On the Difficulty of Seeing What Is Near

Plenary Introductory Address

First NaGISA World Conference
NaGISA, Natural Geography of In-Shore Areas,
The Near-Shore Field Program of the Census of Marine Life
Kobe International Conference Hall
Kobe, Japan
15 October 2006

Jesse H. Ausubel
Program Director, Alfred P. Sloan Foundation
630 5th Avenue
New York NY 10111
Ausubel@sloan.org

On behalf of the Alfred P. Sloan Foundation and other sponsors of the NaGISA program, welcome to the First NaGISA World Conference. Thanks to Prof. Yoshihisa Shirayama, Robin Rigby, and the other leaders of NaGISA for their inspiring global long-range vision and for their practical hard work on the arrangements for this meeting of researchers from 27 countries. Thanks to the 100 researchers who have prepared papers and posters for this landmark gathering to build a consistent baseline description of the biodiversity of marine life near the shore. Happily, our ages span six decades, including high school scientists who will be caring for the oceans in 2050 and beyond, when the dream of NaGISA may be fully realized. We are all honored to meet in Japan, famous for its great tradition of scholarship in marine biology.

In my remarks I would like to introduce you briefly to the Census of Marine Life, of which NaGISA forms an important part. Then I would like to speak about some of the limits to knowledge that the researchers of NaGISA and other projects of the Census of Marine Life confront. Finally, I would like to share a few of the exciting discoveries of the Census during the year 2006.

Let me first offer an orientation to the Census of Marine Life. In the late 1990s several leading marine scientists shared their concerns with the Sloan Foundation that humanity's understanding of what lives in the oceans lagged far behind our desire and need to know.

Some of the scientists emphasized the chance for exciting discoveries about the world in which we live. Much remains to be discovered about the diversity of 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 and described. The age of exploration in the oceans is not over.

Other researchers highlighted the importance of establishing baseline information on the distribution of marine life. For most marine animals, we lack reliable maps of their range or distribution.

Still other researchers pointed to the changing abundance of many species and the need for improved management of fisheries and marine reserves. They noted increasing exploitation of largely unsurveyed areas such as the continental slope and sea mounts as well as violent debates about numbers of supposedly well-known species such as cod, tuna, and salmon.

Happily, the diverse scientists converged on a strategy to address their concerns: conduct a worldwide Census whose purpose would be to assess and to explain the diversity, distribution, and abundance of marine life. The founders of the program organized the Census of Marine Life around three grand questions: What did live in the oceans? What does live in the oceans? What will live in the oceans? They agreed to report in the year 2010 what we know about the oceans, what we do not yet know but could readily learn, and what may still be very hard to learn.

From the outset, the founders of the Census recognized that a survey of contemporary marine life would have much more value if compared with historical information. Their first grand question, "What did live in the oceans?", motivated the CoML program on the History of Marine Animal Populations.

This history program meets three challenges:

a) To create pictures of what lived in the oceans before fishing became important, a time 50 years ago in some areas, 500 in others, and one thousand or more in a few;

b) to dissect the influence of fishing, habitat loss, climate variability, and other factors on changes in marine animals populations since fishing became important; and

c) To create and make accessible long time-series on marine animal populations and related factors so that future researchers could more effectively study why marine animal populations change.

Joining the history program, the key components of the CoML are its constellation of field projects making new observations in diverse realms to address the question "What does live in the oceans?" The 14 major field projects together with affiliated programs span near-shore to open ocean, surface to abyss, equator to pole, and microbes to mammals:

- **Near shore** - Natural Geography of In-Shore Areas
  - Coral Reef Ecosystems
- **Coastal** - Regional ecosystems (exemplary study in Gulf of Maine)
  - Continental Shelves (Pacific Ocean Shelf Tracking)
- **Continental Margins** – Continental Margins Ecosystems
- **Abyssal Plains** – Census of Diversity of Abyssal Marine Life
- **Active Geology** - Chemosynthetic Ecosystems (hot vents, cold seeps)
  - Census of Seamounts
- **Mid-waters & Deep Oceanic** - Mid-Atlantic Ridge Ecosystems
- **Ice Oceans** - Arctic Ocean Diversity
  - Census of Antarctic Marine Life
- **Swimmers** – Top predators (Tagging of Pacific Pelagics)
- **Drifters** – Census of Marine Zooplankton
- **Microbes** – International Census of Marine Microbes

NaGISA shines especially brightly in this constellation of 14 field programs because its studies the ocean that most people actually see and feel, the near-shore.

Along with the History program and the Field Projects, the Census of Marine Life also embraces a program to help foresee what will live in the oceans. Named the Future of Marine Animal Populations, the FMAP program engages experts in numerical modeling and statistics who may become powerful allies for the scientists of NaGISA, as NaGISA builds up its observations and thus the basis for more speculative analyses.

The final element of the CoML is the database that makes the information of the Census of Marine Life widely and durably accessible. Called the Ocean Biogeographical Information System, OBIS already contains more than 10 million records on more than 70 thousand species. Every record in OBIS tells where an observation occurred, usually latitude, longitude, and depth, and includes other crucial information that qualifies the value of observations. By the time of the publication of the Census in 2010, OBIS will have records on all of the 220,000 or so known marine species. Moreover, OBIS links to other powerful databases, for example, databases that provide genetic descriptions of species and information about the location of specimens available for study in natural history museums.

I have already mentioned the year 2010. All the components of the Census have agreed to aim toward the 2010 synthesis. The synthesis is only four years away, so all the programs of the CoML must already ask themselves: What is the most we can say by 2010? How should we adjust our research plans to make the best possible contribution to the 2010 Census? Of course, marine biology will continue after 2010, but the CoML in 2010 provides the community unique opportunities to establish a baseline of information and to draw worldwide attention to the state of the oceans and coasts.

Although we are now about halfway along in time, in effort the Census will reach much higher peaks during the next four years. During the next three days we will hear the growing results of NaGISA, and we will also advance our plans to accomplish even more by 2010. My hope is that the accomplishment of NaGISA by 2010 will be so great, that the world will demand that NaGISA continue to the year 2050 and beyond. In a world of climate change, acidification of the oceans, great flows of nitrogen from the land to the sea, and urbanization of coasts, the continuation of NaGISA is, I believe, a necessity. The attendees at this meeting must persuade the world of the importance of NaGISA.

Limits to Knowledge

Let me now turn to limits to knowledge. I strongly believe that it helps to understand what you know and why you know what you know, what you do not know but might readily learn, and what it is very hard to learn or might even be unknowable. That is, it helps to understand the limits of knowledge. In the Census we often refer to these limits by speaking of the known, the unknown, and the unknowable. For both producers and consumers of knowledge, knowing what you do not know, like writing *terra incognita* on a map as Roman geographers used to do, can be as valuable as adding detail to lands you have explored. Disclosing the limits to knowledge can be among the most useful of acts. Such disclosure helps people to choose where to explore, to avoid frustration, and to hedge bets or choose insurance.

The limits that separate knowledge into the known, unknown, and unknowable are numerous and diverse. Like biodiversity, these limits call for taxonomy. Let me offer a taxonomy of limits to knowledge in which I classify the limits into five families:

1) the vast expanse of the oceans
2) difficulties encountered when assembling parts into a whole
3) blinders we put on ourselves
4) surprise interventions from outside
5) the invisibility of the lost past

The first family of limits, the vast expanse of the oceans, encompasses physical and practical barriers. It is hard to see what is far or dark or deep or at high pressure. A fundamental reason that knowledge of marine life remains crude is simply the impermeability of water to light. The expanse also challenges the timeliness and frequency of observations. Only a few governments regularly send out research vessels or divers to make direct scientific measurements for assessments of stocks. The ships trawl nets whose mesh size matters greatly. They trawl only in a few locations. Their sonars probe only narrow swaths which fish might avoid because of vessel noise or pressure waves. The survey vessels sample a tiny fraction of the sea, mostly near shore and at shallow or a few depths. Technology offers stunning progress in observing marine life, but an ocean observing system that regularly reports a quite complete picture to us is many decades away.

We may think of the near-shore as in some way easier to study than ocean realms. Light penetrates it. Our biological research stations are often located nearby. Near-shore researchers can retreat from storms. Yet, NaGISA reveals many limits. No one understands better than coastal researchers the vastness of the ocean. We cannot study every meter of coast-line. Rarity and patchiness are very hard problems. The size spectrum of animals challenges sampling. So does the frequency of fluctuation. We must carefully choose where and when to make transects. So, the vastness of the ocean creates limits to knowledge for NaGISA that we must consider.

The second family of limits, assembling parts into a whole encompasses both statistical challenges and models. Serious problems mar fisheries and biodiversity statistics. Fishers tend to underreport catches, and commercial activity addresses fished stocks, rather than fish stocks. "By-catch" data are used to fill in estimates of some other species but also suffer biases. The question of whether a species is truly absent or present and uncounted bedevils many biodiversity data sets. And even species counted as present may be misidentified. The notion of "effort" to index the intensity of observation is all too human and vulnerable. In turn, little is known about the validity of the mathematical models used to turn available data into assessments of stocks or abundance. For many species, the sparse knowledge of life cycles may limit the realism of models. Models themselves suffer limits of many kinds, including simplification, mathematical forms used, and errors in describing initial conditions. Few models capture extremely sensitive, non-linear systems where, for example, an ecological regime shifts from dominance of one species to another. The near-shore offers some opportunities to conduct controlled experiments that allow testing of hypotheses and verification of models, but many factors may be difficult to control or unrecognized. Scaling affects near-shore studies acutely.

Eventually NaGISA aims to address critical large-scale questions such as equator to pole latitudinal gradients for biodiversity. Can we assemble the parts of NaGISA, already 128 transects from 51 countries, into a whole? The next three days will reveal some of our present limits to knowledge in this regard and challenge our creativity to overcome these limits as the Census grows toward 400 or more NaGISA transects.

The third limit, the blinders we put on ourselves, stems from economic as well as cultural factors. The agencies that carry out stock surveys, such as environmental or fisheries ministries, have little funding for them and thus obtain small or short samples. The bias is often toward commercially important and charismatic species and convenient or attractive locations and seasons. Governments in most countries have weak means to verify or rectify the numbers they receive. Disciplinary myopia causes experts to overlook species or data, too. Although by weight microbial life might make up 90% of ocean biomass, researchers largely ignored it until recently.

We all bring cultural biases to our work as well that lead us to exclude or discount certain kinds of data and information. What is near may seem so familiar that we cannot observe it objectively. Often we know only what someone else is willing to pay for, whether an oil company or a local government. Sometimes a limit arises because a researcher cannot find or afford a colleague with expertise to resolve a species identification, or pay for a genetic test or recover DNA. Most of us believe that NaGISA transects repeated at least once per year for 50 years would produce a treasure of science, but the practical limits our society creates limits our knowledge. NaGISA might create practical tools, like species checklists and software for identification and information registration, that help prevent blinders from settling on our eyes.

A tsunami exemplifies Surprise Interventions from Outside, family 4 of Limits to Knowledge. It certainly would change a NaGISA transect. So do oil spills. A prohibition against fishing would be a surprise intervention by people as surprising to fish as Earth's surprise of a tsunami. Abrupt changes do from time to time disturb our orderly world. Events whose distribution is not well understood can harshly limit our knowledge.

A fifth family of limits, supremely important for the near-shore, is the invisibility of the lost past. Some phenomena leave no traces or; or they may have left traces but we cannot find them. Reasoning backwards to what has disappeared challenges the imagination. What Scripps historical ecologist Jeremy Jackson calls "shifting baselines" may fall into this category of lost in the past. In New York City, my home, many are shocked and disbelieving that reefs of oysters almost the size of Kobe's Portopia Island dotted New York Harbor 200 years ago. Having forgotten what existed, we simply think something different never existed. Even if the animals may be lost in the past their oil, bone, dyes, and fur may survive intact or in records. NaGISA researchers need to keep in mind the invisibility of the lost past and confront this limit. NaGISA can open the eyes of the world not only to the actual but to the potential richness of the near-shore.

During the next three days let us win improvement by exploring the limits to our knowledge of seeing what is near. Our apparently easy problem is in fact very hard. Let us define limits and then devote ourselves during the next four years, and fifty-four years, to rapid advances into the knowable unknown.

<u>Discoveries</u>

Limits may discourage us, but overcoming limits brings joy. Before closing let me share 8 examples where, during 2006, the Census of Marine Life, pushed out the extremes that mark the boundaries of knowledge. Extremes of speed written in record books define the limits of one sort of human accomplishment. Similarly, extremes can define the limits of knowledge, with each record-breaking extreme pushing out the limits.

Hottest. At a thermal vent three kilometers beneath the equatorial Atlantic, CoML vent researchers encountered water at a broiling 407 degrees C. In this heat that could easily melt the metal lead and nearly melt zinc, life went on! Although the species resembled those around other vents, differences in chemistry open an opportunity to learn how life adapts to the melting point of zinc.

Deepest. Five km below the surface of the Sargasso Sea, in the deepest zooplankton trawl yet accomplished, CoML experts from 14 nations caught these drifting, often soft and elusive animals in a sophisticated net. They collected more than 500 species, likely including 12 wholly new species, eating each other at the great depths the net reached or living on the organic matter falling like snow from above.

Oldest. CoML seamount researchers found a shrimp, believed extinguished 50 million years ago, alive and well on a seamount in the Coral Sea. Living so long ago, it merits its common name of "Jurassic shrimp", but the scientists who study invertebrates call it *Neoglyphea neocaledonica* and feel they have rivaled the discovery in Indonesia of the coelacanth, a prehistoric fish once known only in fossils.

Richest. In the sense that biodiversity is richness, the liter of sea water from near an eruptive fissure 1500 meters deep on a seamount in the Northeast Pacific where CoML researchers found 20 thousand kinds of bacteria floating is the richest. Revealed by DNA studies, most of the 20 thousand kinds were unknown and likely rare. The richness of the diversity invites speculation about what rare species contribute to their biosphere and also invite an estimate that the kinds of bacteria in the oceans eclipse five to 10 million.

Farthest. With tags first attached to sooty shearwaters and then continuously monitored by satellites, CoML researchers of top predators mapped a small bird's 70,000 km search for food, back and forth across the Pacific Ocean, from Chile to Japan to California and New Zealand in a giant figure eight. Making this longest trip of an animal ever recorded electronically in only 200 days, the bird averaged a surprising 350 km per day.

Most. CoML coastal ecosystem researchers of the Gulf of Maine area project's observation off the New Jersey coast of 8 million herring swimming in a school the size of Manhattan Island qualifies as most abundant. Sound focused by a new technology scans oceanic areas a million times larger than previously studied. It updates its images and censuses instantaneously and continuously, revealing the extension and shrinking, fragmentation and merging of the island-sized schools as a person might watch schools of minnows swimming in a brook beneath a bridge.

Darkest. A whole community of marine life shrouded beneath 700 meters of thick ice in the Southern Ocean surprised CoML Antarctic scientists. Who could have expected that the dark sea floor deep beneath ice and 200 km from open water could provide a habitat for so many species?

Biggest. Among the many new species discovered by CoML participants during 2006, the 4 kg lobster that NaGISA's Charles Griffiths found off Madagascar may be the biggest. Named *Palinurus barbarae*, it extends two-thirds of a meter and prompts questions how the giant reached the isolated habitat and how it replenishes its population.

This last extreme surprise, from the NaGISA community, exemplifies the excitement we will share in the first NaGISA World Conference. The set of discoveries was made collectively by the 2000 scientists from 80 countries of the CoML, including the hundreds of scientists of NaGISA, more than a hundred of whom are in Kobe. The shearwater that flew 70,000 kilometers did not carry a passport. I hope for the next three days everyone in this room carries only a Census of Marine Life passport with a NaGISA stamp, exemplifying our systematic challenge to the limits of knowledge of marine biodiversity and to the science and conservation of ocean life. Together, we can see clearly the marvels of what is near and excite the world to preserve and increase them.