PREFACE

Echinoderms play an important ecological role in marine communities, especially in relation to food chains, occupying diverse trophic levels such as herbivores, carnivores, detritivores and omnivores in the marine environment. These animals feed on many different kinds of food but the majority eat only small particles of edible matter suspended in the water or lying as detritus on the sea bottom. Although echinoderms occur at all depths from the intertidal to the abyssal zones and are present throughout all of the world's oceans, their distribution is limited by the composition and topography of the sea-bed, by temperature and pressure differences according to locality and depth, and by salinity and food supply. This book discusses echinoderms and their habitual environments as well as their reproductive biology and the ecology in which they form their habitats.

Chapter 1 - The rapid increase of marine trade and shipping imply that we are now capable of moving more organisms around the world in one month, than we used to in one century. The consequences of these marine introductions to new geographic areas not only are wide, ranging from environmental and ecosystem impacts (e.g., changes observed in the ecosystem functioning and loss of native biodiversity); to economic (e.g., damage caused to infrastructure such as fouling of pipes, etc.); and public health impacts (e.g., introduction of pathogens), as are a global issue. This review summarizes the importance of echinoderms as non-indigenous species (NIS). Past echinoderm introductions are revised. Accidental dispersal pathways by humans are identified and vectors and mechanisms of introductions are characterized in terms of relevance for echinoderm species. It is largely known that NIS not only are a cause by itself of biodiversity loss but also interact with biodiversity as a modifier factor for habitat destruction,

compromising the integrity of marine ecosystems. The total number of NIS echinoderm around the globe are about 15 species, and despite the majority of these species cannot tolerate marked changes in salinity, temperature and light intensity, they can aggregate into colonies with significant densities causing bio-erosion in the surrounding habitat. Moreover, some of the economic impacts are huge and well known, such as the introduction of *Asteria rubens* in Turkey, where it become a voracious predator of the marketable mussel *Mytilus edulis*. This review outlines the current global known non-indigenous echinoderms, their potential impacts on marine environment and associated entry vector.

Chapter 2 - Some echinoderms are benthic marine organisms that live on shallow-water habitats and for so are constantly exposed to relatively high concentrations of bacteria, viruses and fungi, some of which are pathogenic. These animals play an important ecological role in marine communities, occupying different trophic levels in aquatic food chains. Recently it was reported for the first time that *Enterococcus* spp. and *Escherichia coli* isolates from echinoderms fecal samples, recovered from Azores archipelago (Portugal), are resistant to several antibiotics frequently used in human and veterinary medicine. Also, these bacteria constitute a reservoir of antimicrobial resistance genes and for so they could play an important role in the spread of antimicrobial resistance into the environment. Similar results were reported in several other studies performed in samples from marine and terrestrial animals, targeting humans and sewage waters. Nevertheless, no further related studies were performed in echinoderms and only few studies are available in the literature on the susceptibility of marine animals to antibiotics in *Enterococcus* spp. and *E. coli* isolates. Antibiotic resistance is considered to be an ecological problem, particularly when associated with commensal bacteria from intestinal tract of several animals and humans, reveling that these antimicrobial resistant bacteria could be used as indicators of marine pollution from fecal sources. It is still not very clear how wild echinoderms which presumably were never exposed to high concentrations of antibiotics may have acquired bacteria resistant to antibiotics which are usually associated with selective pressure induced by excessive use of those antimicrobial agents. Although, it is possible that sewage discharges into the sea could be the main source of antibiotics and resistant bacteria from terrestrial sources. Resistant strains or antibiotic resistance genes could be transmitted to other wild animals, which could translate into unforeseen implications involved in the transfer through food chain to other animals or humans. Therefore, in this chapter the authors aim to discuss how resistant bacteria prevalence in

echinoderms could be explained, the indirect effects of the presence of these bacteria in marine ecosystem and the evaluation of the long term ecological consequences on the animal population living in this ecosystem.

Chapter 3 - The phylum Echinodermata constitutes a successful and widespread group comprising Asteroidea, Ophiuroidea, Echinoidea, Holothuroidea and Crinodeia. Nowadays, marine organisms are being given a lot of attention in drug discovery pipelines. In these studies, sponges and nudibranchs are frequently addressed, however an increasing number of works focus their attention in echinoderms. Given the fact that many of the bioactive molecules found in echinoderms are diet-derived, different feeding behavior and surrounding environment plays a critical role in the chemical composition of echinoderms.

In this work, the most relevant chemical classes of small molecules present in echinoderms, such as fatty acids, carotenoids and sterols will be addressed. When data is available, the influence of the environment on the chemical profile of these organisms will be discussed.

Chapter 4 - Hong Kong has a long and indented coast-line, featured by its complex hydrography. Of the twenty-one recorded sea urchin species in Hong Kong, the purple sea urchin *Anthocidaris crassispina* is the only species of commercial importance in which its gonads are considered a delicacy regionally. Over the years this species has retained the attention of researchers on its role as a dominant grazer in the regulation and maintenance of algae assemblages in distinct coastal habitats of Hong Kong. However, there is hitherto a paucity of studies examining the densities and frequency-distribution of size of individuals between contrasting local habitats. Moreover, there is no updated information available on sea urchin stocks to guide fisheries management decisions. With the environmental gradient of Hong Kong waters which provides an excellent research location for testing the hypothesis of the importance of morphological plasticity and resource allocation in response to food limitation and hyposalinity of sea urchin, a study was initiated on the sea urchins species, *A. crassispina*. Findings of a laboratorial experiment concur with field observation that both stressors had a significant negative effect on various aspects including test diameter, total weight, test weight, gonad weight and gonad index. It is revealed that *A. crassispina* has substantial adaptability to food limitation and hyposalinity, and such adaptation can have important consequences in resource allocation and body allometry. In response to hyposalinity, this species reduces test weight, thereby increasing the relative weight of the lantern. Alternatively, this species appears to allocate energy to body maintenance, rather than to

increasing the relative size of the lantern in response to food limitation, which is considered a very different strategy employed by other sea urchins. Besides, marine protected areas in Hong Kong, for example the Cape d'Aguilar Marine Reserve, are effective management measures in protecting sedentary species such as sea urchins. Lau et al., (2011) showed that *A. crassispina* populations in non-protected sites suffered from a higher mortality rate than the sea urchin population in Cape d'Aguilar. Although sea urchins in the reserve grew slower, likely due to a higher population density, the size at maturity was reached within two years. The high abundance of mature urchins may enhance their fertilization success, and promote a potential spillover effect to surrounding fished areas. Therefore, even small no-take reserves in highly disturbed coastal areas such as south China are important refugia for at least sedentary species like sea urchins.

Chapter 5 - The corallivorous crown-of-thorns starfish (*Acanthaster planci*) is perhaps one of most well known echinoderms on coral reefs, notorious for episodic population explosions and coral consumption on such unprecedented scales with major consequences to community structure. Outbreaks of *A. planci*, represent one of the most significant biological disturbances on coral reefs and remain one of the principal causes of widespread decline in live coral cover in Indo-Pacific reefs. At several locations, the effects of severe outbreaks on reef-building corals have been far greater than combined effects of all other major disturbances, including climate-induced coral bleaching. Increasing frequency and intensity of outbreak episodes have resulted in progressively slower recovery, which consequently degrades the integrity of reef ecosystems. Despite previous and ongoing efforts to control *A. planci* populations, outbreaks continue to pose serious reef management challenges. Long-term or permanent solutions depend on understanding the different biological and ecological aspects of the life history of *A. planci* to establish key limitations in recruitment and population replenishment. Outbreaks are manifestations of inherent instability within certain systems, attributed to either unique life-history features (e.g., high fecundity, short generation times, high mortality during their early life-history, and generalised patterns of prey and habitat use) which predispose *A. planci* to major fluctuations in population size, or major changes in the physical and biological environment that release populations from usual regulating factors. The three most prominent hypotheses put forward to explain outbreaks of *A. planci* all involve natural variation and constraints on the reproductive biology and early life history. The 'natural causes hypothesis' is based on the assumption that population sizes of highly fecund organisms

with planktotrophic larvae, such as *A. planci*, are inherently unstable. The 'predator removal hypothesis' suggests that *A. planci* populations are normally regulated by high rates of predation on post-settlement juvenile starfish and that outbreaks arise as a consequence of the release from predation pressure due to overharvesting of predators. The 'larval starvation hypothesis' suggests that terrestrial runoff due to heavy rainfall causes elevated nutrient levels and lead to phytoplankton blooms, which provides nutrition for otherwise starved *A. planci* larvae. These hypotheses are not always mutually exclusive and will most likely vary spatially and temporally. This chapter reviews the unique features of *A. planci* reproductive biology and early life history that make it predisposed to population fluctuations and discuss factors that regulate gametogenesis, fecundity, spawning, fertilization, larval development, and post-settlement survival. These stages of the life cycle of *A. planci* are subject to stochastic processes involving food availability, predation, disease, settlement and spawning cues, dispersal, and environmental factors. Understanding the collective response of *A. planci* to this array of factors is essential in developing strategies to manage *A. planci* populations and reverse sustained declines in coral cover.

Chapter 6 - Sublittoral rocky bottoms are prominent habitats in benthic topography along the coastline of the Aegean Sea, exhibiting high spatial complexity and supporting species-rich communities. In the shallow zone, usually up to 40 m depth, algal-dominated communities prevail. Canopy forming algae typically thrive, being replaced by turfs, coralline crusts, or even animal species of various morphological forms, depending on abiotic and/or biotic interactions. Sea urchins, as dominant grazers in those habitats, are keystone species that determine benthic community structure by controlling the transition from macroalgal beds to coralline barrens. Within this context the present study aims to integrate the results of various studies together with field data, to provide a general review about the population ecology of the most common and widespread sea urchins on algal-dominated communities in the Aegean Sea, namely *Arbacia lixula*, *Paracentrotus lividus* and *Sphaerechinus granularis*, addressing the following issues: (1) assess population density distributions across main biogeographic areas of the Aegean Sea, (2) provide density distributions with respect to prominent environmental parameters and / or fisheries, and (3) discuss the role of sea urchins in controlling benthic community structure on algal-dominated rocky shores.

Chapter 7 - Echinoderms are widely distributed in marine environments, from the coastal shore to the deep ocean. Underwater caves are an

environment with very scarce information, especially about echinoderms. In the world only two echinoderm troglobites (limited to live inside of caves) species are known, the starfish *Copidaster cavernicola* (Mexican Caribbean) and the brittle star *Amphicutis stygobita* (Bahamas). Worldwide, the El Aerolito system (Cozumel, Mexico), is the marine cave with the highest species richness (25) of echinoderms (Asteroidea, Echinoidea, Holothuroidea and Ophiuroidea).

In this study, for first time in an underwater cave was realized a quantitative ecological base line with the aim of knowing the density and dominance of the species. Echinoderms represented the dominant group with 65% of total abundance of the benthonic macro invertebrates, with a density up to 18 org/m^2. This information is antagonist with the rest of the caves, since the crustaceans are the dominant fauna with 90% of the species. The dominant species in El Aerolito is the brittle star *Ophionereis* cf. *reticulata* with an average of 45.4 org/10m^2, follow by *Ophiomusium testudo* (1.4org/10m^2) and *Asterina* cf. *pompom* (0.2org/10m^2). Also the sea urchin *Eucidaris tribuloides*, often referred to as exclusively marine, was found inhabiting at El Aerolito system living both in marine and brackish water, where it was very uncommon. This information, with continuous monitoring will allow knowing the health status of this invaluable ecosystem, to bookmarking foundations for conservation. Furthermore a bibliographic review of the echinoderms inhabiting underwater caves in the world is presented.