Preface

Most of the chapters of this book were presented as oral communications at the Seasink conference that was held at University Fernando Pessoa, Oporto, Portugal, between the 26th and the 28th of June 2008. The main objective of this conference was to discuss the role of the oceans as a sink for most of the residues from human activities. The conference had several sessions devoted to such topics as organic and inorganic compounds and their effects, global changes, regional approaches to pollution problems and future prospects with respect to the assessment of human impacts upon the marine environment. Some time before the conference, we were invited by Springer to prepare a book on part of the conference topics. Considering the communications presented at the conference and the actuality of issues related to climate change and all its direct and indirect effects upon the oceans, it seemed a good opportunity to prepare a book about the role of the oceans as a carbon sink. In the 2007 synthesis report prepared by the Intergovernmental Panel on Climate Change (IPCC) it is stated that:

> Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level

In spite of the fact that some people within the scientific community remain skeptical about the causes and the relevance of climate change patterns, there seems to be, at least, a reasonable doubt about its existence and its consequences upon the biosphere. Therefore, it seems reasonable to follow the precautionary principle and try to anticipate and mitigate those consequences. Historically, there is an important time lag between the environmental alerts raised by the scientific community and the political response of human society to those alerts, as discussed in the book "Limits to Growth" by Meadows et al., published in 2004. It is perhaps time to reduce the mentioned time lag and we hope that this book may give a small, yet honest contribution to it.

Globally, the oceans act as a CO_2 sink, as suggested in recent literature. However, this sink role is based on the quantification of CO_2 air–sea exchanges with a low spatial resolution. An important issue is quantifying the source/sink CO_2 role of continental shelves, mostly in near shore urban and industrial high density areas, which emit CO_2 more intensely to the atmosphere. It has been suggested that worldwide the

continental shelf acts as a very important CO_2 sink – "the continental shelf pump hypothesis". However, this hypothesis deserves further investigation, due to the very low spatial and temporal resolution of available data on CO_2 fluxes and to our limited knowledge about the benthic contribution to these fluxes.

Another important issue is to understand the way in which the ocean CO_2 sink may be impacted both by increasing CO_2 levels and global warming. It is expectable that CO_2 fluxes are influenced by upwelling, land drainage, sea surface warming and pH decreasing trends. A pH variation in the ocean could have an important ecological impact as a result of changes in the marine ecosystem and biogeochemical cycles of the elements. Processes that may be changed include organism calcification, carbon and nutrient assimilation, primary production and trace metal speciation. Physiologic and biogeochemical processes tend to be temperature dependent and, therefore, increasing temperature may induce changes in those processes and, consequently, on biologic consumption/production CO_2 processes. Changing temperature may lead to changes in the geographic ranges of several species with potentially important feedbacks to the carbon biogeochemical cycle as well. Furthermore, on one hand, increasing temperature will contribute to saturation of sea water with respect to CO_2, enhancing net efflux from the water to the atmosphere, on the other hand, the opposite effect takes place upon increase of atmospheric CO_2 levels. The awareness raised by the consequences of increasing the so-called greenhouse gases is stimulating the development of several carbon dioxide sequestration technologies and there is already a European directive (Directive 2009/31/EC of the European Parliament and of the council of 23 April 2009) regulating the application of geological storage of carbon dioxide. It is expected that oceans will be used as a ground for some of the mentioned technologies and it is important to anticipate their potential impacts.

This book is divided in eight chapters. Chapter 1 describes the climate variability in the north-western Iberian Peninsula during the last deglaciation, based on a high-resolution pollen analysis in cores retrieved from the Douro estuary and it is also a contribution towards chronologically synchronizing data sets from different origins. It is important to have knowledge about natural and human-induced climate variability to improve projections of future climate changes. Chapter 2 addresses the potential impact of carbon dioxide from a large metropolitan area over the adjacent coastal zone, using an atmospheric dispersion model, and it stresses the importance of having high resolution atmospheric carbon dioxide data to estimate accurately air–sea CO_2 exchanges. Chapter 3 is an in-depth review of present- day carbon dioxide fluxes in the coastal ocean and their potential feedbacks under global climate change, emphasizing the role of coastal oceans as a CO_2 sink and their vulnerability to climate change. Chapter 4 addresses some detailed aspects of phytoplankton community responses to climate change with emphasis on decreasing pH trends in sea water and its ecological effects. Chapter 5 discusses pH decrease and its effects on sea-water chemistry from a 10 year time-series at the ESTOC station, located approximately 100 km north of the islands of Gran Canaria and Tenerife. Chapter 6 presents results on the effect of pH decreases on metal bioaccumulation in the sediments. Chapter 7 analyses possible consequences of

increasing temperatures and pH changes on contaminant cycling. Finally, Chapter 8 presents an application of the Weight-of-Evidence approach for environmental quality assessment regarding the geological sequestration of CO_2 in sediments above sub-seabed geological formations to determine effects of possible leaks.

Results presented and discussed in the chapters of this book suggest that important changes may be occurring in the oceans, as a result of the carbon dioxide increase in the atmosphere, and point to possible effects of these changes over the next decades and their complex synergies with physical, chemical, biological and ecotoxicological phenomena. Furthermore, some of the chapters draw our attention to the necessary precautions regarding the application of some of the technologies used to mitigate problems arising from CO_2 increase in the atmosphere. In synthesis, the contents of this book draw our attention to the importance of dealing with observed global change trends and their effects upon the oceans using an interdisciplinary approach due to their complexity and interlinks between different areas of knowledge.

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