

Foreword

The world's seas and oceans have never been more impacted by human activities than they are today. As the global population has increased over the last 200 years from c. 1 billion to c. 7.6 billion currently, we have dramatically increased the use of the marine environment as a source of food and energy, as a means of transporting huge amounts of goods globally, and as a site for the unprecedented disposal of waste. In addition, we have deliberately, accidentally, or uncaringly let contaminants of all kinds enter inshore and, ultimately, offshore waters, from the equator to both polar seas.

What then is the fate of the denizens of the deep? Those mammalian species high in the marine food web may provide early warning of, and important insights into, damaging effects on marine ecosystems. In the past, efforts have been made to examine individual threats, one at a time. However, this is not how marine organisms experience their world day to day. Instead, across their life course, they are simultaneously exposed to multiple stressors, both natural and anthropogenic, that combine to push animals to the limits of their tolerance. It is only by understanding the nature and extent of these integrated adverse impacts that we can be sufficiently well informed to take effective mitigatory action.

This book represents an important step on the path toward more effective action to manage our seas and oceans so that marine mammals, as well as other species, can maintain their populations in sustainable ecosystems. Guided by the editors, the authors explore the effects of exposure to multiple stressors, including anthropogenic pollutants, on marine mammals in different seas and oceans. Currently, both on ecotoxicologic and conservation grounds, it is crucial to determine the status of marine mammal populations and to instigate measures for their conservation. As top predators in complex marine food webs, several marine mammal species are especially vulnerable to environmental contaminant accumulation and to associated detrimental effects on important health endpoints.

Marine mammals, and particularly cetaceans, are widely regarded as reliable environmental sentinels due to their position near the top of the marine food web, their conspicuous nature, and their reliance on marine resources. As their physiology and/or diets are similar to those of humans, they can also potentially provide an early indication of adverse health effects and insights into the toxic mechanisms of diverse, well-known, and emerging hazardous substances. Such toxicologic stress, arising from the bioaccumulation of anthropogenic contaminants, combines with infectious diseases, competition from invasive species,

food deprivation, and climate change to pose a growing risk to marine mammal populations worldwide. For this reason, efforts have intensified recently to find ways to use marine mammals as charismatic sentinels of ocean change.

The impacts of multiple stressors are extensively explored in this book. It is well known that the various cetacean species exhibit different home ranges and occupy different habitats. This knowledge can be exploited in hot spot areas where a range of species can serve as sentinels of marine environmental quality at different times during the annual cycle. Marine mammals have relatively long lifespans, thereby permitting the study of chronic diseases including reproductive failure, abnormalities in growth and development, and cancer. As apex predators, some marine mammals feed at or near the top of the food web. Consequently, biomagnification of the levels of anthropogenic contaminants is found in top predators and long-living species' tissues.

One of the main outcomes of this book, which is based on the recent findings in the field of ecotoxicology of marine mammal species worldwide, is that the application of robust examination procedures and biochemical, immunological, and microbiological techniques, combined with pathologic examination and behavioral analysis, has led to the development of health assessment methods at the individual and population levels in wild marine mammals. With these tools in hand, investigators have begun to unravel the relationships between exposures to environmental multiple stressors (e.g., climate change, pollutants, marine litter, pathogens, biotoxins) and to identify a range of disease endpoints that can be used as indicators of ecosystems health.

This book paves the way to the development of a comprehensive approach to the study of the threats to marine mammals combining conservation approaches to new and emerging technologies. It comprises 17 chapters contributed by 59 scientists from 13 countries. Part 1 examines legacy and emerging contaminants in marine mammal populations; Part 2 explores the effects of toxicologic threats and cumulative stress on marine mammal health, while Part 3 considers some implications for monitoring and conservation of marine mammals. A brief overview follows:

SECTION I: LEGACY AND EMERGING CONTAMINANTS IN MARINE MAMMAL POPULATIONS

Four chapters (Chapters 1, 4, 7, and 8) focus primarily on organochlorine contaminants (notably polychlorinated biphenyls and dichlorodiphenyltrichloroethane) that still persist, bioaccumulate, and biomagnify within marine food webs. Many of these legacy pollutants are endocrine disruptors that can potentially exert adverse effects on hormonal and immune functions in humans, laboratory animals, and wildlife. In Chapter 2, McHuron and coauthors, evaluate feeding ecology as a tool for estimating contaminant exposure in coastal mammals. Chapter 3 focuses on an important class of pollutants related to oil exposure,

while Chapter 5 addresses a class of emerging pollutants, poly- and perfluoro-alkyl compounds. In Chapter 6 the impacts of the marine litter are discussed in several cetacean species.

SECTION II: EFFECTS OF TOXICOLOGIC AND CUMULATIVE STRESS ON MARINE MAMMAL HEALTH

Part 2, the most extensive of the book, is composed of eight chapters focused on the effects of toxicologic and cumulative stress on marine mammal health. Three chapters (Chapters 9–11) review new technologies for monitoring marine mammal health, from biochemical and gene expression biomarkers to omics techniques. In Chapter 12, the authors report a new approach to evaluate the immunotoxic effects of environmental pollutants in marine mammals. Chapter 13 proceeds to describe ecotoxicologic stressors in Arctic marine mammals, with a particular focus on polar bears. The toxicologic risks and considerations associated with lipophilic contaminant burdens of Mysticetes in Antarctic ecosystems are dealt with in Chapter 14. The authors of Chapter 15 report on the emerging pathogens and stress syndromes in cetaceans in European waters, especially cumulative effects. Part 2 is completed with Chapter 16, in which the ecotoxicology of the Sirenia is presented as a case study of cumulative stress in marine mammals.

SECTION III: IMPLICATION FOR MONITORING AND CONSERVATION OF MARINE MAMMALS

The third and final section of the book is composed by one concluding chapter that explores in detail the implications of the previous chapters for monitoring and conservation of marine mammals.

Chapter 17, written by Simmonds, provides a final overview of multiple stressor effects in marine mammals and the implications for conservation and policy. The author states that marine mammals face many threats in the 21st century, and a comprehensive description is provided of these threats and some of the efforts to try to study their combined effects. This draws mainly on work undertaken under the auspices of the International Whaling Commission and, most recently, the US National Academies of Sciences, Engineering, and Medicine.

The consideration of combined or cumulative effects is complex, but progress is being made, leading potentially to improved conservation policy. However, the pathway from better scientific understanding to real conservation action in the field is frequently difficult. In addition, the potential of veterinary sciences, including health studies of wild animal populations, to identify problems is noted, and a cross-fertilization between conventional conservation approaches and wild animal "welfare science" is encouraged.

The challenges inherent in addressing multiple stressors make the need for precaution in marine mammal matters all the greater. However, for decision-makers to properly respond to complexity, they need to have the limitations of science clearly and honestly explained.

In summary, this book provides an important contribution to the investigation of the status of the world's seas and oceans, and the marine mammals that live within them. Hopefully, it will be a useful guide for those working in this research area and help to generate further interest in the practical management and conservation of marine mammals, seas, and oceans.

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