Cold-Water Coral Habitat Mapping

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Cold-water coral (CWC) habitats are considered important centers of biodiversity in the deep sea, acting as spawning grounds and feeding area for many fish and invertebrates.

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1. Introduction

It is estimated that less than 5% of the seafloor is mapped at a resolution comparable to similar studies on land [1]. However, over the last few decades, advances in new technology have enabled better exploration of the deep sea, revealing new ecosystems and environments; from micro-organisms' communities at superheated hydrothermal vents to complex, interconnected pelagic habitats. Nevertheless, such limited knowledge of the deep sea limits our capacity to predict the future response of marine organisms' to increasing human pressure and changing environmental conditions [2]. Cold-water coral (CWC) reef habitats are a remarkable example of such ecosystems found in shallow waters to more than 2 km [3]. Although corals are popularly associated with warm, tropical waters, and exotic fish, it is in the cold and dark waters of the deep ocean, that azooxanthalate CWC species develop reefs which rival their tropical counterparts in terms of species richness and diversity [4][5].

CWCs are long-lived and slow-growing cnidarians, encompassing stony corals (e.g., Scleractinia, with Desmophyllum pertusum, recently synonymized from *Lophelia pertusa* [6], *Madrepora oculata* and *Oculina* spp.), soft corals (*Octocorallia*, including "precious" corals, gorgonian sea fans, and bamboo corals), black corals (*Antipatharia*), and hydrocorals (*Stylasteridae*) (see Cairns, (2007) and Roberts et al., (2009) for a review). They grow, in general, where the interaction between topographic heterogeneity and water mass dynamics (bottom currents, internal waves) create moderate to strong hydrodynamics, coupled with the occurrence of hard substrates, a high flux of particulate organic matter (POM) and reduced terrigenous inputs [7][8][9][10][11]. Many CWCs develop calcium carbonate skeletons that trap current-suspended sediments to generate structural habitats like coral gardens, reefs, and mounds [12][13][14].

Several recent studies have highlighted the environmental importance of CWC habitats as biodiversity hotspots because they develop complex local and regional food chains, serving as important spawning, nursery, and feeding areas for a multitude of fishes and invertebrates [15][16][17][18]. In particular, they support speciose, high-biomass ecosystems at water depths where life is otherwise relatively scarce [5][19]. Since these communities live in deep, dark parts of the ocean, they possess no light-dependent symbiotic algae (azooxanthellate) and are therefore predominantly dependent on the supply of POM.

2. Significance of CWC

Nevertheless, quantitative research and process-oriented analysis that relates CWC structure, geographic distribution, and physical settings (e.g., currents, depth, temperature, geology, and ecology) are scarce due to their complex structure and limited accessibility [17]. Thus, we are still only beginning to understand the specific environmental tolerances of CWCs. It is evident that there are large knowledge gaps which need to be filled by further mapping and integrated, multidisciplinary, and multi-scale research including integrated modeling of distribution, geology, biology, ecology, and the assessment of human impact [20]. Given their occurrence in deep, inaccessible parts of the planet, the most common way of understanding these habitats is through marine remote sensing and subsequent analyses. As such, many studies are completed in isolation and are not comparable due to methods employed or the scale of the research area.

Although there are studies pointing to the regional role of CWC reefs in organic matter cycling and significance in local pelagic benthic couplings [17], the lack of systematic knowledge of the global extent of the oceanic substrate covered by CWC makes it difficult to understand their importance as control agents for biogeochemical cycles and, as a consequence, for global climate change. Nevertheless, CWC are constantly listed as high priority environments for conservation in several international marine environmental protection initiatives as deep sea habitat types of special interest [15][21].

Mapping the distribution of CWCs is therefore, essential for understanding conservation, habitat and organismal tolerances, as well as for marine spatial planning and economic impacts.

3. Future Mapping Perspectives

Cold-water coral communities are exposed to several types of anthropogenic threats, which include industrial fisheries, hydrocarbon exploration, and mineral resources exploration, as well as global ocean change including warming and acidification [22] and the study of these ecosystems is a challenging task not only because of their inherent complexity but also because of their crucial importance in global ecology and biogeochemistry. In this context, a large number of surveying exploration missions shall be launched in the coming years and new processing and analytical tools will become increasingly important in dealing with the large number of datasets that will be produced.

In 2017, the UN proclaimed the Decade of Ocean Science for Sustainable Development (2021–2030) whose objective is to increase knowledge of the oceans as a basis for the implementation of management and conservation programs. Concurrently, the Nippon Foundation-GEBCO Seabed 2030 Project issued the challenge to survey the ocean floor across the globe by 2030 using multibeam sonar (MBES). In addition, inter-governmental agreements, including the Galway Statement (2013) for the North Atlantic and the Belém Statement (2017) for the whole Atlantic, seek to encourage collaborative ocean research with bathymetric mapping [23].

With respect to progress in CWC mapping, all this effort in the coming years should produce an exceptionally large amount of data that will need to be modeled and analyzed [1]. However, it should be noted that there is a large difference in context between different regions of the planet: in the South Atlantic and much of the Pacific and Indian Ocean, where much of the current research is based on punctual data [24][25][26][27] or no information whatsoever, the mapping process should have an exploratory approach, in which CWC habitats should be identified, delineated, and characterized. On the other hand, in areas where there are more detailed studies such as the North Atlantic and the Mediterranean, new survey and processing techniques must be developed to investigate more meticulous aspects of the physiology and responses of these ecosystems to local and global environmental changes. In either case, the production of data archives will require the development of new methods of information management, which must be supported by spatial data infrastructures (SDI) and international repositories that can handle the storage and dissemination of this data that can be used to build more complex mapping surveys and modeling.

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