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Editorial: The Azores Marine Ecosystem: An Open Window Into North Atlantic Open Ocean and Deep-Sea Environments

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Editorial on the Research Topic

The Azores Marine Ecosystem: An Open Window Into North Atlantic Open Ocean and Deep-Sea Environments

Lying between continental Europe and North America, the Azores is the most isolated archipelago in the North Atlantic Ocean. Its one million square km Exclusive Economic Zone (EEZ) comprises mostly deep seafloor interspersed with shallower portions offered by the Mid-Atlantic Ridge, over 100 seamounts, and the slopes of the nine islands. After the seminal expeditions in the late nineteenth century (Porteiro, 2009), extensive scientific research based in the Azores in the last three decades opened a window on the functioning of oceanic, deep-sea and seamount ecosystems, as well as the impacts from human activities. These discoveries helped to raise awareness on the need for protecting a rather fragile marine environment, and resulted in a pioneering role on the implementation of multiple conservations actions within and beyond the EEZ (Santos et al., 1995, 2009). This Research Topic expands our current knowledge on the marine ecosystem of the Azores, and highlights the need for improved, science-based management and conservation. It brings together 12 research papers (nine research articles, one review, one data report, and one perspective article) within four main themes: (1) geological and environmental settings, (2) biodiversity and food web structure of open ocean and deep-sea environments, (3) anthropogenic impacts, and (4) the future of marine science, management, and conservation in the Azores.

GEOLOGICAL AND ENVIRONMENTAL SETTINGS OF THE AZORES REGION

A good understanding of the geological and environmental settings is the basis for an improved knowledge of the Azores region, but also helps addressing broader scientific questions and inform management. Peran et al. compiled and made publicly available 18 layers of seabed characteristics, providing new evidence of the high geomorphologic diversity and uniqueness of the Azores region in the North Atlantic context. Amorim et al. confirmed a high spatial, seasonal, and inter-annual variability of the marine climatology in the Azores. They further noticed the limited and unevenly distribution of environmental observations of the deep ocean, highlighting the need for expanded *in situ* observatories. Caldeira and Reis analyzed the meteorological and oceanographic conditions in the region to show that the western and eastern islands are dominated by different oceanographic

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processes and water mass properties, proposing the Azores as an oceanic confluence zone where such spatial environmental patterns produce significant effects on biological productivity.

BIODIVERSITY AND FOOD WEB STRUCTURE OF AZORES OPEN-OCEAN AND DEEP-SEA ENVIRONMENTS

Several studies included in this Research Topic increased the current knowledge on the biodiversity of the Azores region. Carreiro-Silva et al. analyzed the deep-sea zoantharians associated with cold-water corals and identified four new species and several new associations with stylasterids, antipatharians, and octocorals. They also found evidences of parasitic relationships and call for a better understanding of the effects of fishing and climate change on the severity of parasitic associations. Das and Afonso reviewed and updated the biodiversity of known elasmobranchs for the Azores, and provided an annotated checklist accounting for 61 species and 19 additions to previous checklists. They found local species diversity to be lower than in north-Atlantic continental margins at comparable latitudes, but also that the Azores represents a transition zone, and pinpointed the threat of systematic species misreporting and misidentification to the effectiveness of management and conservation policies.

Cascão et al. provided the first comprehensive analyses of the distribution and temporal dynamics of micronekton communities at two shallow seamounts. They found a persistent strong acoustic backscatter over the summits reflecting both the retention of vertically migrating micronekton and a resident seamount-associated micronekton community. Tobeña et al. developed species distribution models for 16 cetaceans and found great heterogeneity in distribution, reflecting the contrasting influence and strong dynamics of local oceanographic conditions. Yet, this study also identifies persistent areas of increased species richness, emphasizing the importance of both static and dynamic management approaches to protect cetaceans and their oceanic habitats.

Carreira et al. combined genetic and morphological analyses of Macaronesian limpets to find different patterns of phylogeographic structure among species, consistent with independent processes of colonization and demographic processes. The authors also suggested that the genetic divergence among the Azores, Madeira, and the Canaries archipelagos must be considered a conservative reflection of contemporary isolation, and recommend that each archipelago should be managed separately since isolation increases the vulnerability of local populations.

Morato et al. synthetized a wide range of scientific information and developed an ecosystem model for the Azores EEZ. The authors suggested that cephalopods, pelagic sharks, and toothed whales play a key ecological role for the ecosystem stability, but also that current knowledge gaps on the biomass and abundance of key functional groups still hamper the use of these models to evaluate management scenarios.

ANTHROPOGENIC IMPACTS

Marine noise pollution is an overlooked anthropogenic pressure that became an issue of special concern over recent decades. Romagosa et al. assessed the natural background and the shipping noise in the low-frequencies of most concern for baleen whales. They found lower levels of shipping noise in three seamounts in the Azores when compared to other regions of the globe, suggesting reduced noise-related impacts on the behavior of baleen whales. They also noted that noise might be higher in shipping routes or areas routinely used by whale watching boats and, therefore, requested additional measures to produce a detailed soundscape for the Azores region.

THE FUTURE OF MARINE SCIENCE, MANAGEMENT, AND CONSERVATION IN THE AZORES

A systematic review by Abecasis et al. critically examined the current network of marine protected areas (MPAs) and progress achieved during the three phases of MPA establishment. They concluded that Azores MPAs are limited in number, reduced in size, and lack management plans, apparently jeopardizing their potential net benefits. Yet, they also noted several opportunities for future improved management and conservation in the Azores. On this regard, Afonso et al. argued that the open-ocean in the Azores region is a hotspot of Essential Marine Habitats for key vulnerable or endangered marine megafauna, playing an important role in the migratory pathways of seabirds, cetaceans, reptiles, sharks, and fishes across the wider Atlantic Ocean. They argued that the Azores region offers exceptional conditions to be a priority area for research and conservation of megafauna in the Atlantic, and proposed an action plan to acquire new knowledge, develop synergies between marine science and technology, and promote/test effective management and conservation measures.

SUMMARY

A key finding from the collection of novel papers integrating this topic is that, despite the significant scientific advances, our current knowledge of the Azorean open-ocean and deep-sea biodiversity and biogeography results from the scientific exploration of only a small fraction of these habitats. Although the region has contributed internationally with a pioneering vision and action on many conservation measures, improved management needs to consider well-defined and clear objectives, be grounded on sound monitored and effectively enforced management plans, and sourced with the adequate resources. Thus, developing adequate long-term strategies and marine spatial planning to advance scientific knowledge and inform policies emerges as a strategic objective in the quest to ensure the sustainable use of natural resources while promoting conservation of its biodiversity in the wider north-Atlantic context. Such strategy should provide the appropriated infrastructures and technological means but also long-term,

stable, and predictable scientific careers for current and future scientists.

AUTHOR CONTRIBUTIONS

All authors helped writing this summary and contributed to summarize the published papers.

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