PREFACE

Marine Benthos: Biology, Ecosystem Functions and Environmental Impact is a book dedicated to show a series of case studies about how benthic habitats are organized and how they function as a tool for any environmental impact studies. The present book documents how the natural condition of these communities is and aims to expand the authors' present knowledge about their organization. The human population growth is driving a very strong pressure over coastal areas, and now more than ever the author urgently need elements to evaluate environmental impacts. One of the most striking situations is the loss of biodiversity and the increase of invasive species who modify the trophic networks as well as the community structure. Many endangered species and species related to fisheries depend on the benthic habitat for their basic life cycle stages (reproduction, recruitment, nursery and feeding grounds) who might be impacted by natural and human induced causes. Ranging from species richness studies to population and community structure chapters, this book will bring the reader many options on how to measure environmental impacts. In particular, an analysis of how these environmental studies are made in Mexico provided a good example of how the present report base model is overdue and expresses the need for another approach. Keep in mind the present model does not take into account any statistical approach and is not mandatory in terms of the synergic and accumulative impacts; the lack of this consistency makes evaluation impossible to tell if the impacts are really happening.

Chapter 1 - The Gulf of California comprises a great diversity of benthic ecosystems. The western coast in particular is dominated by rocky and coral reefs that shelter a wide diversity and abundance of species. Despite the importance of benthic ecosystems for the structure and organization of associated communities, few studies have focused on the importance of benthos in the trophic organization of the fish community. In this chapter the fish communities of four areas of the Los Frailes rocky reef differing in benthic structural complexity (BSC) were evaluated through visual censuses. According to the BSC two low benthic structural complexity (LBSC) areas and two high complexity (HBSC) areas were identified. The HBSC areas had a higher number of cavities, greater depth and greater substrate heterogeneity. However, despite differences in structural complexity, the trophic organization of the ichthyofauna did not show significant changes in terms of formation of functional trophic groups (FTG) between the HBSC (21 FTG) and LBSC (19 FTG) locations. The biomass flow diagram of the different prey species of carnivorous, omnivorous and herbivorous fish present in the reef showed variable connections and biomass flow, with

dominance of benthic prey species, which highlights the importance of benthic invertebrates as a source of energy for the reef ichthyofauna.

Chapter 2 - The Mexican Caribbean and the Atlantic coast of Mexico have 3,294 km of coastline with diverse habitats and rich biota. Coastal ecosystems, unfortunately, are experiencing wide range of pressures due to siltation, eutrophication, coastal development and climate change. Those species that adapt to these pressures will expand their living boundaries while others may fade away. Accordingly, the study of coastal biodiversity is of great concern globally and constitutes an important element of global change research. Peninsula of Yucatan has 1,940 km of coastline, reportedly with rich diversity of seaweeds. Previously published accounts on seaweed biodiversity were mainly in the form of checklists. The present study is a timely publication based wholly on primary data. Data were collected through extensive and systematic field studies conducted by the authors during different seasons over an eleven years period since 2004 to 2014, also the authors checked herbarium's specimens that are housed in the herbarium ENCB. Analysis of the information showed that Rhodophyta has the greatest diversity with 317 species; Chlorophyta has 180; Phaeophyceae 70 and finally Cyanobacteria with 38 species. One of the groups best represented in the study area is the Order Corallinales with two families and 43 species, these organisms are of major ecological importance in the reefs of the Peninsula. Three species are new records from Mexican Caribbean, *Centroceras hyalacanthum*, *Metapeyssonnelia tangerina* and *Sarcodiotheca divaricate*, and sixteen species are new records for the study area The importance of epiphytic algae in the study area is discussed as well as the use of molecular markers in order to solve taxonomic problems of selected genera of algae. The floristic list includes data on distribution, tidal level and habitat. On the other hand Quintana Roo is the state that has the greatest diversity of marine algae in the Gulf of Mexico and Mexican Caribbean's shores with 551 species. Topics on economic importance and extraction of bioactive substances are discussed, as well as suggestions on conservation of seaweeds from Yucatan Peninsula. Finally, several coastal towns in the Yucatan Peninsula are being impacted by natural events such as hurricanes as well as urban; tourism and industrial development, so it is important continue studies that allow us to characterize the changes that populations of seaweeds are undergoing.

Chapter 3 - Rocky shores are areas of high diversity and productivity providing goods and services. Since humans are altering nature at an unprecedented rate, producing shifts in important parameters for life such as temperature, habitat availability, water quality, among others, it is expected that species will respond by changing their natural distributions and/or abundances. To understand how species will respond to such changes, it is necessary to learn the processes that determine these patterns. The South American Research Group on Coastal Ecosystems was established to assess marine diversity and biomass along both coasts of South America through an international collaboration. The main goals of SARCE are to: (1) Test hypotheses about latitudinal gradients and patterns of local and regional biodiversity, (2) Identify the relationship between biodiversity and ecosystem functioning, (3) Assess the effect of environmental gradients and anthropogenic stressors, (4) Carry out capacity building and training activities aimed to solve environmental problems for the benefit of society. The SARCE network has sampled the coasts of nine countries around South America with a standardized protocol in more than 150 sites (2010-2014), ranging from 11° North to 55° South. This chapter provides a description of the biodiversity of the sites sampled by SARCE,

along with a review of the uses and services that these ecosystems provide to human populations and the main threats and impacts these uses have caused.

Chapter 4 - *Acanthophora spicifera* is a red algae, native to the Caribbean, was introduced to the Hawaiian Islands in the early 1950's, where he Invasive catalog. His success as an invader is attributed to having the ability to reproduce both sexually and vegetatively by fragmentation or by spores. Their growth is accelerated and invades Pacific coral reefs. Prevents nutrients and sunlight to penetrate these ecosystems producing that reduce populations of resident seaweeds and corals. In Punta Roca Caimancito, BCS, a blanket of *A. spicifera*, which formerly dominated the brown algae of the genus Sargassum found. The temperature at which develops in Punta Roca Caimancito was 20-29. It can be found growing on a variety of substrates epilithic hard rock, dead coral or shells, even as an epiphyte on other species of macroalgae or epizoica invertebrates. They have a simpodial and apical growth, presents secondary branches, has a rough or rough texture, has a disk-shaped, in its main axis no thorns. It is characterized by a highly branched and bushy, leafy thallus. Apical meristem, spines of 3 mm, which may vary morphologically. In cross-section was observed that pericentral cells are dense. Commonly axial cells in the center. In the study area this invasive algae reproduces asexually (fragmentation). The extension of the mantle in Punta Roca Caimancito of has continued to increase since 2006 in which you registered for the first time. The current extension (2009) is 31536.93m^2 or 3.16 Hectares. The maximum average biomass dry weight was 8.12 t/ha and 3.16 minimum 1.18 Ton/3.16 h. The color varies from brown to red. The average length of the thalli was 163 mm and 108 mm maximum minimum in the period October 2008 to October 2009. The annual average was 154 mm. The ANOVA showed differences between different months being October others to present longer that season. The maximum number of branches value was 7 and at least 5 branches per thallus. ANOVA performed for the numbers of branches not show significant differences. The average monthly number of spines has a maximum value of 5.4 mm^2 and a minimum of 3.9 mm^2. The ANOVA shows differences per month, October being the one with the highest number of spines. The biomass is higher in the autumn season. And in winter drastically reduces the population. The average of the highest biomass is 0.26 kg/m^2 and was presented in November; the minimum dry weight biomass was presented in February 0.0375 kg/m^2. The average annual biomass dry weight is 0.29 kg/m^2. The flora and fauna that was associated with *A. spicifera* goes from epiphytic algae molluscs, echinoderms, sponges to fish. The maximum monthly average was 0.20 kg/m^2 and a minimum of 0.031 kg/m^2. The result of the correlation indicates no relationship between biomass and plant-fauna (r = -0.1892.). The authors conclude that *A. spicifera* its development at temperatures ranging from 20-29°C. Morphological characters posing *A. spicifera* of Punta Roca Caimancito are similar to those reported by other authors. The main mode of reproduction of *A. spicifera* is asexually by fragmentation and occurs all year round (perennial). Sexual reproduction was limited in spring-summer, only empty conceptáculos were observed. Presents greater lengths during autumn and lower in winter. The number of spines is not related to the length of the branch. The maximum number of branches was 7 in autumn and winter and minimum of 4 branches per talo in summer. The maximum number of thorns thorns was 5.4 mm-2 and the minimum was 3.9 mm^{-2} spines. The percentage of wet weight biomass of *A. spicifera* is greater in autumn with 3.50 kg/m^2 and the lowest was in winter with 0.59 kg/m^2. The percentage of biomass dry weight of *A. spicifera* is greater in autumn with 0.86 kg/m^2 and the lowest was in winter with 0.0375 kg/m^2. The impact of *A. spicifera* in Punta Roca Caimancito is negative

for coral reefs because high densities of this algae can affect the uptake of light and nutrients and thus affect their growth.

Chapter 5 - The twin island state of Trinidad and Tobago is the Caribbean's southern-most island state located between 10^0 to 11^0 North latitude and 60^0 to 61^0 West longitude. Like most of the Caribbean small-island states, Trinidad and Tobago's coastal waters are an economically important natural resource and at the same time, a vulnerable one. Trinidad and Tobago is a producer of oil and natural gas with the energy sector being by far, the most important contributor to the country's GDP, Government revenues and foreign exchange. Crude oil production averaged 122,902 barrels per day (bbl/d) in 2004, while natural gas production averaged 2,938 million standard cubic feet per day (Ministry of Planning and Development Central Statistical Office, 2007). The petrochemical sector (at Point Lisas Industrial Estate, west coast of Trinidad) has continued to expand in line with natural gas production producing methanol, ammonia, urea, and natural gas liquids. In this respect, Trinidad and Tobago is the 5th largest exporter of liquid nitrogen gas (LNG) in the world, and the single largest supplier of LNG to the U.S.A. (between 70-75% of all LNG imported into the U.S.A, Ministry of Planning and Development Central Statistical Office, 2007). Coupled with this, La Brea on the south-west coast of Trinidad is home to the world famous Asphalt or Pitch Lake. This coastal area in Trinidad has one of the highest known natural seepage rates on earth - an estimated 100 barrels per dy per 2560 km^2.

Chapter 6 – The authors examined the possibility of using the length of the outermost sheath (OSL) to predict values of different variables of *Zostera marina* (eelgrass), as the authors' previous observations indicated a strong correspondence between eelgrass length structures (leaves and sheaths) and its biological and morphometric variables, i.e., growth, production, and leaf area. The authors first determined leaf growth and production by means of the Ibarra-Obando and Boudouresque (1994) technique, and then used correlation matrixes to explore the relationship between length of shoot leaves and sheaths, and the following variables: shoot growth (SG), leaf production (LP), shoot weight (SW = sum of weights of all leaves and sheaths in a shoot), and shoot leaf area (SLA) in order to predict them, based on a single shoot structure easy to measure in the field. The authors' results indicate that the OSL is a reliable and easy technique to measure a variable that can be used to predict the variables mentioned above on two-week and monthly periods. Then the authors must emphasize the importance to developing predictive equations for each study region as the only way to prevent over or underestimation of the variables of interest.

Chapter 7 - The geographic and bathymetric patterns of distribution of *Nephropsis occidentalis*, the only marine decapod crustacean of the infraorden Astacidea known from the eastern Pacific Ocean, were studied on the continental slope off the Mexican Pacific, and environmental drivers of those patterns were investigated. Samplings were performed using an Agassiz dredge and a benthic sledge in three main areas: the Gulf of California, the west coast of the Baja California Peninsula and the southern Mexican Pacific. Twelve sampling cruises were performed from 1991 to 2014, by which 171 hauls were obtained between 522 and 2309 m. Temperature, oxygen, salinity and total organic matter from sediments were sampled simultaneously, and data of surface production were recorded. The relationship between the patterns in abundance of *N. occidentalis* and potential environmental drivers was explored through generalised linear models. In addition, all previously published and unpublished records of the species were compiled and bathymetric patterns of distribution along latitude were explored. Within Mexico, 85 specimens of *N. occidentalis* were captured

over a narrow bathymetric range, mainly between 1000 and 1300 m, at oxygen concentrations above hypoxia. Because of its high level of activity, this species is likely excluded from hypoxic waters. Males and females were of similar size and larger individuals were restricted to depths greater than 1100 m. The bathymetric patterns of distribution of *N. occidentalis* were associated with oxygen and temperature, probably because of the interdependence between aerobic capacity and temperature tolerance in ectothermic animals. In addition, surface production enhanced aggregations of *N. occidentalis* four months later. In the Mexican Pacific, *N. occidentalis* occurs in environmental conditions with 0.22-0.87 ml O_2 l^{-1} and 3.4-4.4°C. Including unpublished records, a total of 61 localities where the species occurs were compiled and a continuous distribution of *N. occidentalis* along the continental slope of the Eastern Pacific from Mexico (ca. 27°N) to Chile (ca. 33°S) was confirmed. The first depth of appearance of *N. occidentalis* slightly decreased southwards and somehow followed the bathymetric distribution of the OMZ, thus confirming the effects of such structure on the distribution of the species. Finally, fishery potential of the species is briefly addressed and compared to what is known about similar deep-water species worldwide.

Chapter 8 - Sea turtles are migratory vertebrates that are linked to many coastal and marine habitats in different parts of the world depending on the stage of their life cycle. These agencies have given them a higher value as a sentinel species by characteristics such as longevity, size, resilience to environmental changes of the seas, and even changes induced by humans as environmental pollution. One of the main risks to sea turtles is drowning in gill nets or trawl fisheries used in flake or shrimp; it has been extensively analyzed in different regions of the country and the world. However, the effects of environmental pollution on the health of sea turtles is the least studied. The environment has been altered dramatically in recent years by rising temperatures, increased severity, and frequency of storms and rising sea level, where most human settlements have been deforested and changed land use for urban, port and tourist developments. In the case of turtles, these changes affect species differentially throughout his life. For example, climate change and temperature variations can affect the sex ratio of the hatchlings and nesting patterns since they depend on healthy beaches to lay eggs, so the migration patterns of females could be affected significantly by climate change. The dependence of sea turtles of seagrass meadows, mangrove forest, rhodolith beds, Sargassum forest, coral reefs and deep ocean to live, give them the importance of indicators of the environmental health of these ecosystems. Understanding how pollution and climate change may affect these ecosystems not only benefit conservation programs of populations of sea turtles, but also the diversity associated with them. On which they depend on millions of people living along the shores of the world using marine resources and ecosystem services for their economic activities and food safety.

Chapter 9 - Mollusks mesograzers are an important ecological factor in subtidal environments. The authors analyzed conspicuous habitats from Gulf of California and Mexican Pacific littoral in northwest to answer: 1) How are formed the associated mollusks assemblages? 2) Is taxocenosis structure maintained over time and space inside habitats? 3) How does biodiversity change between habitats? Mollusks were found in critical habitats *Zostera marina*, rhodoliths and *Sargassum* forest, and invasive red seaweed *Acanthophora spicifera*. The authors made clusters about their presence in different geographical sectors and surveys using qualitative and quantitative data. 75 small species were recorded. Rhodoliths was the habitat with higher richness (25) and diversity, as well eelgrass beds (24). The grouping shows one assemblage that contains localities with eelgrass, the second rhodoliths,

and the third seaweeds. Small gastropods *Acteocina*, *Alabama,* and *Barleeia* were essential components in all hosts. The structure changed over time and between habitats. Results suggest similar assemblages in eelgrasses and distant regards brown/red seaweeds as well rhodolith beds. This study highlights the importance of *Zostera marina* beds by evidence of similarity even localities inside and outside gulf; coralline beds by preserving atypical diversity and brown/red seaweeds as transitional microhabitats and temporary corridors subject to further change. These interactions are more complex than estimated, but this contribution helps to understand these critical habitats as biological corridors and implications on mollusk distribution.

Chapter 10 - By means of behavioral studies it has been determined for the first time in Mexico the critical habitat of a semi-resident group of coastal dolphin *Tursiops truncatus* (bottlenose dolphin) in Ensenada de La Paz and the south-southeast of Bahia de La Paz. In this zone it is more frequent to observe small groups of mothers with calves and juvenile dolphins. Through the years it has been recorded a habitat shift of these cetaceans induced by environmental and anthropogenic factors: loss of southwest basin in Ensenada de La Paz due to silting, dredging and tropical cyclones; similarly a reduction of the feeding activity has been observed in the northwest basin due to fisheries and the increase of nautical traffic which overlaps with the main transit route of bottlenose dolphins near El Mogote, thus affecting their conduct. The disturbance could increase because of dredging realized in 2012 by the touristic development Paraiso del Mar to build a dock for a marina in El Mogote, affecting particularly zones where females teach juvenile dolphins to feed next to mangroves. Unfortunately, the ecological, social and economic importance of these coastal wetlands it is not considered, subject to a stress and risk increase in the last decades due to non-regulated deforestation and dredging, as a consequence of the mentioned touristic development for the construction of a golf course, and affecting the mangrove zone. It is imperative a decree by SEMARNAT stating Ensenada de La Paz and south of Bahía de La Paz as a critical habitat for dolphins, based on the scientific information available; given the current threats on this Ramsar site and its communities, the lack of acknowledgement as a critical zone, and the need to be included in the environmental impact evaluation for coastal developments. By including them as part of the environmental policy other species will be protected too, establishing general management plans for its conservation, building agreements with environmental authorities, researchers, government agencies, society organizations, fishermen, and general public.