A count in the dark

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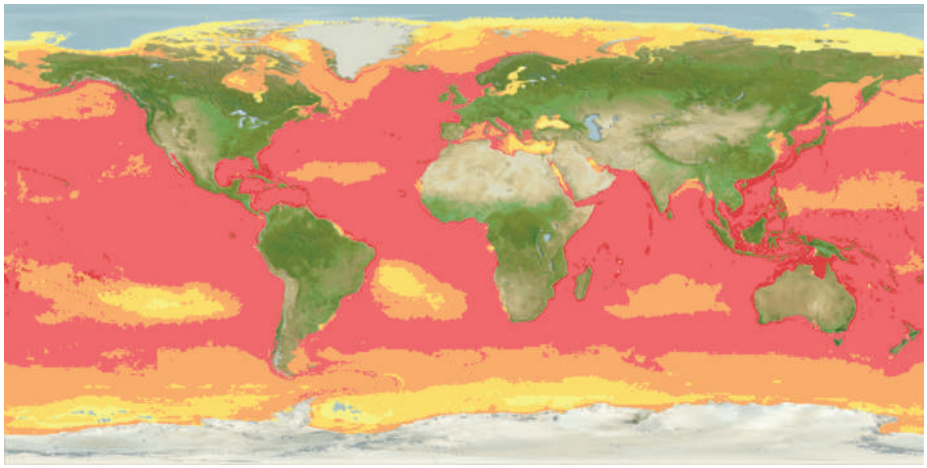
The Census of Marine Life has succeeded in raising awareness about marine biodiversity, and contributed much to our understanding of what lives where. But the project has fallen short of its goal to estimate species abundance.

There was widespread interest when the Census of Marine Life[1] was launched in 2000 as a ten-year international cooperative project. The aim was to chart life in the oceans[2]. As a result, over the past ten years we have been regaled with accounts of fascinating new 'walking sharks' in Indonesia[3], 'hairy crabs' in the South Pacific[4] and past abundances of now much diminished species[5].

The census had three main goals: determining which species live in the ocean, where they live and how abundant they are[2]. Ten years on, we can roughly evaluate the success of the first of these goals. There are an estimated 230,000 marine species known to science[6], and, according to an emerging consensus, the total number of species living in the oceans is closer to 1,000,000 (ref. 2) than to the 10,000,000 estimated previously[7]. Census researchers have described about 1,200 new species, and around 4,800 more are being worked on[2]. This is a modest contribution if the number of unknown marine species is truly greater than 700,000.

The reasons for our imprecision regarding the number of unknown species are twofold. First, the branch of biological science that identifies new species and formally describes them, taxonomy, is grossly underfunded. It is therefore incapable of marshalling the human resources necessary to keep up with the description of marine biodiversity. Second, comprehensive, global databases, which concentrate knowledge about the various described species of the world, exist for only a few taxa; examples are FishBase for fish[8] and AlgaeBase for marine plants[9]. Hence, we cannot straightforwardly assess, in quantitative terms, the extent to which the Census of Marine Life has added to the store of existing knowledge on marine organisms and, for example, calculate the return on our investment.

The second goal — determining where marine life occurs — is in part achieved by the Ocean Biogeographic Information System[10], the information component of the Census of Marine Life. This database contains millions of occurrence records. These records document what species were collected where, when and by whom, and were provided mainly by natural history museums. For any column in the global ocean, this system returns the names of the species collected there, and links to databases that give further information. These databases range from FishBase[8], which was established 20 years ago and provides detailed nomenclatural and biological information on every known species of fish, to the Encyclopedia of Life[11], which simply 'mashes up' information taken from a variety of sources of varying reliability. Together, the data can be used by others to infer the properties, such as temperature, depth and salinity, preferred by the animals in question, and this can be used to project tentative distribution maps. One such map was started in 2003, and probably gives the most accurate representation of global marine biodiversity so far[12] (Fig. 1).



WWW.AQUAMAPS.ORG

Figure 1 | Best estimate of species richness in the oceans. The map is based on standardized range maps for over 10,000 marine organisms. The colours represent a logarithmic scale; dark-red areas correspond to regions with more than 700 species per half-degree square. Coverage is reasonably complete for marine vertebrates (fishes, reptiles and mammals), but invertebrates and algae are under-represented. Lists of species for any given spot can be obtained by clicking on the online map at www.aquamaps.org.

The third goal that the Census of Marine Life set for itself was to estimate how much life there is in the sea, and that, clearly, has not been achieved. Various census projects document the decline of this or that marine organism, but there is no systematic attack on the problem of estimated abundance of marine species globally. This would not be impossible to do, but we argue that the Census of Marine Life could not achieve this for a structural reason.

Large collaboration projects in science can be considered as being of two kinds. One encourages the spontaneous generation of ideas through the funding of broad conceptual 'framework' projects; we may call this a 'bottom-up' approach. The other entails specific goals, set by the funding agency, which expects specific products to result, in a 'top-down' approach. Examples of the latter are the Manhattan Project and the Human Genome Project, which

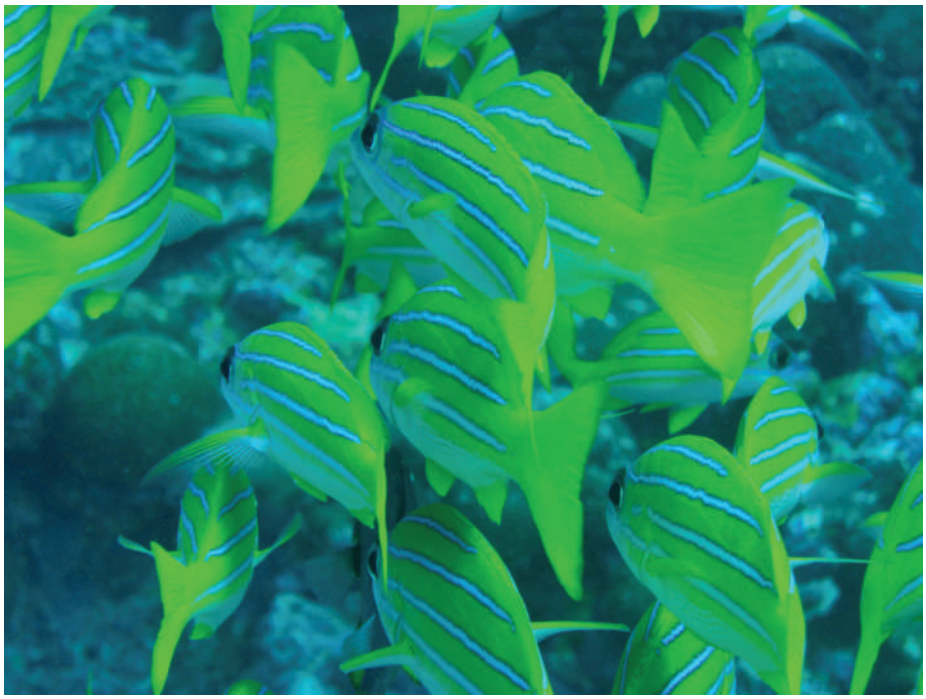


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Figure 2 | Bluestriped snapper, *Lutjanus casmira*, is a typical reef fish photographed here on Christmas Island in the central Pacific Ocean.

were run centrally. The same holds for census projects in different contexts, from the Domesday Book, a census of land, livestock and possessions in eleventh-century England ordered by William the Conqueror, to the US census, run by the US Census Bureau. Attempting a population census bottom-up would probably yield something like the number of jazz musicians in New Orleans, lumberjacks in Oregon and financial analysts in New York City, but no countrywide population estimate.

We are not aware whether the leaders of the Census of Marine Life ever considered that they should choose between two such approaches, but in fact they chose the bottom-up approach. However, to estimate the abundance of marine species would require an agreed-upon metric, which would have to be consistently applied. This also implies an effort to define strata for the entire ocean a priori, because different ocean ecosystems — such as coastal areas, coral reefs (Fig. 2), shelves, canyons and seamounts — require different sampling strategies; something our often cantankerous colleagues would probably be forever unable to agree upon from the bottom up. At present, such global accounting of marine life is being done by only a few research groups. It involves not only prior agreement on a fine stratification of, or a grid system for, the ocean, but detailed sampling protocols for each group of species and ecosystem type, just as is necessary for population census agencies.

It is not surprising that the Census of Marine Life only partly achieved its ambitious goals. As Nancy Knowlton of the Smithsonian Institution and leader of the census's coral reef project puts it: "At the end of the Census of Marine Life, most ocean organisms still remain nameless and their numbers unknown. This is not an admission of failure. The ocean is simply so vast that, after 10 years of hard work, we still have only snapshots, though sometimes detailed, of what the sea contains. But it is an important and impressive start"[13]. We concur. But we suggest that if a census of marine life were attempted a second time round, a top-down approach should be considered. ❐

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