The Census of Marine Life and the Partnership for Observation of the Global Oceans

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Good afternoon and many thanks to the Partnership for Observation of the Global Oceans (POGO) for the chance to share with you, the leaders of the community that plans and implements novel observation of the oceans, news of progress toward the implementation of a scientific program to carry out a worldwide Census of Marine Life. The POGO member institutions have much to contribute to the Census and, in turn, the Census can help lift the value of your institutions. I have reported to you at your earlier meetings in La Jolla and Paris about the plans for the Census. Because several are here today who were not present at the earlier meetings, let me also speak briefly about the origins and motives of the Census. In accord with the emphasis of this meeting on observations in the oceans of the southern hemisphere, I will point to the needs and opportunities for the Census to develop in this half of our globe.

First, let me introduce myself. I am Jesse Ausubel, program director for the Alfred P. Sloan Foundation, a private philanthropic foundation located in New York City. The Sloan Foundation works with different parts of the scientific community to try to bring to fruition important scientific programs. About three years ago, several leading oceanographers approached the Foundation. They wanted to begin a new international scientific program to assess and to explain the diversity, distribution, and abundance of marine life. In brief, they want to organize a worldwide Census of Marine Life (CoML). I speak to you on behalf of the distinguished international Scientific Steering Committee (SSC) that is now planning the program, whose members include Patricio Bernal, a fellow participant in this POGO meeting.

Three main reasons motivate the Census of Marine Life (CoML). The first is simply the chance for exciting discoveries about the world in which we live. Much remains to be discovered about life in the oceans. For example, ichthyologists have so far identified about 15,000 species of marine fishes. They also believe about 5,000 species of marine fishes remain to be discovered. The age of discovery in the oceans is not over.

The second reason for a Census is improved management of marine resources. Big opportunities exist to improve management of fisheries and other human uses of the oceans.

The third compelling reason for the CoML is the International Convention on Biodiversity. For this Convention to become useful, good baseline information on ecology is required. The present baseline information on marine ecosystems for most of the world's oceans is weak. The CoML can help greatly to create the needed baseline information. In the Netherlands earlier this month 10,000 people gathered to negotiate about climate change. Much of the debate in The Hague was about terrestrial carbon storage, its past, present, and future. Sadly, terrestrial carbon inventories

remain incomplete and intensely disputed. Leaders of the climate research community, including Roger Revelle, former director of Scripps Institution of Oceanography, foresaw the need for more reliable carbon estimates more than 20 years ago, but ecologists and governments did not commit to the work. In the area of marine biodiversity we can commit now to the research and exploration that will greatly ease the job of international negotiators one or two decades hence. A continuing series of international workshops, about 15 so far, have defined the challenges for the Census and the ways they can be addressed. Three "Grand Challenge" questions encompass the program as a whole. These are 1) What did live in the oceans? 2) What does live in the oceans? 3) What will live in the oceans? The International Scientific Steering Committee is now working hard to integrate the most valuable, feasible ideas into a 10-year strategy and plan for the Census to answer these questions. The draft strategy will soon be circulated to the various potential stakeholders in the Census for review and comment. Let me share with the likely main components of the program.

The historical component of the Census, addressing the history of marine animal populations (HMAP), will try to create a picture of what lived in the oceans before fishing become important, and how these populations have changed since fishing loomed large, a time 50 years ago in some areas, 500 in others, and one thousand or more in a few. HMAP will try to create and make accessible time series on marine animal populations. It will try to rescue and put in electronic form historical data that could otherwise be lost. The Danish environmental historian and Steering Committee member, Poul Holm, who chaired an exciting workshop on HMAP in February 2000, has taken the lead in organizing the network of researchers and institutions that will conduct this part of the Census (http://www.fimus.dk/hmapindx.html). The Steering Committee for the Census expects soon to announce the launching of Centers for HMAP in Denmark, the U.K., and U.S.A.

The history of marine animal populations is a blind spot in environmental history that the combined efforts of historians, paleo-ecologists, and ecosystem modelers can surely fill. We expect that the HMAP research during the next 5-10 years will lead not only to compilations of statistics but to the creation of beautiful visualizations of the marine environment in earlier historical times. Imagine the visual re-creation of marine life as it may have existed centuries ago in the bays of Naples, Rio de Janeiro, or Tokyo. As an American, I would love to have a picture of the life in Massachusetts Bay around the year 1620 when the English settlers came. Exhibits or other visualizations about the history of marine animal populations could be inspiring and influential, for example, in considering goals for Marine Protected Areas. I find the reconstruction of the oceans before fishing, or what we might call the primal or pristine ocean, one of the most exciting parts of the Census.

The present component of the program, addressing what now lives in the oceans, involves new field programs. The Steering Committee believes that about half a dozen pilot programs are needed to demonstrate that new technologies can make synoptic and synchronous measures of large ocean areas. These pilot programs need to address diverse marine environments. Pilot programs now under development address

a) the Gulf of Maine & Georges Bank in the Northwest Atlantic. Marine populations in this area are of course important for fisheries. Much surveying has been done in this region, but we really do not know if we have the numbers right, so the region provides an

excellent chance for the demonstration, calibration, and integration of new technologies (http://www.whoi.edu/marinecensus/).

b) the Mid-Atlantic Ridge and overlying deep water. These areas exemplify the vast largely unexplored areas of the open ocean, and the technological challenges to see deep and far. Dr. O. A. Bergstad of the Institute of Marine Research in Bergen, Norway, is leading the development of this pilot project.

c) vent and seep communities on the bottom of the North Atlantic. Studies to date have examined only a few such communities and tended to focus on a tiny area, say, a few square meters. Big questions pertain to the numbers and distribution and diversity of these communities.

d) Pacific populations of large pelagic species, including tunas, whales, seals, and sharks. A tremendously exciting opportunity exists to describe what must live in the ocean at several trophic levels based on obtaining a much more reliable and complete view of life at the top of the food chain. Tagging technologies offer revolutionary chances. http://www.sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/2000/11/16/MN110279.DTL

e) North Pacific and Gulf of Alaska salmon populations. Remarkably, it is still largely unknown where most salmon go when they leave their rivers.

f) diversity of near shore populations in the Western Pacific. A classic yet unanswered question is how marine biological diversity changes with latitudinal gradient. Steering Committee member Yoshihisa Shirayama is leading an effort to answer this question with strict survey protocols that would describe populations from the New Zealand in the south to the Bering Sea in the north. So far, this is the only one of the possible pilot projects proposed that will explore the southern oceans.

Eventually, there may be 30-40 field programs in diverse parts of the world oceans, which, taken together, will form the Census and vastly improve our knowledge of the diversity, distribution, and abundance of present marine life. Obviously, many of these field programs must be in the southern oceans. The selection of the field programs must rely on an improved biogeography or stratification of the oceans on which scientists are now also working. They can also benefit greatly from pairing with new systems soon to be deployed for observing environmental features of the oceans, such as the Argo floats. I hope POGO will be a forum that seeks and creates synergies between the Census of Marine Life and other plans for ocean observation.

Obviously, the gaining of commitments, financial and political, to conduct the field programs is the biggest step to make the Census a reality.

The prospective portion of the program, addressing what will live in the oceans, requires improved models of ecosystems dynamics, attentive both to trophic levels and questions at the species level. It is important to note that such models can, in principle, work both backward and forward in time. With appropriate data, they can help fill in the picture of what did live in the oceans as well as what will live in the oceans.

A requirement for the CoML is an improved system for absorbing, integrating, and accessing data about life in the oceans. Already we are working to create an Ocean Biogeographical Information System (OBIS). The idea of OBIS is that anyone anywhere at a computer can click on an area on a map of the oceans and bring up information on what has been reported to live there. The CoML may be said to have begun in a formal sense with the announcement in May 2000 of eight grants totaling about 4 million US$ to create the OBIS, as reported in *Science* magazine, 2 June.

The grants, made by the Sloan Foundation in partnership with the US National Science Foundation, Office of Naval Research (ONR), and other organizations belonging to the US National Ocean Partnership Program involve researchers in more than 60 institutions in 15 countries. The idea is to evolve OBIS cooperatively, worldwide. OBIS will be a distributed system, a system of systems, also integrating and linking to geo-referenced databases for ocean optics and other physical, chemical, and geological parameters. The initial OBIS grants address overall system architecture as well as 5 species groups: fishes, cephalopods, gelatinous zooplankton, mollusks, and corals and anemones. OBIS aims to include all species groups. A September 2000 conference brought together all the initial grantees as well as other interested parties to share information and plans and to agree on how to manage development of the system. A special issue of Oceanography magazine (Vol, 13, No. 3, autumn 2000) describes many of the challenges and aspirations for OBIS.

A potentially important partner in the Census is the Global Biodiversity Information Facility (GBIF). The GBIF was in June 1999 in Paris by 29 ministers of science or similar governmental leaders meeting in the Global Science Forum affiliated with Organization for Economic Cooperation and Development. The GBIF is expected to begin its operations early in 2001. Most preparatory activities for GBIF concerned terrestrial ecosystems. The CoML can form the major marine component of the GBIF. In the US, the Census has already been invited to be the marine part of the U.S. affiliate of GBIF, the U.S. National Biological Information Infrastructure.

The Steering Committee estimates the Census as a whole will require 10 years and a total of about $1 billion US$. In an international scientific program of this type, about half of this amount would typically come from US sources, public and private. The main cost of the program will be the field projects, which are likely to cost about $5-$25 million each. While Sloan and other private funders can catalyze the Census, most of the support will need to come from government agencies concerned with science, with fisheries, and with environment, as well as organizations such as the World Bank dedicated to capacity building in developing countries as well as with implementation of agreements such as the Convention on Biodiversity.

Planning and development for the Census will require about two more years. Pilot field projects should take place in 2002-2004. The main field projects should occur in 2005-2007. Analysis and integration of information should culminate in 2008-2010.

The direct goals of CoML are to create the historical data base on marine animal populations and a much more complete present picture. However, a census is most valuable when it is repeated. In this regard, we are paying careful attention to the relation of the CoML to the emerging Global

Ocean Observing System (GOOS), that supporters hope will become operational over the next 1-2 decades. The CoML can help bring the living marine resources component of GOOS into existence. The Census can help determine the design specifications for parts of GOOS and demonstrate its value.

Management of the CoML is centered on the International Scientific Steering Committee chaired by Frederick Grassle, director of the Institute of Marine and Coastal Sciences at Rutgers University. Dr. Grassle was the first biologist to explore the hydrothermal vents off the Galapagos Islands. The Census Secretariat, led by benthic ecologist Dr. Cynthia Decker, is housed at the Consortium for Oceanographic Research and Education in Washington DC. The Steering Committee has met 5 times since its formation in June of 1999, and will meet in 2001 in Bergen in February and Buenos Aires in October. The Buenos Aires meeting provides an excellent occasion to deepen Southern Hemisphere participation in the Census. The CoML website http://www.coml.org describes the program, which is now growing fast. We expect the Census team soon to be joined by a full-time senior scientist now being recruited in a worldwide search. This job should be one of the most exciting in marine science in the coming decade. Both individuals and institutions are critical for the success of the Census. I do want to note that the CoML does not require the creation of *new* institutions. In contrast, the success of the CoML depends on continuing, strong partnerships with organizations such as the International Council for the Exploration of the Seas (ICES), the Pacific International Council for the Exploration of the Seas (PICES), DIVERSITAS, the fisheries branch of the Food and Agriculture Organization of the UN, and the Intergovernmental Oceanographic Commission. PICES has formed a working group on the Census, as has the Scientific Committee on Oceanographic Research (SCOR). The SCOR working group, chaired by Canadian acoustician and Steering Committee member David Farmer, focuses on new technologies for the observation of marine life and their transition into practice. The work of the SCOR committee could stimulate POGO III, which will focus on technologies for biological observations. Such technologies, and the Census in general, require close partnership between national fisheries agencies and oceanographic research institutions. The Census also requires the contributions of marine laboratories and museums of natural history, repositories of much of our knowledge of marine biodiversity. At the instigation of Annelies Pierrot-Bults of the Zoological Museum of Amsterdam, more than a dozen such institutions participated in a meeting 15-17 November at the Institute of Marine Biology of Crete to explore their roles in the Census, and their goals for it. A consortium of aquariums for the Census is also forming, with leadership from the directors of the aquariums in Barcelona and Boston. Aquariums can make the goals and plans of the Census known to many of their 100 million or so yearly worldwide visitors, and thus to help build the public support that will assure continuing broad political and financial support for the Census. Later, they can help share the discoveries and findings of the Census as well as participate in the design and conduct of the field research.

Researchers in marine science, in my estimate, have made too little effort to communicate the excitement of their programs and findings with the broad public and to learn the public's goals and concerns for marine science. The major oceanographic programs of the past 20 years, such as the World Ocean Circulation Experiment (WOCE), Joint Global Ocean Flux Study (JGOFS), and Global Ocean Ecology Program (GLOBEC), are largely unknown even to the public

interested in science. And, the program on Acoustic Thermometry of Ocean Climate (ATOC) was extensively remodeled and delayed due to early inadequate public participation.

In closing, let me mention three ways in which POGO can help the Census of Marine Life and particularly the emergence of the Ocean Biogeographical Information System.

The first is to help a new culture emerge in biological oceanography with regard to data. Meteorology and, increasingly, physical oceanography have a tradition of sharing data, archiving it systematically, and keeping it accessible. Biological oceanographers need to become accustomed to building and using large, integrated databases. Within biology, geneticists already enjoy the immense benefits of such strategies with their databases of sequences. The bioinformatics revolution will penetrate all aspects of marine biology.

In helping lead this revolution, the POGO institutions need to consider their roles as digital libraries. What are long-run institutional obligations for maintaining web sites and servers? Who hosts? Who pays? OBIS will be a system of systems, but it cannot rely only on the good will of individual scientists maintaining good sites as hobbies or sidelines. Nor is it likely that national ocean data centers within government can or will carry the full digital burden in biology. Universities and research institutes are accustomed to operating traditional libraries, but few have given thought to reliably maintaining research resources in the form of the digital archives and websites that are rapidly become the infrastructure of marine science.

Along with inculcating a new culture into individual researchers, and facing new obligations at the level of the institution, POGO can play an important role in assuring wise national and international processes for the governance and management of OBIS, indeed for all data contributed to and collected for GOOS. Goals such as free access for data have been set for OBIS and GOOS, but the processes for making decisions about data are largely undefined. Issues include interoperability, standards, and quality control as well as intellectual property. Because the POGO institutions will be among the first to deploy the observing systems that populate OBIS and GOOS with data, they should think early and jointly about defining fair and efficient processes for running the global systems.

In closing, let me say that, like the Partnership for Observation of the Global Oceans, the Census of Marine Life begins with grand questions, but its successes will depend on mundane decisions about data handling, exemplified by the building of the Ocean Biogeographical Information System. The eventual glory will surely make us forget all the scut work to which we soon must attend.