PREFACE

Zooplankton organisms comprise very important elements of the structure and function of marine and freshwater ecosystems, not only as consumers of primary production grazing on algae, bacteria, protozoa and other invertebrates, but also as food items for juvenile stages of several fish species. Moreover, its strategic position in the aquatic ecosystems, as well as its sensitivity to both man-made and natural changes, makes zooplankton quite suitable for assessing alterations in the trophic dynamics and the ecological state of aquatic ecosystems related to changes in nutrient loading and climate. In this sense, changes in zooplankton abundance, species diversity and community composition can provide important indications of environmental change or disturbance. However, multiscale, spatial and temporal relationships between zooplankton variability and environmental heterogeneity are still not satisfactorily understood, due to the complexity of the different aquatic ecosystems (considering both biotic and abiotic elements), along with the global climate change. Thus, it is important to investigate the main factors that may govern the biology and ecology of these organisms, in order to have a better possibility to predict future changes, which might influence the biodiversity worldwide. The ambition of the present edition is to contribute to the understanding of the role of zooplankton by investigating ecological aspects such as the species diversity, their spatial distribution and seasonal dynamics in relation to the environmental influence in various aquatic ecosystems around the world.

Chapter 1 is dealing with the understanding of the role of zooplankton in transfer of pollutants through trophic food webs. Zooplankton is a group of organisms of key importance in regulating patterns and mechanisms through which matter, energy and pollutants are transferred from the base to the upper

levels of food webs. Even if regarded as a homogeneous compartment, in reality zooplankton is composed by organisms which differ substantially one from each other, not only in their taxonomy, but also in body size, metabolic rates and ecological roles. While heterogeneity of the zooplankton compartment has been quite well documented in basic ecological studies, it is often overlooked in ecotoxicological ones, models in particular, which are usually mainly focused on sources and on top-levels of pollution patterns, the latter being directly related to human health. Such approach where intermediate steps are poorly considered, however, may result in detection of anomalous concentrations of toxicants in top-levels of the food chain, and in missing the essential links responsible for patterns and mechanisms of biomagnification. In the present chapter, the intension was to provide evidence for the need to incorporate into ecotoxicological studies, concepts and approaches developed in zooplankton ecology, not least the fact that zooplankton is made up by two hierarchical levels, or ecological roles, of primary and secondary consumers. By applying this perspective, it would be able to address mechanisms responsible for temporary mismatches and anomalies in concentration of pollutants, as a consequence of changes in space and time of these two hierarchical levels within the zooplankton community.

Red tides are remarkable phenomena implying sudden density increases ('blooms') of certain phytoplankton species and the subsequent toxin release from the phytoplankton cells, which can cause serious effects in the aquatic organisms. Chapter 2 focuses on mathematical modeling of plankton. First there is a review on few mathematical systems for plankton dynamics that have recently been proposed in the literature, in particular focusing on models for toxin producing phytoplankton. Then, new mechanisms are proposed that may possibly explain the toxin release as a phytoplankton reaction to zooplankton attacks, giving thus new material for testing to field marine biologists. In particular, three new models were introduced and compared in order to assess under what conditions red tides may occur. Specifically, the authors explore the possibility that phytoplankton specimens gather together for defense purposes, and then release the toxin through the surface of these agglomerates. The models suitably take into account this mechanism as well as the possible effects on zooplankton. A final discussion summarizes the results and compares the findings on the three models among themselves and with the earlier findings in the literature.

In Chapter 3, the authors evaluated the effect of inputs of nutrients, mainly nitrogen and phosphorus, on the structure of the zooplankton community, including diversity, evenness, dominance and richness, in a tropical reservoir

(Pampulha Reservoir) in the city of Belo Horizonte, Brazil. A series of thematic maps was used to describe the horizontal distribution of some variables and to examine whether areas with higher nutrient concentrations are associated with increases in dominance and decreases in diversity and species richness. The samples were taken on 15 September 2009 at 23 sampling stations, covering the entire reservoir. A spatial analysis showed that the species richness gradually decreased in those sites where increased nutrients and several highly opportunistic species increased in density along this same spatial gradient (such as *Thermocyclops decipiens*, *Metacyclops mendocinus* and *Brachionus calyciflorus*). Thematic maps showed that areas with higher nutrient concentrations were associated with increases in dominance and decreases in diversity and species richness. Finally, establishing the horizontal distribution patterns of zooplankton organisms in a reservoir allow the authors to perform a detailed ecological zonation of the water body and one of the most interesting applications of this zonation is the identification of ecological gradients related to pollution sources.

Chapter 4 provides elements on the community structure, the spatial and seasonal variation and the relation of zooplankton to environmental parameters in five Greek lakes through an extensive investigation between 2003 and 2010. In particular, the studies were conducted in four natural lakes (Trichonis, Amvrakia, Lysimachia and Ozeros) and one reservoir (Stratos). Zooplankton surveys of 12 to 24 months were conducted in all ecosystems, while at the same time the most important physicochemical parameters were recorded. The number of species in the five lakes varied between 25 (Lake Ozeros) and 36 (Lake Lysimachia). The general similarities in species composition in the five lakes can be attributed to their common geological origin, while differences among them are ought either to geographical isolation, to the particular water chemistry, or to their trophic state. The group of copepods, and especially the calanoid *Eudiaptomus drieschi*, dominated the zooplankton community in the oligotrophic Trichonis Lake, the oligo-mesotrophic Amvrakia Lake and the meso- eutrophic Ozeros Lake. Instead, the group of rotifers dominated in the eutrophic Lysimachia Lake and in Stratos reservoir. The cladoceran species presented clear seasonal dominance succession patterns, with *Bosmina longirostris* and *Diaphanosoma orghidani* occupying the greatest percentage in winter and summer months, respectively. The larvae of the mollusk *Dreissena blanci* were important constituent on the zooplankton community in most of the lakes, except Lysimachia. In the deep lakes Trichonis and Amvrakia, the higher zooplankton density was recorded in the surface 0–20 m layer and was decreasing with depth, while small numbers of zooplankton

specimens were found also in the hypoxic/anoxic hypolimnion of the latter lake. The vertical separation of the numerically most important species of crustaceans and rotifers is attributed possibly to the reduction of intra- and inter-specific competition. Temperature was the most important environmental parameter for most of the species variation, while other elements like dissolved oxygen, water level fluctuation, conductivity, chlorophyll-a and nutrients concentration played also important role in the zooplankton spatial and temporal distribution in the five lakes.

Chapter 5 is dealing with a zooplankton community in a particular freshwater ecosystem such is the cooling reservoir of the Beloyarskaya Nuclear Power Station (BNPS) in the Middle Urals. In particular, this chapter reports the results of an extended investigation (1986–2011) on the state of the zooplankton complex, focusing on species characteristics and their capacity to accumulate radionuclides and microelements from the water of this reservoir. The zooplankton species composition, abundance and biomass were investigated in four zones of the reservoir: the heated water discharge zone, the discharge and water intake channels, the control region and the central water area. In the observation zones the investigated parameters were different. Thus, in Teplyi Bay and in the discharge channel adjacent to the power station the abundance and biomass of zooplankton were much lower after its entrance through the cooling system of the station. The analysis of mortality among the predominant species evidenced of the greater sensitivity to injuring factors of copepods in comparison to cladocerans. The main attention was paid to the water discharge channel through which low-radioactive water was discharged into the cooling reservoir. The quantity of radioactive pollutants entering the cooling reservoir together with zooplankton was estimated. The investigation of the accumulation levels of ^{90}Sr and ^{137}Cs in the zooplankton, as well as in other hydrobionts and in the sediment, showed considerably higher accumulation coefficients in the case of phyto- and zooplankton in comparison to fish species, mollusks and the sediment. The accumulation coefficients of 70 chemical elements in the zooplankton ranged from 10^2 to 10^7. A significant positive correlation between the concentrations of chemical elements in zooplankton and the water medium indicated that zooplankton generally reflected the chemical composition of its habitat and responds quickly to changes in the chemical composition of the water. Thus, zooplankton can be considered as a highly sensitive biogeochemical indicator of water pollution with heavy metals and radionuclides.

Some aspects of the spatio-temporal dynamics of certain zooplankton groups (Cladocera, Copepoda) in the Danube River were investigated in Chapter 6. Despite rapidly growing insights into zooplankton spatio-temporal dynamics in lotic environments, syntheses of prior case studies have not yet been given much effort. Thus, in this chapter the authors aimed to assemble the pieces of some of their previous case studies performed in the Danube River near Budapest and to put all those findings into a more coherent framework. It is pointed that these studies do not cover the full range of dimensions affecting microcrustacean dynamics and diversity in the river, but rather demonstrate a representative subset of spatio-temporal aspects of microcrustacean dynamics. The chapter discusses the horizontal variation of crustacean zooplankton abundance across the river channel and demonstrates that different taxonomic and life-history clusters exhibit various patterns. The complex interactive effects of the flow regime with nutrient inputs on riverine zooplankton are discussed on the example of the waste water discharges entering the river at Budapest. The short-term variation of microcrustacean dynamics on the basis of samples collected on a daily basis was demonstrated. This sampling design allowed for testing the effects of sampling effort and sampling frequency on the estimation of the composition and abundance of microcrustacean assemblages in a side arm of the river. Furthermore, the authors discuss the possible effects of climate change on microcrustacean dynamics by means of a simple simulation model. Finally, a list of recommendations is given as how to improve the understanding in this evergreen field of limnology.

Chapter 7 is dealing with the abundance and trophic position of gelatinous zooplankton in a productive marine area such as the Namibian upwelling region in the west coast of South Africa. In this investigation the term "gelatinous zooplankton" is used for Coelenterata only, such as Cnidaria and Ctenophora. These carnivorous gelatinous organisms mainly feeding on zooplankton, fish larvae and small fishes and are considered as end members of the food web as they are only eaten by a few species like some fishes, other cnidarians and sea turtles. Since the 1970's the abundance of large gelatinous zooplankton increased in the northern Benguela probably due to overfishing and/or climate change. Although several papers about the taxonomy and ecology of gelatinous zooplankton in the northern Benguela region exist, data on the vertical and horizontal distribution of small Medusae and their role in food web dynamics are still limited. Only the distributions of large jellyfish like *Chrysaora* spp. and *Aequorea* spp. were examined in several studies, as well as the effects of advective processes on gelatinous zooplankton. Thus,

this chapter presents data about the onshore/offshore and vertical distribution as well as the taxonomical composition of these organisms in the northern Benguela Current System. Furthermore, it provides insights into their trophic position using a stable isotope analysis. Samples were taken with a multiple opening and closing net in March 2008 and in December 2009 along a transect off Walvis Bay (Namibia) from the shelf towards the open ocean. Additional samples were taken with different types of gears at several stations in the northern Benguela for stable carbon and nitrogen isotope analyses in December 2009. The taxonomical composition of all groups revealed an inshore/offshore gradient with higher diversity offshore. Medusae and Siphonophora were treated separately since Siphonophora live in colonies which break into pieces when caught by nets. Medusae were generally smaller in size at the offshore station, whereas no size distribution gradient was found for the single individuals of Siphonophora. The numerical abundance of both Medusae and Siphonophora parts were variable along the onshore-offshore transect. Within the Medusae, Trachymedusae dominated the offshore system and Leptomedusae the inshore system. Within the Siphonophora, the system was dominated by Diphyidae in offshore and costal waters and on the inner shelf in 2008 and by Agalmatidae at the slope, shelf-break, outer shelf and inner shelf in 2009. A heterotrophic level of two and higher was calculated for the gelatinous zooplankton.

Finally, Chapter 8 is dealing with the seasonal dynamics of a zooplankton community in a particular environment such as a man-made solar saltern (Sfax solar saltern in Tunisia), as well as with the interrelation with the environmental parameters. Sfax solar saltern is an artificial system formed of interconnecting ponds of different salinity extending over an area of about 1500 ha, along the coast to the south of the town of Sfax (Tunisia) over a distance of 12 km. In this area, four ponds of increasing salinity (A1: 41 psu; A5: 46 psu; A16: 67 psu; and C31: 77 psu) were selected to be the study sites for the investigation of the seasonal distribution of zooplankton abundance, along with the environmental factors. Measurements were taken monthly, during a year (September 2007 to August 2008). A total of 21 zooplankton taxa, belonging to copepoda (17 species), rotifera (3 species), cladocera (1 species) and other zooplankters, were identified. Copepoda was the dominant group in all sampling ponds and accounted for 65% of the total zooplankton density in the Sfax solar saltern. The results showed that salinity differ significantly among the four ponds and that the zooplankton abundance decreased with increasing salinity of the ponds. However, the highest density of total zooplankton (70.76×10^4 ind.m^{-3}) the author recorded in the first pond

A1. Differences in the density of zooplankton were found between ponds. The density of total zooplankton as well as of copepods and rotifers were negatively correlated with salinity, while positively correlated with total phosphorus. In conclusion, in this particular ecosystem, spatial and temporal variations in zooplankton abundance can be related to the environmental variability, while salinity seems to play the major role in determining spatial and temporal patterns.