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Editorial

Biodiversity, Adaptation Strategies, and Opportunities in Extreme Marine Environments

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Extreme marine environments are peculiar ecosystems characterized by extremely variable and hostile physicochemical parameters. These conditions, including very low/high temperatures, hypoxia/anoxia, extreme photoperiods, and variations in salinity, pH, and pressure, are stressful for various organisms.

Although many relevant studies have already been conducted in this area, knowledge about the marine organisms that inhabit extreme habitats remains limited compared to that of organisms living in more accessible sites. In fact, the exploration of extreme marine ecosystems was only made possible within the past few decades and represents an important opportunity for new discoveries.

Experiments and analyzed data, as well as significant interest from the research community, gradually allowed us to discover the presence of huge biological and genetic diversity in extreme environments, encompassing both micro- and macroorganisms. To cope in such challenging habitats, extremophile marine organisms have evolved a set of peculiar defensive mechanisms, including both structural adaptations and the activation of metabolic pathways involved in the production of a plethora of protective molecules. Interestingly, these compounds have been shown to exert several bioactivities with possible biotechnological applications.

The aim of this Special Issue was to collect high-quality papers, including reviews and articles, directly related to various aspects of marine extreme environments, their biodiversity, perspectives, and challenges for novel products, such as marine bioactive compounds, with possible industrial applications. This Special Issue comprises 10 papers, which are primarily related to biodiversity and biotechnological applications. Studies have mainly focused on microorganisms, both bacteria and microalgae, and fish.

In their paper on bacteria, Coppola et al. [1] studied 31 UV-resistant bacteria collected from surface sea waters/ice and shallow lake sediments in Antarctica. These bacteria were isolated via UV-C assay and, successively, genetically characterized by 16S rRNA gene sequencing, thus providing information on the available species and their distribution. Twenty of these isolates were pigmented, and it was suggested that these pigments could help them to survive in Antarctic low temperatures and harmful levels of UV radiation. Meanwhile, in their work, Calogero et al. [2] focused on luminescent bacteria isolated, for the first time, from the cephalopod *Neorossia caroli* and the teleost *Chlorophthalmus agassizi* from deep sea environment. The authors obtained twenty-four luminescent isolates and also investigated their biotechnological potential by studying the production of extracellular polymeric substances (EPSs).

In their study on microalgae, Trentin and collaborators [3] focused on the biological diversity of two diatoms collected in Antarctica during the XXXIV Italian Antarctic Expedition. These diatoms were studied via morphological, 18S rDNA-rbcL-psbC sequencing, and chemical analysis, and were designated new species named *Craspedostauros ineffabilis* sp. nov. and *Craspedostauros zucchellii* sp. nov., respectively. Bazzani and collaborators [4] focused

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on the microalgae *Chlamydomonas* spp. which has adapted to live in various environments, including polar regions. In particular, they focused on salinity stress studies, considering both physiological and molecular aspects, including key responsive genes, and metabolic pathways that can be used as future biomarkers. In a subsequent study, Bazzani et al. [5] reviewed how iron limitation affects primary producers in the Southern Ocean, and synthetized the available predictions on the possible additional effects induced by climate changes.

Moreover, in this Special Issue, Lauritano and Coppola [6] reviewed bacterial and microalgal compounds of great interest for the market, which are produced as strategies implemented by microorganisms during the cold-adaptation process. In particular, they focused on polyunsaturated fatty acids, antioxidants, and antifreeze proteins, for which the compound annual growth rate is expected to increase by 5.35–36.3% in the near future.

In this Special Issue, we also published several papers on macroorganisms, which mainly focused on Antarctic fishes. In particular, Carlig et al. [7] studied six *Trematomus* species from Terra Nova Bay (Ross Sea) through feeding apparatus metrics and geometric morphometrics, showing how shape of the head differs between benthic and pelagic species; Amelio et al. [8] focused on the hemoglobin-less Antarctic teleost *Chionodraco hamatus* (icefish) and in particular, on involvement of nitric oxide in the Frank–Starling response, an intrinsic heart property; Bakiu et al. [9] studied the evolution of metallothioneins in notothenioid fish, which evolved under the selective pressure of relatively high oxygen partial pressures, cold Antarctic seawaters, and relatively high concentrations of metal ions—Cd and Cu in particular. Their analysis indicated the presence of two metallothioneins clades, suggesting that the evolution of these genes has been characterized by purifying selection.

Finally, De Falco et al. [10] reported current knowledge on miRNA-mediated responses to the extreme conditions of marine species, both micro- and macroorganisms. Information is available, for instance, for the sea snail *Littorina littorea*, the Antarctic fish *Trematomus bernacchii*, and the microalga *Dunaliella salina*.

As editors of this Special Issue, we believe that this collection of papers will provide an important reference source for researchers interested in expanding their knowledge regarding marine micro- and macroorganisms' strategies for adapting to extreme environments. These studies mainly focused on cold environments, highlighting specific adaptation features, but also suggesting the necessity of additional studies to further our knowledge of this topic.

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