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Editorial

Marine Nearshore Biodiversity: Introduction to the Special Issue

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Millions are nourished, economies are fueled, and culture is inspired—these are just a few of the extraordinary benefits stemming from the coastal waters adjoining the shorelines of the world. These nearshore waters serve as the first step to understanding the marine world, a springboard for scientific curiosity, and a gateway to less accessible oceanic spaces. The importance of the nearshore is clear by positing its benefits to society. What economies could possibly be sustained without the services provided by the nearshore? And yet with its deep history of importance and exploration, the nearshore continues to yield new insights to understanding global patterns in the distributions of algae and animals and the influence of societal interactions with them.

This Special Issue assembles pioneering research on nearshore ecosystems distributed among all world oceans, from waters spanning the Artic and Antarctic (Figure 1). These works are organized according to the major themes of biodiversity, biogeography, and species distribution, bridged by the subjects of species discovery, species loss, and habitat change. Imbedded topics relevant to the present day direct and indirect societal impacts on marine nearshore biodiversity include fishery management, coral reef biodiversity, and extinction. The use of innovative molecular tools to address taxonomic questions and biodiversity distinguishes this collection from any published before the relatively recent development of the field of metagenomics. Likewise, the advantages of global databases founded within the last 15 years, like the citizen science platform iNaturalist, are demonstrated with their application in reporting species richness in difficult environments that challenge observations. In summary, this Special Issue presents an informed overview of current and pressing topics in marine nearshore biodiversity.

Of great concern is the loss of nearshore biodiversity, and bottom-trawl fisheries using destructive catch methods have indiscriminate effects on non-target species and benthic habitats [1]. The effectiveness of fishery management in minimizing effects is examined by Fondo et al. [2] for a shallow-water bottom-trawl prawn fishery in Kenya. Nine years of catch data and four years of catch composition data following the enactment of regulations indicate their effectiveness in restraining declines in the status of the stock and integrity of the bays examined based on diversity and trophic indices. The authors highlight the benefits of technologies which reduce effects on non-target species and recommend more by-catch be retained and its economic value maximized in local markets and elsewhere.

Conceptually, marine protected areas reduce the biodiversity loss resulting from resource harvesting, whether they be commercially valuable species, minerals, or hydrocarbons [3]. Baselines of species incidence and richness are key for evaluating the effectiveness of conservation protections, and Ginsburg and Huang [4] provide an updated one for Santa Catalina Island, California. Their survey illustrates the high biodiversity of the region and identifies a number of species that are either introduced or are range shifters, and others that are vulnerable and endangered species deserving protection.

Globally abundant in nearshore coastal areas, ubiquitous, and ecologically diverse, *Roseobacter*, a marine bacterium, plays important roles in biochemical cycles and climate change [5]. Using a highly conserved gene transfer agent, the g5 gene, Zeng et al. [6]

extend the current knowledge of the biogeography of roseobacters in polar marine waters. Interestingly, bipolar distributions exist and with others endemic to either the Antarctic or Arctic. Since GTA-related gene transfer is widely considered a mechanism for maintaining metabolic flexibility in changing conditions, these discoveries may relate to the adaptation of *Roseobacter* g5 clades to polar environments.

The importance of local oceanographic features in shaping marine nearshore biodiversity cannot be overstated. In the Gulf of Maine, Trott [7] shows that the similarity of rocky intertidal species assemblages is correlated with latitude and is distinguishable into two groups that correspond with the two principal branches of the Gulf of Maine Coastal Current. Thermogeography of the nearshore is largely influenced by these hydrographic features, and the dissimilarity of the two Gulf regions is significantly related to temperature. Consequences of the rapid warming of the Gulf of Maine [8] on rocky intertidal community patterns are forecast as species range shifts and non-native species introductions disrupt assemblage composition and community dynamics.

Marine nearshore biodiversity can be difficult to estimate, particularly in subtidal habitats located in environments that challenge costs for sampling associated with accessibility, time, and expense. Adapting the rover diver method for non-destructive sampling of benthic taxa, Bravo et al. [9] successfully demonstrate the effectiveness of this sampling procedure when paired with photography in kelp forests at the sub-Antarctic Bécasses Island, located in the Beagle Channel, Argentina. Their innovative use of the citizen science platform iNaturalist to archive photographs, thus creating records of species occurrence, permits transparency in taxonomic curation and facilitates data sharing. Long-term monitoring of subtidal benthos like that associated with kelp forests, globally threatened by climate change [10], can use this approach for cost-effective surveys and reporting.

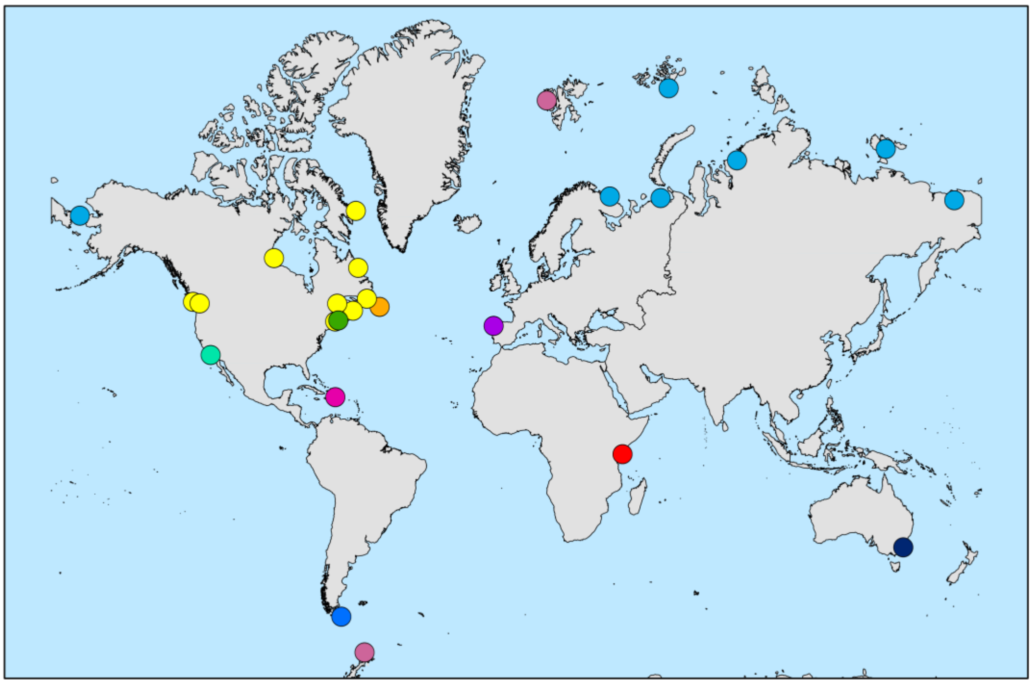

Figure 1. Nearshore study areas investigated by authors published in this Special Issue. Symbol and reference: ● [2], ● [4], ● [6], ● [7], ● [9], ● [11], ● [12], ● [13], ● [14], ● [15], ● [16].

Regional-scale management strategies to mitigate the degradation of nearshore habitats and diversity rely on similarly scaled observations and not ones from only one or a few locations. Steneck and Torres [11] present differences in trends among Caribbean coral reefs monitored for health in six regions within three sectors of the Dominican Republic coastline for 7 years. Country-wide declines in coral cover and reef fish are shown, most steep for reefs once among the Caribbean's best. However, the degree of negative trends is not the same among all sectors, a result that can steer management and continued monitoring. The abundant and increasing macroalgal cover that seriously interferes with reef recovery from disturbances could be mitigated by beneficial gains from improved fishery management.

Knowledge gaps from understudied habitats and taxa compromise the assessment of biodiversity, the detection of change, and extinction in extreme cases. Worldwide, marine flatworms, i.e., polyclads, present a prime example of this situation, where the dearth of basic ecological knowledge for this taxonomically challenging group, like habitat preferences, seriously hinders an accurate evaluation of species occurrence and richness. Tosetto et al. [12] tackle this problem in surveys of intertidal boulder beaches in southeastern Australia and report distribution patterns related to beach exposure, boulder size, and latitude. Their work constitutes one of the few studies of this kind for marine polyclads and will stimulate more investigations of these understudied predators.

There are few pan-Arctic studies focused on nearshore biodiversity. These are of particular need considering the rapid environmental alterations to polar seas resulting from climate change. With so few works to date, the scarce knowledge of this region has fueled some disagreement about nearshore community structure. Denisenko and Denisenko [13] settle a long-standing debate about the degree that bryozoans contribute to benthic biomass in coastal regions of the Arctic by evaluating samples spanning 43 years of collection throughout the Eurasian seas prior to the onset of rapid warming. They reveal biogeographic patterns in the distribution of dominant, key-biomass species related to oceanography and bottom type. The intensive coastal erosion of permafrost and consequential increase in turbidity in some regions may influence colony growth in shallow depths by interfering with suspension feeding.

Many monitoring programs aim to assess nearshore biodiversity and changes due to societal impacts, but surveys can be costly, and the taxonomic identification of retrieved organisms is time intensive. Since some habitats like hard bottom communities are difficult to sample, this problem is approached by deploying artificial substrates and monitoring their colonization. Using a cost-effective and innovative molecular approach, Leite et al. [14] compare hard-bottom macrozoobenthic species colonization of different standardized structures. They report that shape and structural complexity strongly affect colonization, with some taxa exclusively colonizing more dimensionally rich simulated seaweed. Monitoring programs using artificial structures can better assess biodiversity when habitat complexity is modelled by more than one kind of artificial substrate at a time.

Marine organisms with life histories characterized by alternation between generations with stages that are strikingly different in appearance pose challenges to ecologist and taxonomists alike, particularly when only one form is known, or each stage has been described as a different species. These situations can lead to a mismeasure of biodiversity and misrepresent biogeography. Focusing on Pacific and Atlantic Canada shores, Saunders and Brodie [15] use taxon-targeted metabarcoding to explore these domains for red algae in the order Bangiales, for which only the cryptic sporophyte (Conchocelis) stage is known. Their work extends the vertical (depth), host, and biogeographical ranges of an asexual Conchocelis-only species and uncovers known and possibly new species among their samples. Taxon-targeted metabarcoding is forecast to bring significant gains in understanding bangialean ecology and reveal its dark contribution to nearshore biodiversity.

Habitat-forming species, ecosystem engineers, enhance species colonization and increase biodiversity. Kelps, corals, and mussels are a few examples. Rhodoliths, free-living nodules of coralline red algae, can aggregate under favorable conditions to form rhodolith beds, dimensionally complex benthic habitats supporting highly diverse communities in otherwise somewhat featureless bottoms. In a sub-Arctic rhodolith bed, Bélanger and Gagnon [16] track the variability in structural complexity and macrofaunal diversity for nearly a year. In addition to relating macrofaunal diversity to rhodolith complexity, the unprecedented fine taxonomic resolution of their study supports the notion that rhodolith beds are biodiversity hotspots. Changes in macrofauna abundance are due to seasonality, but a disturbance from sporadic intensive physical forcing from storms, for example, can rework beds. The predicted intensification of wind and wave storms may pose challenges to the resilience of these biodiverse habitats.

Global biodiversity is facing an extinction crisis, the Sixth Mass Extinction [17]. But if comparisons of numbers of publications on topics make sound evaluations of importance, the wealth of papers devoted to estimating the number of species in the world oceans published in the past few decades (for examples [18,19]) assigns the topic of marine extinctions second place at best. This observation defies a common sense of importance and urgency for knowledge. Both topics confront the difficulty of observing (or not) organisms that are "hidden" beneath the ocean waves, so what makes the study of marine extinctions so different? Carlton [20] answers the hidden complexity of this otherwise simple question by providing reasons for the resistance to declare marine invertebrate species extinct. His call for inventories of globally missing marine invertebrates provides practical guidelines to sway the current state of affairs largely driven by global authority definitions of extinction and absence of evidence.

Investigations of marine nearshore biodiversity are needed now more than ever, the situation fueled by the predicted changes in ocean climates driven by societal impacts. The collection of papers in this Special Issue address many of the most vital topics related to this invitation. They provide a source of inspiration for further research to help understand and guide decisions about global changes in marine nearshore biodiversity.

Conflicts of Interest: The author declares no conflict of interest.

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