will respond to abiotic changes. During recent years many databases have been screened to determine whether change in ecosystems diversity and functioning did have occurred and whether some general patterns could be detected. This lead to a more objective definition of regime shifts which, even when assessed on robust statistical methods, still elude our capability of a mechanistic reconstruction. As discussed in other lectures, coastal ecosystems are exposed to changes in terrestrial, atmospheric, oceanic sources, with a foreseeable increase of the main driver, the human pressure, through expanding urbanization and conflicting demands of tourism, aquaculture, water diversions, wind parks and other developments. Therefore, while open ocean processes are particularly suited to monitor the large scale impact of climate change and anthropogenic activity, costal areas are the ideal sites to perform process studies on time varying biotic-abiotic interactions and, more important, to detect changes coupled with changes in fluxes.

Systematic observations of seasonal cycles in relations to environmental variations have been at the base of agriculture management since Neolithic time and are also an important component of fishery management.

Biota is the dominant term of present Earth system functioning and, because of this, it plays the double role of crucial actor in good and services provided by natural ecosystems and of best sensor for environmental changes. The only way to exploit the information derived by the latter role is a regular monitoring of the biota dynamics in the environment.

Many time series of different duration have been produced in the last decades, and the insight provided by them will be discussed. Even focusing on just one component, the phytoplankton, the dominant scales of variability in abundance, floristic composition, species composition, and/or species diversity display patterns which hints at mechanisms more complex than those assumed if only geochemical fluxes are considered. The patterns among ecosystems in terms of relationships between environmental parameters, phytoplankton biomass and changes in species/floristic composition are not always consistent. This, on one hand, calls for a more in depth analysis of existing data; on the other hand, stresses the need to increase the number of sites where time series observations are carried out. Both aspects will be analyzed, while methodological aspects will be briefly introduced and dealt with more in depth during the second week of the school.