

One fish



two fish



red fish



blue fish

What is the value of a census of marine life?

James N. Sanchirico and Michele T. Callaghan

Experts estimate that vast areas—approximately 95 percent—of the world’s oceans remain unexplored. Hundreds of scientists all over the world are attempting an equally vast undertaking to rectify this—a census of marine life (CoML). Unlike a typical census, this 10-year project, which was launched in 2000, has the ambitious goal of cataloguing what once lived in the oceans, what lives there now, and what is likely to live there in the future.

Advocates argue that the potential impact of the census for science and policy is almost as large as the undertaking itself. Ideally, it will lead to greater scientific returns than the status quo in ocean research (now an idiosyncratic set of research efforts); increase funding for ocean research; and inspire a new generation of marine scientists. Coordination in the development and purchasing of scientific instruments for the census might also spur technological advances and lower prices.

Census research and outreach could also be a vital force in fostering two dramatic shifts in what we know about ocean science and management. Marine populations were once thought to be open and distributed evenly across a homogenous ocean environment. An emerging perspective, however, is that marine populations reside in neighborhoods, possibly connected by dispersal of larvae and adults. Because oceans have historically been managed by relatively uniform systems of regulatory actions over space, this shift enables fine-tuning that will lead to more biologically and socioeconomically sustainable management. Second, countries appear to be moving away from managing the ocean solely for extractive uses, even as the number of economic activities is growing, toward a more holistic approach that includes conservation. One new trend that symbolizes both of these changes is the movement to establish networks of marine reserves, areas that are closed to all extractive uses.

Whether the full benefits of the CoML are realized will depend on the researchers involved, but the question goes beyond them. Rigorous science and outreach alone do not lead to sound policies. Management institutions need to have well-established means of turning science into policy, which requires adaptability. It will also be difficult to identify a causal relationship from CoML research because measuring the benefits of the research will be a difficult, if not impossible, task. And, even if the potential benefits could be quantified, there are socioeconomic and political potholes that must be navigated and filled along the way; otherwise, the magnitude and sustainability of the scientific returns are in jeopardy.

Some of these potholes can be avoided if CoML project leaders integrate stakeholders, social scientists, and regulators into the natural science work currently under way. Only a handful of such people are participating, out of the hundreds of natural scientists now involved.

Successfully navigating CoML research through the political economy of ocean management might not achieve the maximum returns possible, but it will ensure that the gains are greater than under the status quo.

From top left: A robotic arm and video camera record life at 3,000m deep in the Charlie Gibbs Fracture Zone (photo by Michael Vecchione, NOAA Fisheries Systematics Lab, National Museum of Natural History, Smithsonian Institution); A new species of grenadiers or rattails, *Caelorinchus mediterraneus*, found in the western Mediterranean (photo by Tomio Iwamoto); An undescribed and perhaps new species of Narco, a sub-group of jellyfish collected south of Banks Island, Canadian Arctic (photo by Kevin Raskoff). All photos courtesy Census of Marine Life.



Above right: The tube worm, *Lamellibrachia luymesii*, lives symbiotically with bacteria on sulfide produced by anaerobic oxidation of oil and gas. Many oil and gas seeps in the Gulf of Mexico feature dozens of dense, bush-like aggregations. This tube worm “bush” shows the red gill-plumes of several worms (photo by Ian MacDonald, Texas A&M University, Corpus Christi).

Opposite: A new species of scorpionfish, *Scorpaenopsis vittapinna*, found in the Indo-Pacific area, one of a rapidly growing list of more than 15,300 marine fish species now logged in the CoML database (photo by Bill Eschmeyer and John E. Randall).

Along with improving the use of CoML science in ocean policy, such integration would help to address the concerns that governments will not be able to prevent a “gold rush” to exploit any new populations uncovered by the census.

How will the census work?

The census is jointly sponsored by governments and foundations across four continents and is coordinated by a secretariat at the Consortium of Oceanographic Research and Education in Washington, DC. It will entail developing baselines of what once lived in the oceans using archival information from monastic annals and ship logs, as well as sediment cores and other records. Scientists will also document present-day populations and where they are found. These baselines will be combined with oceanographic data in mathematical models to predict potential scenarios for the future state of the oceans. CoML researchers are working with the Ocean Biogeographical Information System to have all the data included in a central clearinghouse for marine biodiversity information.

A brief look at three pilot projects that comprise only a portion of the CoML will give a broad idea of how the census will affect important facets of ocean research and management in all oceanic zones. These projects are Tagging of Pacific Pelagics (TOPP), which includes animals that live in the open sea with broad public appeal such as sea lions and whales, as well as commercial fish stocks; Natural Geography of Inshore Areas (NaGISA), which offers local communities a chance to be involved in studying their shorelines; and exploration of ecosystems of the deep seas in the northern Mid-Atlantic.

In the TOPP program, researchers are developing and deploying state-of-the-art technologies to tag pelagics so that they can be tracked by satellite. In an example that predates the census, fisheries managers and scientists were surprised to learn that what they believed to be two populations of bluefin tuna might, in fact, be one group that moves between the eastern United States and the Mediterranean. CoML research will strengthen our knowledge of underwater “highways” and “watering holes” shared by turtles and swordfish, among others. In addition to learning about migration patterns, as these animals dive repeatedly, the tagged specimens will, in effect, provide a temperature profile of the ocean’s depths.

By its very definition, TOPP does not limit itself to one part of the ocean, but follows pelagic species wherever they go. In contrast, NaGISA researchers are measuring the abundance and diversity of marine life in the nearshore, a zone less than 20 meters deep. A unique

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aspect of this project—named for the Japanese word *nagisa*, meaning where the ocean meets the shore—is that it is both worldwide and fine in scale. Sampling is being done in an equatorial study from the east coast of Africa to the Palmyra Atoll in the Pacific Ocean and in a longitudinal study from Alaska to Antarctica.

A third part of the census will cover the Mid-Atlantic Ridge, an underwater volcanic mountain range created by the spreading of the Eurasian and American continental plates that stretches from the polar regions in the north to Antarctica. Because its sampling will often occur along the seabed at depths greater than 3,500 meters, this facet of the census will likely be the most challenging. Scientists hope to determine if ridges and seamounts (mountains under the sea) have their own fauna or if coastal fauna are using them as stepping-stones. Documenting this region before economic forces drive people deeper into these areas in search of exploitable resources is vital for developing sustainable management.

Discovering patterns and potential oceanic biodiversity hot spots could be used in the design of marine reserves, which are typically thought of as being fixed in location and set aside for perpetuity. However, as we are already learning from CoML data, boundaries and locations of hot spots are dynamic, shifting with changes in the physical environment. This being the case, management agencies might need to use real-time oceanographic information to define the boundaries. These boundaries could be monitored and enforced with satellite tracking systems that either allow or lock out certain activities by various species at certain times and places.

What is the potential value of the census?

The services or outputs generated by the CoML, such as potential pharmaceutical discoveries, and the type of management institutions in place, along with other factors, all affect the economic value of scientific research. In many industries, rates of return from investments in R&D are measurable, because the outputs are typically traded in the marketplace—revealing both the customer’s willingness to pay for the product that embodies the information and the producer’s net returns, taking into account the R&D costs.

Most of the CoML outputs, however, will not be traded in a marketplace but rather are inputs into policy discussions regarding the conservation of natural resources, which are public goods. For example, information on the spatial and temporal distribution of endangered marine animals could be used to refine fishery management and maritime activities, reducing

the likelihood of fishing gear entanglement and animals being hit by vessels. In many cases, the information generated by the CoML will not even be the sole input but rather one component of a much larger analysis.

Given that the CoML is less than halfway complete, it is hard—and foolish—to predict what its value will be. This value may never be accurately accounted for, but it is clear that actions can be taken now to increase the census's worth to society. In particular, the benefits will depend in large part on the institutional structures using the research. This does not bode well for the CoML, since the marine regulatory environment is highly charged with many competing users, all of which are vying for limited resources where rights are not well defined. Pelagic species, deep-sea marine resources, and inhabitants of the coastal environs are all affected.

Institutional factors are more pronounced in CoML projects because many of the species spend time in the high seas, thereby requiring coordination among countries. For example, CoML research could be used to improve fishery management where increases in the returns to fishing will represent a portion of the value of the research. The sustainability of these increases, however, depends on the allocation of rights to the resource. Free-for-all will lead to a tragedy of the intellectual and ocean commons.

The lack of well-defined rights and established regulatory institutions contributes also to many of the distributional conflicts that affect how the research is used and valued. Distributional issues are often not acknowledged when advocates for more scientific research argue that the benefits of such efforts outweigh the costs. New information and the methods and effectiveness of dissemination strategies can, however, create winners and losers. Whether the net value is positive will, therefore, depend on the relative weights placed on the groups affected.

Distributional effects are not limited to current users of the information. Improved information on the life cycle of commercially harvested fish species resulting in reductions of total allowable catches will benefit future fishers, as the fish stock recovers and lowers the costs of fishing. The current set of fishers, however, face a cost in lost revenue from harvesting that might affect their ability to repay bank loans for fishing gear and equipment.

How to avoid potholes along the way

Driven by advances in scientific knowledge over the past 25 years and a growing marine conservation ethic, ocean management is moving away from the traditional production focus toward a multi-objective ecosystem approach. However, many basic questions remain to be explored, such as which areas are to be restricted and for what uses. Creating guidebooks on species' ranges will help in this endeavor, as will research on the causal factors that have an impact on oceanic systems, trophic interactions, and variations across space in population abundances.

While such a system is on the horizon, a more pressing issue for CoML researchers will be to avoid potential unintended consequences. For example, a biodiversity hot spot may be present in an area with insufficient marine management and enforcement to ensure protection. Individuals with economic interests could act on this information faster than governments. It is also easy to imagine that as scientists learn more about the diversity of species and local abundances that commercial fishers will also learn about them, especially if efforts are made to disseminate the research broadly. One study illustrated how improved El Niño forecasts resulted in a range of unintended consequences in Peruvian fisheries, including increased efficiency in exploitation by some groups that were given advance notice of likely shifts in population abundance.



Above: A MIR submersible being lowered into the depths of the Atlantic Ocean holds two researchers, the first people to visit the Charlie Gibbs Fracture Zone in the Mid-Atlantic Ridge (photo by Michael Vecchione, NOAA Fisheries Systematics Lab).



Above: These three sunflower sea stars, *Pycnopodia helianthoides*, were photographed during a NaGISA sampling dive in Prince William Sound. The Latin, which translates to dense-footed sunflower, refers to the thousands of tube-like feet on the underside of the arms that stretch out, making them resemble beautiful aquamarine sunflowers (photo by Casey Debenham).

The results from the CoML will stretch the limits of our current regulatory system and potentially make the regulated more disgruntled. This could occur, for example, if an endangered marine mammal or a deep-sea watering hole exists in an area, restricting commercial uses. Also, the prediction that new species inhabit heavily exploited areas could result in further restrictions, drawing the ire of current users, who might already feel overburdened with regulations.

Unintended negative consequences and ill-equipped institutional frameworks need not be a foregone conclusion. Under the current model, however, they are likely to come about unless efforts are made to ensure that rigorous policy analysis that incorporates CoML science is done along the way. Successfully navigating the research results through the political economy of ocean management might not achieve the maximum returns possible from the CoML, but it will ensure that the gains are greater than under the status quo.

To achieve this goal, a policy advisory committee should be created for each project. Such a committee could include anthropologists, economists, lawyers, political scientists, natural scientists, government representatives, industry (those using or affected by the information), and nongovernmental organizations.

The team of natural scientists behind the census is striving to create a flexible and adaptive research program on a scale not seen before in oceanic research. Such an undertaking will transform ocean science in the questions asked, methodologies employed, and the allocation of research funds. If the team does not reach out now to include other disciplines, however, they will not achieve the best transformation possible. ■

James N. Sanchirico is an RFF fellow. This article is a synopsis of his research project investigating the potential benefits of the Census of Marine Life. Funding was provided by Resources for the Future and the Alfred P. Sloan Foundation, which is a major supporter of the CoML. Sanchirico wishes to acknowledge the assistance that Assistant Editor Michele T. Callaghan gave in developing this article.

Further reading

Census of Marine Life website: www.coml.org

O'Dor, R. 2003. *The Unknown Ocean: Baseline Report of the Census of Marine Life*. Consortium for Oceanographic Research and Education: Washington DC, 28pp. (www.coml.org/baseline/index.htm).

Sanchirico, James N. 2004. *A Social Scientist's Perspective on the Potential Benefits of the Census of Marine Life*. RFF Discussion Paper 04-23, June, available at www.rff.org/Documents/RFF-DP-04-23.pdf.