PANEL REPORT BY THE MODERATOR

Roberto Danovaro
Department of Marine Science, Polytechnic University of Marche, Ancona, Italy - danovaro@univpm.it

Keywords : Deep Sea Ecology, Deep Sea Basins, Deep Sea Processes, Deep Sea Sediments, Biodiversity.

Panel 5 was conceived with the objective of giving a brief but highly interdisciplinary picture of present knowledge and recent advances in Mediterranean deep-sea research, starting from the geosphere and hydrosphere settings, to microbiology and faunal diversity and ecosystem functioning, to conclude with the presentation of Programmes on Mediterranean biodiversity and ecosystem functioning.

The Panel started with a general overview on deep seas presented by the moderator Roberto Danovaro. Deep-sea sediments, covering 65% of the world surface, are the largest ecosystem on Earth. Here microbial processes, driving nutrient regeneration and global biogeochemical cycles, are essential to sustain primary and secondary production of the oceans. Deep-sea ecosystems are also the largest reservoirs of biomass and key elements/compounds. There are no direct estimates of the value of deep seas. However, since the deep-sea floor covers an area $\sim$100 larger than that of shelf, even assuming a deep-sea dollar/ha/yr value 10 times lower than that of shelf, the value of deep sea functions is 10 times higher than that of shelves, and potentially higher than actual estimates of world total ecosystem value. In addition, the census of life in the deep sea is just at the beginning and the largest portion of its biodiversity is still unknown (from 0.3 to 8.3x10^6 species to be discovered). The moderator illustrated also the reasons why the deep Mediterranean Sea can be considered the best existing model to investigate the impact of changes at global scale. The main reasons can be summarized as follows:

1. The Mediterranean is a miniature Ocean (therefore a model of circulation and processes occur at much smaller time scales);
2. There is a long-term history of investigations and impacts in the Mediterranean basin (but not in the deep sea);
3. High deep-sea temperatures, which imply faster responses.
4. Susceptible and sensitive to climate changes (already evident in the deep, relevance of episodic events; EMT, Gulf of Lion);
5. High biological diversity in coastal systems vs. very low biodiversity in the deep.
6. Strong environmental and biodiversity gradients (e.g., West-East gradient in trophic conditions);
7. Complex paleo-ecological history, with periodic mortality events (sapropel formation): scenarios of recolonization;
8. The Mediterranean is the ideal basin for testing factors forcing the evolution of deep-sea life: large proportion of continental margins - source sink hypothesis;
9. The deep-Med contains the most extreme environments for life (e.g., DHABs);
10. The deep-Med is full of hot spot ecosystems at very short distance (cold seeps, deep corals, canyons, slopes, slides, seamounts, anoxic etc).

Deep-sea ecosystems, and the Mediterranean in particular, are highly vulnerable, and increasingly subject to direct and indirect anthropogenic impacts (deep-sea trawling, dumping, oil, gas and mineral extraction, other pollution sources). Moreover, recent findings have revealed that climate change can exert also a significant and rapid impact on deep-sea Mediterranean biodiversity.

The presentation of the first panelist (Miquel Canals) focused on the description of the drivers of Mediterranean deep water sedimentation. Recent observations suggest that the functioning of deep Mediterranean benthic systems, as expressed by particulate fluxes and benthic variables, are characterised by a large interannual variability, which is highlighted by the evidence of episodic or stochastic events, or long-term climate change. Two such large events - the Eastern Mediterranean Transient and the Gulf of Lions cascading - affected significant parts of the eastern and western basins respectively. M. Canals described in detail a highly significant massive sediment transport and seafloor shaping process, not previously documented, and illustrated how Dense Shelf Waters (DSW), flowing down submarine canyons and slopes, carried large amounts of coarse sediment that eroded and shaped canyon floors (e.g. giant furrows). The main conclusions coming out from this presentation were:

1. This is a mechanism of massive transfer of fresh organic matter, and hence C sequestration, to the deep ocean;
2. DSW flowing down canyons may carry large amounts of highly nutritive fresh organic matter that in intense events (twice from 1993 to 2005 in the Gulf of Lion) reaches the very deep basin thus massively injecting C into the deep ocean;
3. Submarine canyons in the Gulf of Lion drive the deep Western Mediterranean Sea;
DSWC in the Gulf of Lion imprints intermediate and deep waters, and the functioning of the deep ecosystem in the Western Mediterranean Sea;
4. According to predictive models, climate change holds the potential to significantly modify dense shelf water cascading;
5. Global warming will likely lead to a lowering in the frequency of dense shelf water formation, thus reducing the frequency of cascading processes which in turn will cause a severe reduction of the episodes of massive injection of organic matter into the deep ecosystem. The example reported here on the cascade event in the Gulf of Lion is providing new perspectives of investigation and management of the Mediterranean.

Jean Mascle illustrated the geosphere component of the deep-Mediterranean Sea and discussed the present knowledge on the topographic description of the deep Mediterranean seafloor, which is a prerequisite for any subsequent investigation on deep-sea life and ecosystem functioning. He showed the recently published (2005) CIESM/Ifremer high resolution multibeam maps which cover large portions of the seabed morpho-bathymetry in both the Western and Eastern Basin. Additional maps detailing specific areas of the Mediterranean Sea such as the Nile Deep Sea Fan were produced under the same scientific collaboration. J. Mascle also underlined the high scientific value of these maps which provide detailed information on large scale geological processes of the Mediterranean Basin and reveal specific features of the seabed (e.g. mud volcanoes, gas and fluid seepages) which are extremely important to understand biogeochemical processes occurring in the deep.

Anastasios Tselepides illustrated some peculiar aspects of the biology and ecology of deep-sea benthic biota in the Mediterranean, with a specific focus on benthic community structure and function of the deep Eastern Mediterranean Sea. High temperature, high salinity and the strong oligotrophy make this ecosystem very different from all other ocean deep-seas. This difference is also reflected in the species diversity and functional role of the macro- and microbiota of the deep Mediterranean, as illustrated by the author. He also focused on main drivers and recent changes related to climatic events such as the Eastern Mediterranean Transient, which indirectly affected the deep benthic communities. The high vulnerability of the Mediterranean deep sea ecosystem to environmental changes and its close interactions with the upper water column and the coastal ecosystems were underlined.

This talk was followed by a summary on the present knowledge and recent advances in deep Mediterranean microbiology by Christian Tamburini and Gerhard Herndl. They reported the key role of deep-sea prokaryotes (DSP), which are a virtually untapped resource for industrial purposes. Recently, a number of novel metabolic pathways have been discovered, shedding new light on the dark ocean prokaryotes. Non-thermophilic Archaea have been recently found to represent the major source of autochthonously produced organic carbon in the deep sea and play a major role in deep-water nitrification outnumbering bacterial nitrifiers in the oxygen minimum zones of the mesopelagic ocean. Anaerobic ammonium and methane oxidizers have been found in the dark ocean sediments and even more recently, in the deep oceanic water column. The Mediter-