Panel D- ***CONTAMINANTS AND MARINE LITTER***

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Points raised during the Panel discussions

A central objective of Panel D was to outline main gaps and main priorities for joint Mediterranean / Black Sea research on contaminants and marine litter. The 8 invited presentations focused only on selected facets of the problem, addressing new operational tools, sources of pollution and marine litter, numerical modeling and monitoring. The restitution of key points demonstrated the consensus on identified gaps in the knowledge, priorities and recommendations to support further research efforts and capacity building.

New methods and approaches

Using RDC SCANEX and other innovative sources of remote sensing (RS) data, such as SAR-equipped RS satellites, comprehensive analysis of the multi-satellite/sensor, GIS technologies, data of automatic ship identification systems (AIS) and modeling, oil spills and oil slicks can now be mapped and monitored at a new level of accuracy and resolution. An example of routine satellite oil spill monitoring in the Eastern Black Sea (2011-2013) using web-GIS technology application and geoinformation approach ("geomixer") developed by SCANEX was presented. This allows for integrating and combining all data and information needed for detailed analysis, such as the offshore and onshore oil and gas infrastructure, ship tracks, boundaries of territorial waters, economic zones and license blocks, bathymetry, locations of known bottom oil seeps, etc.

As a result, oil spill distribution maps for the Eastern Black Sea were generated and their spatial and temporal variability were analyzed. They clearly showed the importance of navigation/shipping as the main source of anthropogenic oil pollution in semi-enclosed seas such as the Black Sea and the Mediterranean. Additional patches that are not produced by crude oil and oil products at all were detected (palm oil, etc.). Combining analysis of SAR, RS, AIS and other kind of data also enables exact identification of sources of oil pollution, and even individual ships responsible for a particular oil spill. Based on actual data of satellite monitoring, the Black Sea can be considered as one of the most heavily polluted inland seas.

Several other novel approaches were presented and discussed during the Panel. The development of a miniaturized UV fluorometer and UV fluorescent lidar for monitoring anthropogenic inputs in the coastal and open ocean waters was reported. Based on Minifluorometers /Uvs for Dissolved Organic Matter (Tryptophan) and hydrocarbons (Phenanthrene) mounted on gliders , tests for the characterization of a coastal environment, water quality, and possible pollution were performed in a large bay (Marseille). The results demonstrated the feasibility of using gliders to evaluate the 1D and 3D profiles of both tryptophan (Organic matter) and Hydrocarbons. Other applications of new types a gliders (surface wave gliders), were also demonstrated with an application for the assessment of floating marine litter. Both systems provide sound technical means for the implementation of both early warning systems or near real time monitoring at sea.

Sources of pollution

Using in situ and satellite measurements, examples of the quantitative characteristics of the hydrophysical and hydrochemical changes at shelves following the continental river discharges were reported for the estuaries of small rivers of the Russian coast of the Black Sea. Measurements were performed for 5 years, mainly in Mzymta River plume and the adjacent shelf, and included a number of indicators of the water quality such as the hydrophysical and chemical parameters, nutrients, suspended matter, primary production and pollutants (metals, sterols and some POPs). Considering also simulations using a Lagrangian numerical model, the results demonstrated both the interannual and the seasonal and short-term variability of the water quality, depending on the atmospheric forcing conditions, the dynamics of the river plume and associated transport of suspended matter and anthropogenic pollution.

Numerical simulations

Numerical simulations proved to be important means to better understand the fate of pollution at sea. Various numerical modeling applications were demonstrated during the Panel sessions with the aim to simulate water movements and pollutant propagation in both coastal and offshore waters.

Modeling of the Black Sea circulation using INMOM (Institute Numerical Mathematics Ocean Model) based on a method of multicomponent splitting with a flexible modular structure was presented. The model was applied to the circulation in the Black sea (4 km resolution) and the transport of polluting substances in the BS region adjacent to the Greater Sochi at 50 m resolution. A computation of pollutants distribution from the rivers Sochi, Khosta, and Mzymta, as well as from 18 pipes of deep-water sewage performed for the high discharge period demonstrated the importance of various sources of pollutants and their advection by mesoscale and submesoscale eddy structures.

At a larger scale, circulation and processes of pollution transport in the Adriatic Sea were presented. Using the DieCAST model (~2 km resolution), mesoscale variability was resolved and results demonstrated instabilities to develop at length scales of 5–20 km over time scales of a few days. Meanders, swirls and eddies were noted along the relatively flat Italian coast while offshore jets and filaments better describe the mesoscale activity along the more rugged coast of Croatia. Seasonal hydrography of the Adriatic Sea was also evaluated such as the mesoscale variability along the Italian coast as a results of baroclinic instability and the local bottom topography. Consequences on the transport and dispersal of pollution were also discussed with implications to pollution transport.

Large scale contamination

The Mediterranean and the Black Seas experience significant influence of a large number of organic pollutant sources due to their nature as semi-enclosed environments surrounded by highly populated areas (more than 400 million people living in the riparian countries), numerous industrial and agricultural sectors, and intense maritime traffic. As fractions of these chemicals, persistent organic pollutants (POPs) are of major concern due to their high toxicity and persistence, their accumulative properties and long-range transport potential. An overview of the current levels, atmospheric transport, loadings and cycling of various POPs, including flame retardants and plasticizers was presented. The overall occurrence of toxic organic chemicals in surface waters far from the shoreline has been confirmed. Spatial and temporal trends have

been identified for some contaminant families. For instance, spatial variability of PAH concentrations and decline in PCB atmospheric concentrations for the last 15 years in the Mediterranean Sea region, were demonstrated. Atmospheric deposition is the main loading pathway at open sea in the environments of both Seas for all studied contaminants with estimation of deposition at ~ 3100 ton/y in the Mediterranean Sea and ~ 500 ton/y in the Black Sea for PAHs. The dynamic coupling of the air-water-phytoplankton POP concentrations allowed to explain the "modulation" of the water column levels for PCBs, OCPs and PAHs in the Mediterranean Sea far from land-base sources.

Assembling the fluxes of pollutants has become an important research topic in the Mediterranean and the Black sea. An illustrative example was given during the panel. The evaluation of fluxes was performed, including atmospheric transport through particles and gas, inputs at sea from rivers, land, rain, particles, exchanges at the interface and, finally, partition in water through the different compartments such as biota, particulate and dissolved matters, organic or mineral, and sinks that include the chemical and biological degradation.

Monitoring

The Panel emphasized the importance of identifying and filling the gaps of the existing monitoring programs, taking into account a variety of pollutants and pollution effects, contaminants in fish and other seafood, marine litter, as well as the emerging new research methods. A good example of an integrated monitoring programme of the transitional, coastal and marine waters was given for the Romanian Black Sea area based on the analysis of water, sediment and biota samples, collected from a network of 44 stations. The contamination parameters analyzed were hydrocarbons, heavy metals, organochlorine pesticides, polycylcic aromatic hydrocarbons (water, sediments and marine organisms - mollusks) and bacteria (bathing waters). The identified gaps refer to the pollution effects which are poorly addressed at the regional and national levels and contaminants in fish and other seafood for human consumption. This is also the case for other Mediterranean and Black Sea countries.

In addition, the threshold values which define the maximum admissible levels are not set out for a number of contaminants in either sediments or biota. Not only for Romanian waters but in a wider perspective for the Mediterranean and the Black Sea, the contamination of coastal areas can be directly correlated with urban or industrial sources. River influence on coastal areas is of utmost significance, being a major source of contaminants, mainly as particulates but also as dissolved matter, with extreme hydrological events (floods) greatly enhancing such an input. Marine litter, of which plastic is the main component, is a new important pollutant taken into consideration in the monitoring program developed by some Mediterranean and Black Sea countries as illustrated by the example from Romania.

Marine litter in the Mediterranean and Black seas

Anthropogenic litter on the ocean surface, beaches and seafloor has significantly increased over the recent decades and both Mediterranean and Black Seas have been among the most affected areas in the world. Plastic, mainly bags and fishing gear, forms the largest part of debris at sea. Cleaning efforts and regular surveys are now providing information about temporal and spatial distribution that is mainly related to the proximity of large cities, major rivers, and extensive use of coastal zone for recreational and other activities. Hydrodynamics, maritime activities and geomorphology of the sea floor are ultimately the main drivers affecting the distribution of litter at sea.

On beaches, studies have demonstrated densities of litter in the range of up to 1 piece per m2. Polymers can be then physically degraded into smaller fragments, the so-called microplastics. Of all surveys accomplished to date worldwide, the highest density was observed in the NW Mediterranean sea (115,000/km2). Microplastics are also found on beaches and sediments, including the deep sea, reaching concentrations of 1000 pellets/m2 of beaches on the Island of Malta. Recent studies of the deep sea floor of the Mediterranean concluded that coastal submarine canyons act as conduits for the transport of marine debris into the deep sea areas with an average density estimated as 179 plastic items/km2 based on 295 samples.

The balance between the increase of waste and plastic productions, protective measures and the quantities found at the surface and on the shorelines is still not quantified. Recent research in the Mediterranean and Black seas demonstrated (i) the governing role of hydrodynamic factors, (ii) the importance of physical, chemical or biological degradation of plastic, involving several steps such as the initial formation of bacterial biofilms and fragmentation, (iii) the impacts of plastic at sea that include entanglement, physical damage and ingestion, the release of chemicals, the transport of species and the alteration of benthic community structures, and (iv) social and economic harm that include the reduction of values of various areas as well as risks to human health, potential threat to navigation and damage to maritime sectors.

The Black Sea and Barcelona Conventions with their Regional Action Plans and the EC through the MSFD are key stakeholders for monitoring marine litter at Sea and for implementing mitigation measures. CIESM recently organized a workshop dedicated to marine litter which summarized priority research topics. Among the priorities, CIESM Monograph 46 recommends to (i) pursue a better definition of standardized/ harmonized protocols, (ii) develop research on nanoparticles at sea, (iii) achieve a better understanding of circulation and transport of litter in the Mediterranean and the Black Seas, (iv) improve our knowledge of microbial life on plastic and its consequences on degradation, species dispersion, and release of chemicals, (v) understand the interactions between species and plastic and the impact of new habitats, (vi) develop a risk assessment approach , and finally (vii) develop indicators of harm.

General recommendations

Accumulation rates of pollution vary widely in the Mediterranean Sea and are subject to factors such as adjacent urban or industrial activities, shore and coastal uses, wind and currents. Additional basic information is still required on sources, inputs, degradation processes and fluxes before a correct global assessment can be provided. Furthermore, anthropogenic inputs may change and sources may shift between tourism, fishing, shipping and marine industry, etc.. More research towards a clear evidence base is necessary to ensure efficient policy decisions. For this purpose, the panel adopted the following recommendations:

- It is highly important to develop and support emerging new technologies of monitoring marine pollution and litter, such as UV lidars and sensors, other instruments aimed at achieving higher spatial and temporal coverage and resolution of pollutant data, gliders and other self-propelled platforms for monitoring contaminants, new and dedicated numerical models, including Lagrangian ones, GIS technologies, etc.);
- New satellite techniques are of utmost importance for monitoring marine pollution. Consolidated efforts of all CIESM countries in sharing their satellite data and technologies are encouraged;

- Sound assessment of marine pollution shall rely on correct and precise evaluation of sources. The primary and secondary sources of pollution should be identified at the global and regional scales. It is also important to consider partition, i.e., different forms of one pollutant;
- The interrelations between pollutants and nutrients should be considered, given that the feedbacks between them may represent multiple stressors for the ecosystem (example: PO_4 and phosphorus compounds);
- The mass balance of relevant contaminants needs to be quantified. The uncertainties in sinks are particularly appaling;
- The contamination impacts should be investigated at the ecosystem level rather than at the level of individual indicators. Therefore, a comprehensive set of relevant integrated indicators should be agreed on;
- Standardized protocols on microplastics in sediments need to be elaborated with CIESM guidance;
- It is important to identify and investigate the accumulation areas for deep sea bed litter. This could be achieved through "opportunistic approach": whenever underwater operations with ROVs, submersibles, or bottom trawling are taking place, the task of documenting litter at the sea floor should be kept in mind.