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EDITED AND REVIEWED BY
Yngvar Olsen,
Norwegian University of Science and Technology, Norway

*CORRESPONDENCE
Pedro M. Félix
pmfelix@fc.ul.pt

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Editorial: Sea cucumbers: the sustainability of emergent and historical resources

Pedro M. Félix[1]*, Ana Pombo[2], Arnold Rakaj[3] and Christopher M. Pearce[4]

[1]MARE – Marine and Environmental Sciences Centre/ARNET – Aquatic Research Network, Faculty of Sciences, University of Lisbon, Lisbon, Portugal, [2]MARE – Marine and Environmental Sciences Centre/ARNET – Aquatic Research Network, ESTM, Polytechnic Institute of Leiria, Leiria, Portugal, [3]Experimental Ecology and Aquaculture Laboratory, Department of Biology, University of Rome Tor Vergata, Rome, Italy, [4]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada

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Editorial on the Research Topic
Sea cucumbers: the sustainability of emergent and historical resources

Sea cucumbers (Holothuroidea) are a class of echinoderms found worldwide from the intertidal to the deep sea, from the tropics to the poles, and on both hard- and soft-bottom substrates. They have a variety of important ecological roles including nutrient cycling, redistribution and oxygenation of surface sediments, enhancement of benthic habitat through excretion of inorganic nitrogen and phosphorus, and amelioration of local ocean acidification impacts on coral reefs. They are fished worldwide as human food and for their various nutraceutical and pharmacological properties. Unfortunately, the fisheries for many species have not been professionally managed, leading to overfishing and population declines across many regions of the globe. Aquaculture of a few species has been developed in order to bolster wild populations and for commercial sale to meet increasing market demand. That has led to increasing research on fisheries and aquaculture of previously unfished or underutilized sea cucumber species. The present Research Topic brings together a number of papers that address the utilization of various holothuroid resources, with goals of conservation and stock management of wild populations and increased production of cultured species.

Understanding the fundamental principles of sea cucumber biology and their ecological processes is crucial to deal with important holothuroid resources. With that in mind, Liu et al. reviewed papers on the fundamental principles, functions, and characteristics associated with various molecular markers employed across a number of both temperate and tropical sea cucumber species. Those markers serve pivotal roles in terms of genetic sex identification, germplasm resource evaluation, population structure assessment, as well as marker-assisted breeding in sea cucumber farming. Prata and Christoffersen assessed the knowledge on Brazilian sea cucumbers over the last 20 years, revealing asymmetries in the conducted studies, either geographical or biased towards specific subjects (*i.e.* taxonomy and molecular analysis) or species (*i.e. Holothuria* (*Halodeima*) *grisea*). Despite the progress, the authors concluded that much more information is required—especially on topics such as morphological variations, genetic distances between populations, population

densities, and reproductive biology of a number of species—all of which are essential topics in ensuring the conservation of all harvested holothuroids.

Using genetic parentage analyses and statistical modelling and working in Papua New Guinea, Waldie et al. studied the population connectivity of sandfish (*Holothuria scabra*), based on larval dispersion. Their study demonstrates the relevance of local indigenous plans to protect spawning biomass of the species by establishing a network of locally-managed marine areas.

On a different ecological topic, Azevedo e Silva et al. determined the growth parameters of three commercial sea cucumber species—*Holothuria mammata*, *Holothuria forskali*, and *Holothuria arguinensis*—from the northeastern Atlantic Ocean, revealing species and seasonal effects. Knowledge on various biological aspects of these marine resources is valuable for both protecting wild populations and enabling or increasing aquaculture production.

Okada et al. examined gene expression in regenerating tissues of *Eupentacta quinquesemita* after evisceration to pinpoint the genes involved in the formation of the eviscerated organs, such as the gut tube and the digestive tract and even the central nervous system. The research is crucial in understanding the molecular mechanisms behind regeneration of eviscerated tissues in this and other holothuroid species.

Fished or cultured sea cucumbers are primarily destined for human consumption, hence, pollutant, including microplastics (MP), bioaccumulation is a pressing concern. Menéndez et al. examined MP pollution in genetically-connected populations of *Holothuria forskali* in the south Bay of Biscay (France/Spain) and found that MP load was higher in sea cucumber tissues than in nearby water or sediment, indicating bioaccumulation within the holothuroid. Moreover, the MP concentration was found to be linked with various MP sources like rivers, fishing ports, and aquaculture farms. The work is essential in understanding pollutant load in various holothuroids used, directly or indirectly, for human food in order to allow the development of suitable mitigation measures if needed.

Aquaculture is another key topic in the management of sea cucumber resources, creating an alternative source of supply to fisheries. In a most relevant review, Ciriminna et al. explored the status of aquaculture of sea cucumbers in the northeastern Atlantic Ocean and Mediterranean Sea. The paper highlights that most of the research has been conducted in Italy, Portugal, and Turkey, with *Holothuria tubulosa* and *Holothuria arguinensis* being the predominant species studied. The article is important as it outlines the most common farming practices used, while identifying gaps and future directions for research on European/Mediterranean sea cucumber aquaculture.

However, sea cucumber aquaculture faces several challenges. As sea cucumber farming becomes more important as a food production system, research on holothuroid diseases will undoubtedly take on more urgency and consequence. Yu et al. applied metagenomic analyses to examine microbial factors associated with intestinal atrophy in larvae of *Apostichopus japonicus*—a disease that has been reported at a number of Japanese sea cucumber farms, hampering production. Several different pathogenic bacteria were found in the diseased larvae of this species, with *Tenacibaculum* sp. suggested as being the most problematic. The use of such a molecular approach for examining the potential linkages between microbes and holothuroid diseases will be invaluable in the identification of the pathogenesis of such diseases and will be important to establishing commercially/biologically-sustainable production systems.

The aquaculture industry aims to produce high quality products. In this sense, and because body color influences several biological functions in sea cucumbers, Liu et al. aimed to understand the molecular mechanisms regulating body colour and examined gene expression in green and purple forms of *Apostichopus japonicus* exposed to different culture conditions. The research revealed that genes in the body walls of specific individuals with particular traits were affected by their environment, a result and technique that can aid selective breeding for production of high-quality individuals.

Landes et al. examined live-storage of *Parastichopus tremulus*, studying the effects of temperature on oxygen consumption rate and condition of individuals in long-term storage. Their results showed that lower temperatures reduced oxygen consumption and increased condition. Studies such as this have implications for live seafood storage and transportation, as well as farming, impact assessment, and management of wild stocks.

The studies presented here provide valuable insights into the biology and ecology of various holothuroid species, serving as basic knowledge for developing evidence-based conservation and management strategies, ensuring the sustainability of populations in the wild. Other findings contribute to the advancement of sea cucumber aquaculture, which is developing into a promising sector within the framework of the advancing blue economy, offering potential benefits for sector sustainability and economic development. While research on holothuroids has been on the rise in the last quarter century, there is a common theme throughout the papers in this Research Topic—there are many species and research areas that remain rife for further exploration!

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declare that no Generative AI was used in the creation of this manuscript.

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