Oceanography Congress 2017: Challenges in marine pollution research - Hans Uwe Dahms - Kaohsiung Medical University

Abstract

Monitoring and valuations of the aquatic environmental health status should become essential mechanisms of adaptive administration plans that are aimed to display and remediate pollution and the damage it causes to the marine environment. Such efforts taken separately may not be sufficient for noticing unwanted changes of integrative ecosystem health in a complex marine environment. Complexity is here provided by spatial-temporal gradients, such as geographic, latitudinal, depth, as well as seasonal shifts. In addition, organisms show commonly variable reactions at various levels of integration (e.g., at the level of genome and proteome, physiology, cell, tissue and organ, individual, population and community). Biota is also characterized by variability in their taxonomic and ontogenetic sensitivity and different reaction norms of sex. The tendency of most toxicants for differential individual bioaccumulation and biomagnification within food webs further complicates the situation. To date, only a few attempts have been made to challenge an integrative approach using, physical and chemical habitat assessments, biological monitoring and physiological, biochemical and Geno toxicological parameters to assess the environmental health status of a contaminated aquatic ecosystem that could directly lead to food safety measurements in ocean fisheries and aquaculture. In order to integrate abiotic and biotic endpoints, different approaches should be pursued in a systems-oriented way: physical, chemical, biological; laboratory vs. field; realms (freshwater, brackish, marine-bottom, water column, interfaces); organisms (producer, consumer and decomposer); biological integration levels (ecological, behavioural, chemical and subcellular).

This holds for observational monitoring as well as for experimental approaches at all integration’s levels-from molecules to ecosystems. Challenges are provided at most levels of aquatic pollution: pollution monitoring, treatment and management, economic, social and policy aspects in the protection of the marine environment at National and International levels. Bioaccumulation occurs within a trophic level and represents the concentration increase of a substance in certain tissues of organisms due to absorption from food and the environment. Biomagnification commonly results from chemical persistence, food chain energetics or rate of internal degradation and excretion. For enhanced biomagnification, the pollutant must be long-lived, mobile, soluble in fats and biologically active. Among the newly emerging xenobiotics are endocrine disrupting chemicals (EDCs), capable of adversely affecting the function of endocrine systems, leading to changes in growth, development and reproduction of exposed animals and human. Although the occurrence and implications of steroid oestrogens in the environment has received some attention, there is only limited evidence for bioaccumulation in wild or farmed fish that provide precious food sources for human consumption.

Given the importance of oceans to humankind and the increasing pressure they are under, it is timely to identify and prioritize oceanic health issues that are covered in their ill-defined state by “marine pollution” (MP). MP increasingly leads to disturbances of the oceanic environment and its biota and adversely affects environmental and human health. Pollutants may have various biological impacts such as death, metabolic malfunction, genetic and phenological damage. If such impacts are sublethal, they will lead to fitness changes. Depleted numbers of sensitive species are causing a decrease in biodiversity, and may cause ecosystem function changes by habitat and food chain alterations and those of productivity patterns.

Major challenges in MP studies are conceptional as well as operational. Conceptionally, pollutants are very much understood as chemicals only. From a largely chemical perspective pollution studies need to open up to any stressor that affects organisms in their respective environment. Stress to organisms in the marine environment can be caused by physical (e.g., electromagnetic radiation, electricity, drag etc.) chemical (e.g., organic or inorganic), physico-chemical (pH) or biological factors (biotoxins, competition, predation, parasitism). MP is also very much perceived as man-made although there exists natural pollution since ever—if natural is understood as stressors of organisms that are not anthropogenic (e.g., input of freshwater, sediments and their contaminants, volcanic activity outside and inside the oceans). Natural pollution happened even before humans contributed to MP so much more in recent centuries.

Humans intensified natural MP and certainly created novel stressors through technological innovations. These got magnified as a new quality in the Anthropocene by man-made changes to soil, atmosphere and waters. The hydrosphere includes the oceans which cover about 70% of the earth's surface and are providing more than 99% of the earth's water resources. Man-made effects include industrial (e.g., noise, radiation, heavy metals, nanoparticles), agricultural (e.g., pesticides, antibiotics, fertilizers), and urban pollutants (e.g., organic matter, pharmaceuticals, CO_2) which reach the oceans via various pathways, from the atmosphere, aquatic drainages and rivers, from coastal groundwater, and through organisms getting dispersed between these realms. Everything that humans are doing will have consequences. Human activities are never environmentally neutral.

As in all sciences it will be important to make temporal and spatial distinctions in MP studies. Spatially—the oceans are not separated from other realms, such as land and freshwater systems and the atmosphere. Multiple interfaces facilitate the fluxes of energy and matter that also allow the influx of stressors. Within the oceans there are interactions between sea bottom and water column, and water column and atmosphere (or seasonal and multi-year sea-ice and atmosphere during winter and in polar seas). Distribution patterns of stressors may exhibit substantial horizontal and vertical patchiness. Several characteristics of the sea surface can remotely be monitored meanwhile by Geographic Information Systems (GIS) approaches. Temporally—stressors may act at a gradient of very different time scales: from geological times shaping the adaptation and evolution of organisms to minutes and seconds demarcating behaviour and even to parts of a second where chemical reactions typically take place.

There is a distinction between field and laboratory approaches. Field-oriented approaches are acting at the natural *in situ* platform where stressors originate or might get transformed, disposed and remobilized.

Field approaches are often seen inferior to laboratory *in vitro* approaches. The latter are expected to provide a better experimental and analytical resolution. It is a major challenge and strongly pleaded here to integrate both approaches in order to obtain a more realistic understanding about the mechanism of action in the natural world which we are ultimately concerned with. Besides taken field samples from natural or experimental sites to the laboratory for further study there is the possibility of micro- to mesocosm studies which provide a gradient from strictly controlled experiments to increasingly complex interaction of various variables that are characteristic for the real world. The main challenge here will be to study the interactions at interphases multidisciplinary and integrate the results in a systems approach.

This work is partly presented at 5th International Conference on Oceanography and Marine Biology on October 18-20, 2017 held at Seoul, South Korea

Hans Uwe Dahms
Kaohsiung Medical University