

# The census of marine life: community access to basic science

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## 1. INTRODUCTION

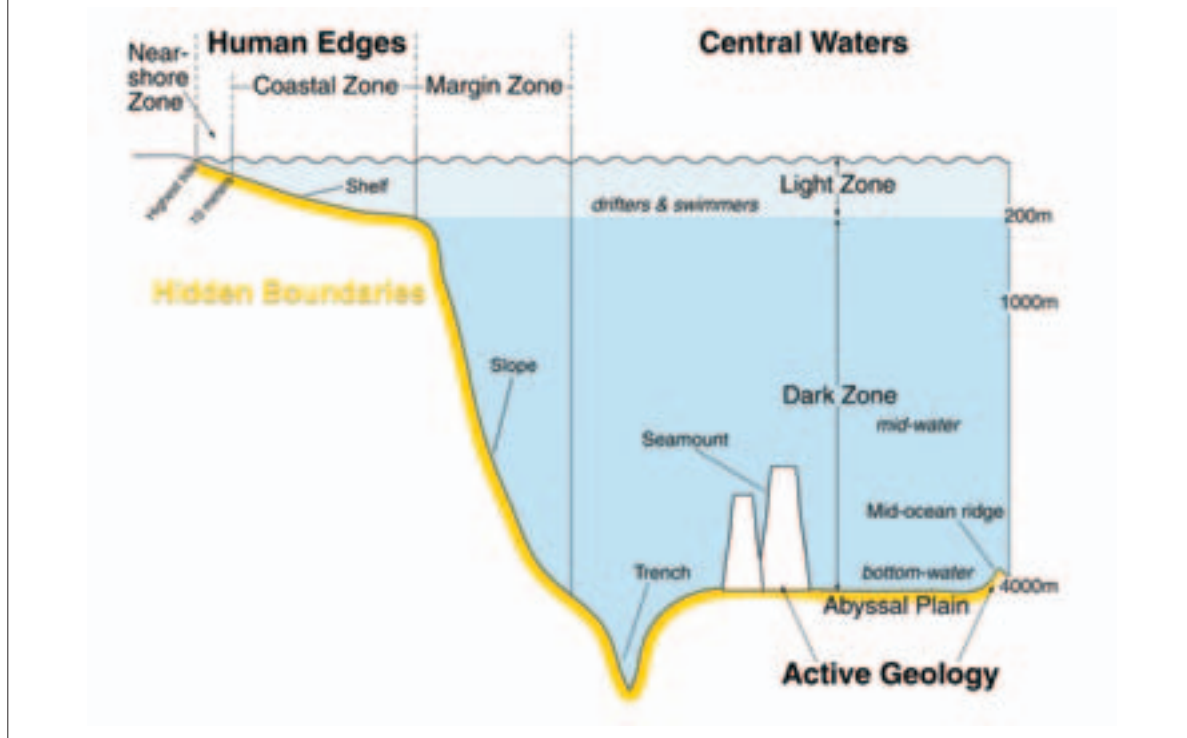
Investments made to explore space and distant planets are far greater than what have been spent to study oceans right here on earth. Is it any wonder then, that we know so comparatively little about them? Perhaps the most striking gaps in our knowledge of the oceans are in what lives there. Answers to questions of where and how many are needed, but we do not even know for certain what species are there. Science has only identified about 200 000 of possible millions of marine species believed to exist (O'Dor 2003). From what we do know, at the genetic level, the oceans contain the vast majority of all biodiversity, a resource whose importance society has only recently begun to realize. Efforts to successfully exploit, and sustain, marine biodiversity are hindered by our lack of knowledge.

Assessing what lives where in the oceans was once an impossible dream, but new technologies available to science make such an endeavor realistic today. The Census of Marine Life is a ten-year international research programme that takes advantage of this opportunity to assess and explain the diversity, distribution and abundance of life in the oceans – past, present and future. Because the ocean habitats span from the only intermittently underwater to depths of over 10 000 m, so the approaches to studying the ocean's life also varies. The Census tackles the unknown by dividing the ocean into six realms: human edges, hidden boundaries, central waters, active geology, ice oceans and the microscopic. Strategically, these realms are sub-divided into zones based on the types of technologies used to survey their marine life (Figure 1). There are currently seven zonal field projects underway and several more in development. These projects, regional to global in scale, are demonstrating techniques and standardizing protocols for observation of life in the oceans. Between 2005 and 2010, the Census will encourage additional sampling in all oceans using these protocols to achieve global comparison (Decker and O'Dor 2002).

Additional research components support the field projects to address issues of time and to develop tools for serving and analyzing biodiversity data. The History of Marine Animal Populations project is uncovering 'baselines' using a unique interdisciplinary approach to interpret changes in marine populations as recorded in historical archives. Computer models are incredibly useful for synthesizing and interpreting biodiversity data. The Future of Marine Animal Populations develops and tests computer models to facilitate analyses of the historical and current state of marine species and their interactions with one another, as well as enabling synthesis of a variety of data types and more reliable predictions on how marine populations may respond to stress from fishing and climate change. Finally, in order to archive and serve data and analytical tools, the Census is supporting the development of the Ocean Biogeographic

FIGURE 1  
Two-dimensional representation of the ocean realms (bold) and zones,  
as addressed by Census of Marine Life research.

Two realms – ice oceans and the microscopic (omnipresent throughout the oceans) – are not depicted here.



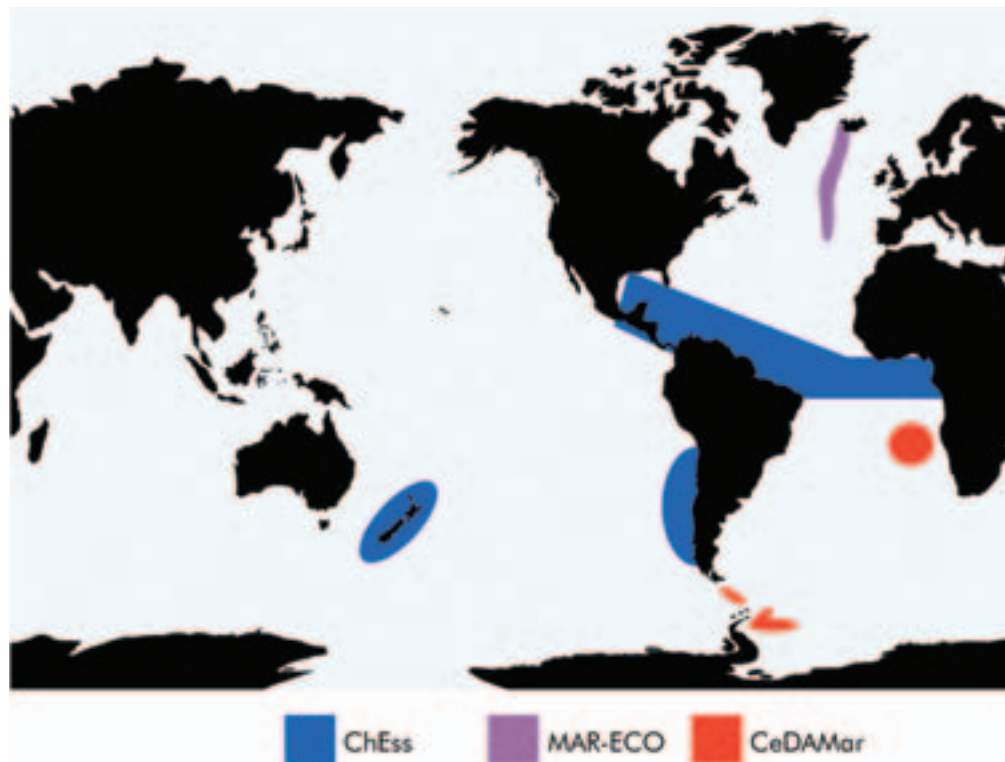
Information System, a web-based, publicly-accessible portal to global geo-referenced information on accurately identified marine species.

## 2. THE DEEP SEA

While the Census of Marine Life includes both coastal and deep ocean environments, for the purposes of this paper the focus will be on the deep-sea projects (Figure 2). The deep sea poses particular challenges to research because of its remoteness and the environmental conditions associated with that environment. So little is currently known about these ecosystems that estimates as to the necessary – or even possible – sampling resolution are difficult at best. The sediments of the deep-ocean floor, for example, are one of the most species-rich marine habitats; undescribed species are discovered in every expedition. Expeditions to date, though, have barely touched this expansive environment, making it also one of the least well known with estimates of species ranging from less than one million to five million (Grassle 2001).

The deep-sea projects of the Census are encompassed under several of the different realms. The first is the “hidden boundaries”, interfaces between major geologic boundaries that form unique habitats, such as the sediments of the abyssal plains, separating the basin of water from the oceanic crust. The project entitled Census of Diversity of Abyssal Marine Life, or CeDAMar, is aimed at documenting actual species diversity globally in abyssal plain sediments and determining what the controlling factors of biodiversity in the abyssal plains may be. For example, what is the role of primary production in the surface waters on deep diversity? Like all Census projects, CeDAMar will standardize approaches to surveying deep benthic marine life so that meaningful comparisons can be made between sites and studies. Target species are primarily small organisms like protists, crustaceans, and worms, in which the sediments are rich.

FIGURE 2  
Map of the study area of the Census of Marine Life deep-sea field projects (in 2003)



The seafloor, however, cannot be solely characterized by these wide expanses of minimal topography. New earth has also been forming for billions of years and creating the isolated habitats of the realm of “active geology.” Because of their isolation these habitats offer tremendous opportunity for exploration, both in terms of locating the existence of a site and of studying its unique – and often highly endemic – fauna. Hydrothermal vents were not discovered until the late 1970s, and with that came the discovery of symbiotic tube worms. Scientists learned that this entirely new ecosystem received energy chemosynthetically from hydrogen sulfide emitted in the black “smoke” from the vents independent of surface organic production. Our understanding of hydrothermal vents and other chemosynthetic ecosystems (cold seeps, whale carcasses, sunken wood and areas of low oxygen associated with subduction zones) is limited to studies of only a few sites around the globe; there is still much unknown. The Biogeography of Chemosynthetic Ecosystems (ChEss) project will assess the diversity, distribution, and abundance of the species in chemosynthetic ecosystem and explain the differences and similarities from place to place at a global scale. ChEss will look at potential processes controlling biodiversity, such as larvae dispersal, topography and sea floor spreading (Van Dover *et al.* 2002).

Another product of active geology is seamounts. Many are geological ghosts of volcanoes and like vents and seeps, seamounts are often geographically isolated, providing a great opportunity to substantially increase our understanding of biogeography by looking at the similarities and differences in the communities between separate seamounts. Of the 30 000 or more seamounts around the world, only about 200 have been sampled. From those surveys, almost half of the species collected were new to science and likely to be endemic to their particular ecosystem. Increased exploitation of seamount fauna has put pressure on scientists to study seamounts. The Census has begun the development of a global seamount project that will synthesize existing

biodiversity knowledge and direct future field efforts towards a comparative ecology of seamounts, categorizing communities and developing proxies for generalized models that will enable us to predict properties of unexplored seamounts, a capability urgently needed for effective management of fisheries on seamounts.

Above the seafloor is the oceanic dark zone of the “central waters” where the Census project known as MAR-ECO (Patterns and Processes of the Ecosystems of the Northern Mid-Atlantic) aims at describing and understanding the patterns of distribution, abundance, and trophic relationships of the organisms in the deep pelagic, near-bottom and epibenthic habitats of the North Atlantic. Even in the dark zone, most animals rely on nutrients from primary production near the surface, which fall through the water column as marine snow. Images collected by the MIR submersibles on a recent MAR-ECO expedition to the Charlie Gibbs Fracture Zone (Mid-Atlantic Ridge) revealed surprisingly high concentrations of marine snow at over 4 000 m depth indicating the environment there may be able to sustain a high diversity of species. MAR-ECO surveys focus on macrofauna and megafauna, including fish, crustaceans, cephalopods and gelatinous zooplankton. Because of the depth and the often rough terrain associated with mid-ocean ridges, many traditional sampling methods (e.g. trawling) are not an option, so MAR-ECO must utilize innovative methods and technology to study and map the distribution of life there.

### 3. ACCESS TO DATA

While the pursuit of a global understanding of marine biodiversity is a laudable goal for the scientific community, there is a crucial societal need to implement effective policies to manage marine resources. The major advancement in basic scientific knowledge that will result from the Census, therefore, will be particularly useful if made publicly available. The Census requires this of all its projects and to facilitate the process, is supporting the development of the Ocean Biogeographic Information System (OBIS, <<http://www.iobis.org>>), a single web-based portal to geo-referenced data on accurately identified marine species collected not only by the Census but from a federation of data providers around the world. The federation ensures inter-operability, but each data contributor separately maintains the datasets and intellectual ownership over the data. OBIS is the marine component of the Global Biodiversity Information Facility.

The development of this dynamic, digital atlas began in 2000 with the funding of a feasibility demonstration to make interoperable eight authoritative data sets of particular taxonomic groups. As of November 2003, OBIS enables simultaneous searches of 19 inter-operable databases, which, in addition to the museum collections, include taxonomically resolved, geo-referenced datasets from genetic studies, time-series, continuous plankton recorders, the Food and Agriculture Organization's Catch and Aquaculture Production and, in the future, industry (e.g. petroleum, bioprospecting).

The data collected by modern ocean science has made OBIS a valuable resource for scientists and managers to identify what is currently known to live and where it lives in the oceans, but with the inclusion of the Census's historical and modeling components, it enables comparisons over hundreds of years. The History of Marine Animal Populations contributes ‘outside-the-box’ approaches to marine research, amassing taxonomically resolved distribution and abundance information from 100 to 500 year-old archives of fishing logs, tax records and recipes (Holm, Smith and Starkey 2001). The result is a historical baseline against which scientists can evaluate current distribution and abundance of marine populations.

With a baseline, projections about the future become more reliable. Though OBIS offers some modeling techniques useful for basic prediction, particularly in terms of marine invasions and, to a certain extent, climate change, the Future of Marine Animal Populations (FMAP) will test and contribute new cutting-edge biodiversity models to

the system. Initial models will focus on interpreting migration patterns from tagged animals, species interactions, and predictions of the effects of climate change and fishing pressure on populations (Worm *et al.* 2003).

OBIS is already a powerful tool with over one million records of some 5 000 unique marine species, which can be downloaded directly or overlaid on maps of physical oceanographic parameters. Based on the scheduled addition of datasets, OBIS will put at least 10 million records of all known species and their location online by 2007.

#### 4. GLOBAL COOPERATION

A global programme requires global participation. In November 2003, researchers from 50 countries were involved in the Census. But, in addition to willing researchers, the success of the Census depends on global partnerships in governance and funding. An international Scientific Steering Committee oversees the conceptual goals and direction of the programme. They have designed the Census in such a way that its products will be of benefit to a wide range of users. The overall estimated cost of the programme is US\$1 billion, making the contribution of a wide range of sponsors important. Though there is some international funding available for this research, much of the sponsorship must be generated at national levels from traditional sources such as governmental agencies and philanthropic foundations. Sponsorship through funding or other services can also come from novel programmes led by industry that have vested interests in marine life (e.g. fishing, pharmaceuticals) or whose work in the ocean affects ecosystems (e.g. mining, petroleum production).

The task of raising funds for Census research is enormous and the ten-year timeframe makes it urgent. To accomplish it, national and regional implementation committees are being established around the world. As of November 2003, implementation committees are operating in Australia, Canada, Europe, Japan, South America and the United States. Developments toward creating a committee are underway in Russia, China, the Caribbean, the Indian Ocean, Sub-Saharan Africa and the WESTPAC region. There is interest in the New Zealand/South Pacific region though appropriate mechanisms must be identified.

These committees are comprised of scientists as well as representatives from conservation, management, industry and other ocean stakeholders to ensure effective implementation of the programme with legacies that will be understood and appreciated by global society. Even with the majority of the effort still ahead, the successes to date in engaging and organizing the scientific community makes Census a proven demonstration of the value of partnership and cooperation.

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