



Editorial

Exploring the potential of large vertebrates as early warning sentinels of threats to marine ecosystems, human health and wellbeing



The use of plastics by human societies continues to increase exponentially. This reflects, no doubt, the many benefits which plastics of different kinds provide in the manufacture of an array of products, ranging from electrical equipment and vehicle components to food containers and medical devices. However, as with all technologies, there have also been disadvantages to their introduction. The virtue of being robust and non-degradable turns into a flaw when plastics become waste products. When discarded in the environment they persist, often for many years. In the seas and oceans plastics have become widely dispersed across the World, only to cluster in some locations where currents deposit them in large amounts. Gradual breakdown results in larger pieces of plastic waste becoming ever smaller, until invisible. All sizes, from plastic crates, bottles and bags down to the smallest nanoscale fragments, have the potential to damage marine life. Incorporation of plastics into the marine food chain generates another potential threat when seafood, containing plastics, is ultimately consumed by humans.

Some have argued that concern over plastic pollution is unwarranted, and that the threats posed are minor compared to the benefits on offer. This seems a singly, short-sighted view. Even without the demonstrable damage that has been done to marine animals such as turtles and marine mammals, it is extremely unpleasant to encounter plastic debris on tourist beaches from Europe to South Africa, from China to Australia and from North to South America. To debate whether plastics are hazardous or pose risks tends to disguise the fact that it is simply bad practice for human societies to take so little care about how they discard their waste, be it plastic or any other kind of surplus material. This being said, tangible damage to marine ecosystems really does result from the presence of plastics in the sea; a claim supported by several of the contributions to this volume and by the wider literature in this area.

These and other issues related to plastics in the sea and contaminant-related impacts were the subject of a workshop held last year (2013) at the University of Siena, Italy. On the 5th and 6th June, 2013, ca.100 scientists from 6 countries met for a conference at the University of Siena, under the umbrella of Society of Environmental Toxicology and Chemistry (SETAC Italian Branch), to review current knowledge and to clarify what is known, and what remains to be discovered, concerning plastic litter in the sea and the potential effects on marine ecosystems, and ultimately, on human health and wellbeing. In particular, the meeting focussed on the use of large marine vertebrates as sentinels to provide early warning of damaging effects. A brief note describing the key findings was published at the time (Depledge et al., 2013). In this volume, papers presented at the meeting provide further details and

information. The workshop explored the biology and ecotoxicology of large marine vertebrates and seabirds and in particular their role as potential sentinels in the context of “Good Environmental Status” for the European Marine Strategy Framework Directive (MSFD) with particular attention to the implementation of Descriptor 10 (*Properties and quantities of marine litter do not cause harm to the coastal and marine environment*). The role of organisms as potential sentinels of Descriptor 1 (*Biological diversity is maintained*) and Descriptor 8 (*Concentrations of contaminants are at level not giving rise to pollution effects*) was also discussed during the meeting. The content of the workshop was designed to contribute further to the MSFD following an inaugural workshop in 2012 (see Fossi et al., 2012a). Finally, 12 out of 14 papers were peer reviewed and selected for the publication in this special issue, five of them covering the topic of the Descriptor 10 (Marine litter), five the topic of Descriptor 8 (Concentrations of contaminants) and one the Descriptor 1 (Biodiversity).

The Special Issue begins with an introductory paper by Galgani and co-authors that covers the main strategic considerations (constraints, specificities and recommendations) regarding the monitoring of impacts of litter using large vertebrates in the Mediterranean Sea. A paper describing the monitoring procedure for microplastics using a multidisciplinary approach was presented by De Lucia and co-authors showing, as a case study, the amount and distribution of neustonic micro-plastic off the western Sardinian coast (Central-Western Mediterranean Sea). Another case study of large filter feeding marine organisms proposed their use as macro-scale indicators of microplastics in the pelagic environment (Fossi and co-authors). Mediterranean basking shark (*Cetorhinus maximus*) and fin whale (*Balaenoptera physalus*) were also discussed extensively as indicators of microplastics in the pelagic environment in the implementation of Descriptor 8 and 10 of the MSFD. Two papers reported the potential threats of plastic and plastic additives to endangered sea turtles *Caretta caretta*. Camedda and co-authors described the interaction between loggerhead sea turtles and marine litter in Sardinia (Western Mediterranean Sea). The ecotoxicological effects of pollutants binding to plastic were explored in depth by Guerranti and co-authors in a pilot study on levels of chemical contaminants and porphyrins in *C. caretta* from the Mediterranean Sea. This species was proposed as an indicator of macro-plastic in the Mediterranean environment in the implementation of Descriptor 10 of the MSFD.

The role of large marine vertebrates and seabirds as potential sentinels of “Good Environmental Status” for the Descriptor 8 (*Concentrations of contaminants are at level not giving rise to pollution effects*) of the MSFD is extensively developed in the second part of the

volume. Environmental monitoring of seabirds such as guillemot eggs, is conducted annually in Sweden to follow temporal changes in environmental contaminants. Miller and co-authors compared in their paper the temporal trends of organochlorines in guillemot eggs and Baltic herring, discussing the advantages and disadvantage for selecting sentinel species for environmental monitoring. Assessment of the levels of polycyclic aromatic hydrocarbons and organochlorine contaminants in cetaceans such as bottlenose dolphins (*Tursiops truncatus*) from the Eastern Atlantic Ocean were discussed by García-Álvarez and co-authors.

Three papers presents the development of *in vitro* tests and molecular biology techniques to detect the toxicological effects of chemicals in vertebrates. Mancía and co-authors reported machine learning approaches to investigate the impact of PCBs on the transcriptome of the common bottlenose dolphin (*T. truncatus*). This work explored the potential use of microarray technology and gene expression profile analysis to screen common bottlenose dolphins for exposure to environmental contaminants through the immunological and/or endocrine perturbations associated with these agents. In the study of Frenzilli and co-authors, the genotoxic potential of nanosized TiO₂ anatase and micro-sized rutile on bottlenose dolphin (*T. truncatus*) fibroblasts and leukocytes was evaluated. Finally, the genotoxic damage of benzo[a]pyrene in cultured sea bream (*Sparus aurata* L.) hepatocytes were investigated by Pastore and co-authors.

The role of cetacean species as potential sentinels of Descriptor 1 (*Biological diversity is maintained*) were presented by Lauriano and co-authors in which the abundance and distribution of *T. truncatus* in the Western Mediterranean Sea were discussed in terms of assessment in the context of Marine Strategy Framework Directive requirements. Finally, Azzellino and co-authors proposed the biodiversity of the cetacean community as MSFD indicator of the environmental status of marine ecosystems and its link with anthropogenic pressures.

In conclusion, as well as continuing concerns regarding well-known environmental contaminants, workshop participants highlighted newly emerging threats, in particular, micro- and macroplastic dispersed in the Mediterranean sea. In addition to many well recognized environmental pollutants such as DDT, PCBs, dioxins, and mercury, large marine vertebrates are able to provide early warning of newly emerging contaminants such as perfluorinated compounds, phthalate and nanomaterials (Fossi et al., 2012b). It was noted that almost all the contaminants thought to be of concern in large marine vertebrates are also of concern to human health (see Depledge et al., 2013). Indeed, there is now increasing recognition that the body burdens of environmental

contaminants in the European human population is a growing cause for concern and may be associated with alterations in the frequency of occurrence of a range of diseases including diabetes, heart attacks, strokes, neurological disorders and cancers (Lang et al., 2008; Melzer et al., 2010). Thus, the relationship between the degree of chemical contamination and health of large marine vertebrates is of great relevance to contaminant-related human diseases.

One of the main outcomes of this volume is to propose the further development of scientific research on large marine vertebrates as indicators of medium and long term marine environmental change for incorporation under the MSFD. This might then be employed in the assessment of the quality of pelagic marine ecosystems elsewhere in the marine ecosystems.

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