

## TITLE: A Census of Marine Biodiversity Knowledge, Resources, and Future Challenges

AUTHOR: ['Mark J. Costello', 'Marta Coll', 'Roberto Danovaro', 'Pat Halpin', 'Henn Ojaveer', 'Patricia Miloslavich']

## ABSTRACT:

The resources available for research are always limited. When setting priorities for research funding, governments, industry, and funding agencies must balance the demands of human health, food supply, and standards of living, against the less-tangible benefits of discovering more about the planet's biodiversity. Scientists have discovered almost 2 million species indicating that we have made great gains in our knowledge of biodiversity. However, this knowledge may distract attention from the estimated four-fifths of species on Earth that remain unknown to science, many of them inhabiting our oceans [1], [2]. The world's media still find it newsworthy when new species are discovered [1]. However, the extent of this taxonomic challenge no longer appears to be a priority in many funding agencies, perhaps because society and many scientists believe we have discovered most species, or that doing so is out of fashion except when new technologies are employed. Another symptom of this trend may be that the increased attention to novel methods available in molecular sciences is resulting in a loss of expertise and know-how in the traditional descriptive taxonomy of species [3]. The use of molecular techniques complements traditional methods of describing species but has not significantly increased the rate of discovery of new species (at least of fish), although it may help classify them [4]. At least in Europe, there was a mismatch between the number of species in a taxon and the number of people with expertise in it [5]. Unfortunately, because most species remain to be discovered in the most species-rich taxa [2], [5], [6], [7], there are then few experts to appreciate that this work needs to be done. Evidently, a global review of gaps in marine biodiversity knowledge and resources is overdue.

## History of discovering marine biodiversity

Although the economic exploitation of marine resources dates back to prehistoric times, and historical documentation has existed since the third century B.C. with Aristotle's contributions in the Mediterranean Sea (e.g. [8]), the establishment of systematic collections of marine organisms began only during the seventeenth and eighteenth centuries. Global marine biodiversity investigations at these times depended not only on the availability of expertise, but also on foreign policies of the colonial powers of the time. For those reasons, the specimens collected from several regions (e.g., Caribbean, Japan, South America, Africa) were mostly brought to Europe, where they were described, deposited in museum collections, and used for the production of marine biological monographs. These early publications contained descriptions and checklists of many marine species, such as molluscs, crustaceans, fishes, turtles, birds, and mammals (e.g. [9], [10], [11]).

The history of research on marine biodiversity can generally be divided into three periods: early exploratory studies, local coastal ?descriptive? studies, and large-scale multidisciplinary investigations and syntheses. These periods vary in timing by different seas and countries. The first exploratory studies in several regions (e.g., South America, Caribbean, South Africa, Pacific Ocean) took place from the mid-1700s until the late-1800s, in association with mainly European, North American, and Russian exploration expeditions, such as the Kamchatka Expedition in the 1740s, James Cook's voyages in the 1770s, the cruise of HMS Beagle in the 1830s, the voyage of HMS Challenger in the 1870s, and the first deep-sea investigations in the Mediterranean Sea [8], [9], [12], [13]. Pioneer investigations on deep-sea organisms were conducted in the Aegean Sea, where Forbes [14] noticed that sediments became progressively more impoverished in terms of biodiversity with increasing sampling depth. The azoic hypothesis proposed by Forbes suggested that life would be extinguished beyond 500 m depth, although a work published 68 years earlier provided indisputable evidence of the presence of life in the Gulf of Genoa at depths down to 1,000 m [15].

The taxonomists who described marine species at these times seldom collected specimens themselves in the field and, therefore, had only second-hand information about the distribution and ecology of the samples they received [4], [8]. Some of the early descriptions of tropical species thus do not even have the locality where the holotype or voucher material was collected (some examples in Chenu 1842?1853). The second period of regional studies was initiated by enhanced availability of research resources (experts, institutes, and vessels) in developing countries around the mid-1900s. The earliest institutions and research stations, many of which continue to operate, were founded in some areas as early as the late 1800s and early 1900s (e.g. [11], [16], [17]). Wide-scale establishment of laboratories in several continents (Europe, New Zealand, North and South America) have only been operational since the 1950s?1960s. The third stage, large-scale multidisciplinary investigations, has evolved since the 1990s, and is related to development and application of modern technologies and implementation of large, multinational research projects. Perhaps the largest of such investigations was the Census of Marine Life (Census).

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