Assessing the Global Distribution and Abundance of Marine Organisms

Overview of an Ocean Studies Board Workshop held on January 13-15, 1998 in Monterey, California

Context for the Workshop

On January 13-15, 1998, the Ocean Studies Board (OSB) organized an informal workshop at the Monterey Bay Aquarium to discuss the "value, timeliness, and feasibility of stimulating, designing, and organizing a period of intense, comprehensive oceanic observation whose purpose would be to assess and explain the global distribution and abundance of marine life." The topic for this workshop was framed by Jesse Ausubel of the Alfred P. Sloan Foundation in materials provided to the OSB in January 1997 under the title "The Census of the Fishes: Initial Thoughts." Based on the initial concept outlined by the Sloan Foundation, the OSB members felt that it would be appropriate to examine whether an in-depth study on this topic would be desirable. The workshop was proposed to begin to explore the potential scientific value of such a projects as well as its technical and political feasibility The Sloan Foundation agreed to fund such a workshop in June 1997, a steering committee was established by the OSB, and initial planning began.

Independent of the OSB workshop, the Sloan Foundation sponsored a number of other workshops to examine specific components of the "Census" concept further. These workshops covered the following topics: (1) effects and characteristics of a global assessment program on ichthyology and ocean ecology (held at the Scripps Institution of Oceanography, March 13-14); (2) the technologies that might be required to undertake a global assessment program (held at the Scripps Institution of Oceanography, October 16-17); (3) characteristics of a global assessment program for marine benthic organisms (held at Rutgers University October 30-31); and (4) characteristics of a global assessment program on non-fish nekton (held at the New England Aquarium December 10-11). The OSB steering committee used the information and topics discussed at these workshops to help formulate the agenda for the OSB workshop. During the course of workshop planning, Melbourne G. Briscoe, Director of the Processes and Prediction Division of the Office of Naval Research, expressed interest in the topics being considered and agreed to co-sponsor the event.

Based on results from the previous workshops and informal discussions with scientists, it appeared that it would be most valuable to provide a cross-section of various scientific disciplines (see attached participants list). This would provide some early indications of whether such a program could have widespread appeal and whether any consensus on possible future activities and approaches could be reached. The participants invited represented a wide-variety of disciplines including benthic ecology, marine policy, acoustics, stock assessment, marine ecology, invertebrate biology, modeling, and physical and biological oceanography. Approximately one-fourth of the meeting participants represented non-North American nations to help provide perspective on the applicability of this topic in other regions. Roughly one-third
of the workshop participants had also attended one of the four previous Sloan-sponsored workshops.

**Structure of the Workshop**

The first day of the workshop was spent in general discussion of the topic. Participants who attended the four previous Sloan workshops provided summaries of those discussions and any consensus that was reached. Participants were encouraged to think broadly and voice their opinions and concerns as openly as possible. They were reminded that this preliminary exploration was not intended to reach any consensus conclusions about the future of a global assessment program.

On the morning of the second day of the workshop, the participants were broken into three groups to discuss possible approaches to an assessment program: (1) a survey of marine abundance and distribution; (2) a survey of marine biodiversity; and (3) a study of ecosystem function and processes. These groups reconvened and provided synopses of their findings. In the afternoon, two new groups were formed and asked to identify technical and scientific challenges to conducting a global assessment program. The participants were shuffled to help encourage cross-disciplinary discussion. On the morning of the third day, both groups reported back to the plenary and a general discussion followed.

**General Overview**

At the end of the workshop both groups indicated that the "grand challenge" to be undertaken in a global assessment program would be to determine the patterns of life in the ocean, the mechanisms by which these patterns are maintained, and the amount of life can the ocean sustain. Both groups agreed that addressing this grand challenge would require an analysis of trophic structure and dynamics, biomasses and fluxes of organisms, species richness, and relative abundance, ecosystem variability, spatial and taxonomic distribution, and ecological processes. Greater understanding in these areas might aid in predicting the causes of ecosystem change and resulting consequences on fisheries, mammal populations, species interactions, and other components of the marine ecosystem.

**Discussion Topics**

*Existing and historic data*

Throughout the meeting, several participants advocated that one of the possible roles of a global assessment program would be to catalyze the coordination and review of historic and existing data sources. Several participants indicated that starting a new program without reviewing the existing data would be a less efficient use of funds, and may not provide a comparative context for new observations. Programs such as Fishbase, Reefbase, and other databases that are attempting to incorporate information from disparate sources were cited as possible examples. Protocols for ensuring data quality, coordinating reporting mechanisms, and other input controls were cited as critical requirements for compiling databases.
Participants discussed the relative roles of observations and modeling extensively throughout the meeting. Several participants suggested that the most appropriate approach would be to compile existing data and review current ecological models (including particularly multi-species fisheries models), focusing any new observational efforts on those processes and taxonomic groups that the models did not adequately describe. Without adequate synthesis, a program focusing primarily on funding observations may not provide cohesive conclusions at the end of its programmatic life. The incorporation of existing and new observations into a framework of ecological theory and modeling should be included in any global assessment effort.

A variety of technological discussions continued throughout the meeting. Participants actively involved in developing acoustic, optic, and other monitoring technologies felt that the integration of various sensors and platforms that currently exist could be valuable for addressing many of the observational needs of a potential program. Tagging technology was felt to hold promise, particularly for marine reptiles and marine mammals. Cataloguing acoustic target strength, combining optics and acoustics, using autonomous underwater vehicles, and developing new platforms were all cited as important components of a potential program. Remote species identification was noted to be a central requirement for any significant effort to assess the biomass of single species. New approaches such as lagrangian sensors and the continued miniaturization of archival and pop-up tags were considered to be important potential contributors to a program. Several participants felt that advocating technological development would provide promising new avenues to address and resolve difficult issues in marine research. Those involved in developing technologies felt that new technology developed best and most rapidly when in response to a particular scientific need.

Much discussion focused on where such a program might be undertaken. Splitting the globe into biogeographical regions for purposes of the study was strongly advocated. The participants recognized that the program could not proceed throughout the global oceans at the necessary level of detail. One possible approach to an assessment program would be to use existing data on better known systems while focusing new observational efforts on less well known regions. Many of the participants remarked that areas such as upwelling zones, coral reefs, the North Sea, and many coastal zones are relatively well-known. Areas such as the open ocean, including specific zones such as the mesopelagic and key taxonomic groups including squid, gelatinous zooplankton, and medium-sized fish, among others, were thought by many to be areas where improved observation and modeling could result in quantum leaps in our ability to make global assessments of higher trophic levels. Several of the participants suggested that specific locations could be selected and an epipelagic to benthic survey could be conducted and compared with other regions. International participants indicated that unless there was significant coordination between better equipped science programs and their national agencies many countries would have little interest or potential role in regional assessments. A number of participants also stated
that getting some preliminary concepts of existing biogeographic units based on existing data would be helpful in guiding future observational and modeling efforts.

*Trophic levels*

Early in the meeting, many of the participants assumed that the focus of a global assessment program would be the higher trophic levels, specifically economically important species. As the discussions developed a focus on ecosystem processes became more attractive to many participants. It was felt that lower trophic levels, including phytoplankton and zooplankton, could be key components to the program. Several of the international participants noted that in many countries economically important species would have to be a key focus to maintain interest and political motivation for participation in such a process. Generally, the participants felt that studying higher trophic levels could be a focus of any potential program but that ecological data on primary production, and biological, chemical, and physical oceanography, would need to be incorporated into any potential program.

*Biodiversity*

Many of the participants stressed the importance of understanding biodiversity and species distributions to detect ecosystem change. It was felt that the global distribution of many taxonomic groups, including benthic corals, anemones, crustaceans, mollusks, and bryozoans, among others, could be generated with some accuracy using existing data. While there was some disagreement, most participants felt information on biodiversity and species richness was crucial for a global assessment program.

*Potential products*

A number of potential products that had been discussed at previous meetings were brought up during the workshop. Several participants recommended incorporating data in zoogeographic maps of species richness and relative abundance for key fish and benthic species. Some participants felt that observational programs could be incorporated into existing ecological models, others felt that data on key fishery stocks would be helpful adjuncts to existing stock assessment processes. Most participants seemed to support the concept of providing data in internet accessible form, preferably in a relational database format.

*Program requirements*

The participants had a variety of different views on what programmatic needs such an undertaking would have. Many participants felt that a pilot program in limited geographic regions might provide an impetus for consolidating funding. There was general agreement that starting out with a decadal time frame seemed appropriate. An initial period of data compilation followed by observation and modeling efforts and a shorter synthesis phase was considered. The participants suggested that typical funding sources such as the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA) should be augmented by additional non-traditional sources including the fishing industry, the International Monetary Fund (IMF), the Food and Agriculture Organization (FAO), or other governmental sources,
particularly in the developing countries. The participants recognized that "selling the idea" to the public as well as program officers at government agencies and elsewhere would require a clear, concise message with strong societal and scientific relevance. Several participants suggested that projected imbalances in marine food supply and demand might help garner public support for a potential program. Furthermore, participants felt that unless the broader ocean science community can be convinced of the value of the project, it is likely to face significant difficulties.