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Report to the Sloan Foundation:
Technology Workshop for the Census of the Fishes

Oct 16-17, 1997

Jules S. Jaffe and Wm. A. Nierenberg,
Scripps Institution of Oceanography

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At the request of the Sloan Foundation of New York, a two day workshop was held at the Scripps Institution of Oceanography. The workshop was convened on October 16-17, 1997 and was led by Jules S. Jaffe and Wm. A. Nierenberg of Scripps. The names of the participants in the workshop are contained in Appendix A of this document. Approximately 15 participants were from the U. S. with another 6 from foreign countries. The format for the workshop consisted of a series of talks by the individual investigators which were followed by more open ended discussions. The questions asked of the workshop conferees, by the Sloan program manager, Dr. Jesse Ausubel, was, whether a "Census of the Fishes" made sense, and if so, what were the appropriate types of new technologies that one could imagine that could be used to accomplish such a purpose in the near future (~ 3-5 years). After the approximately 18 presentations, there was a great deal of interesting discussion relating to these issues. This document is a brief report of the meeting and contains the impressions of the organizers of what transpired and what the impact of the discussions meant for the "Census of the Fishes" efforts.

The bulk of the meeting consisted of the presentations by the attendees. Since the habitat of fish can be divided into a broad range of different types such as coastal and open ocean with special subcategories such as coral reefs and deep sea, investigators whose specialties encompassed these various areas were recruited to attend. A fortunate aspect of the meeting was that participants from all of these areas were in attendance. In addition, since it seemed that the most relevant technologies for the census would be acoustics, optics, and molecular biology, experts in these areas were also invited. Fortunately for the purposes of this meeting, almost all of the invited scientists chose to come to the meeting. Over the course of the two days, all of the participants learned a great deal about their colleagues work and what the state of the art in ocean technology relating to the goals of the program is.

Since the census of the fishes is aimed at addressing the determination of both species and abundance, the presentations were focussed on how the research of the presenters could further these goals. The conferees presented examples of their own work, considered to be "state of the art". The general conclusions of the meeting, as gleaned by the authors of this report were that, due to the ever increasing sophistication of modern technology and the lack of a large scale effort by the funding agencies to take advantage of these technologies, that a great deal could be gained from both the development of new technology and the application of such technology to the "Census of the Fishes". Areas include the ever increasing ability to process more data, with more discriminatory power, the explosion in miniaturization of electronic components, and the development of molecular biological techniques for looking at species diversity and heritage. There was wide spread acknowledgement that, due to the critical nature of the state of the global

ecosystem with respect to fish population and diversity, a census of the fishes program was both valuable and timely.

In the case of the acoustics, the presentations centered on the research programs of the individual investigators and the use of acoustics to measure both the abundance and species of fish. Generally speaking, sound waves offer the capability to assess the distribution of fish in moderately large volumes of water (.1 km^3 - 100 km^3) because of the usable range of the sound which is typically 100's of meters to 10's of kilometers for the frequencies of value to the measurement of fish abundance. The most modern set of acoustical tools employ both multibeam echosounders and also the use of wide band sonars which, as demonstrated at the meeting, have the ability to count the numbers of individuals and also to discriminate (to some degree) the type. In a typical survey, the acoustical information, capable of a broad swath, is combined with the results of net trawls for "ground truthing" of the animals. This then permits extrapolation of the echo sounder results to a larger swath of animals. Several examples of the use of the mathematical and pattern recognition technique of neural nets to discriminate fish species were shown. An additional technique which uses a type of sonar tomography was also presented at the meeting. In addition, in evaluating tools that could be of value using sonar, one of the authors of this report (WAN) noted that methods of synthetic aperture sonar could have promise in that a small towed body could be used to obtain high resolution images. A more detailed comparison of the advantages of these different methods than possible here would be needed in order to evaluate the relative merits of these different techniques for the "Census of the Fishes" program.

Several of the conferees showed examples of the use of optical techniques. In one case, the use of pulsed lasers was demonstrated, and the ability of the method to evaluate the abundance of large schools of fish in surface waters was impressive. Advantages of such a method, for oceanography, are that the technique combines the speed of light with the speed of an airplane, in contrast to the case of the sonar which combines the speed of a surface ship with the speed of sound. Of course, the technique is limited to several "optical depths", a function of water clarity. As such, the method holds the most promise for species that are located in the surface waters.

Special problems exist in several areas: coral reefs, the measurement of species in the open water (pelagic species), and in the deep sea. Certainly, these areas are very exciting because they suffer from the greatest technical limitations. As such, an increase in technological capability in these areas could lead to quite startling advances. In the case of coral reefs, most types of traditional sonars do not work because of the acoustic "clutter". New, multibeam, high frequency systems get around these problems to some extent; however, optical methods are still necessary to recognize exact species. In the case of the large open water pelagic species, it has occurred to one of authors of this report (JSJ) that the evolution of new sensors to allow tagged animals to be more accurately tracked (via inertial sensors or current sensors) could lead to new advances in our ability to monitor these animals. Finally, the deep sea is an area that could yield very interesting data with increased technological help. This area has been somewhat inaccessible, primarily due to the cost and difficulty of preparing and deploying sensor packages to these depths.

Although the meeting discussions were not concerned too much with sampling strategies, it is clear that any full fledged effort to census marine animals would necessarily need to examine

these issues. The use of "ships of opportunity" seemed exciting, especially for areas such as the South Pacific and the west part of the Indian Ocean, widely regarded as extremely undersampled. Other methods which did receive some degree of consensus considered the installation of "toll gates". That is, sets of moorings which were placed in strategic locations where it was known that a great many animals can be found in their migratory routes. Finally, one of these authors (JSJ) was surprised at the lack of interest in the use of satellite imagery. This seemed curious, especially when fisherman are using these techniques more and more to identify potential areas for large schools of fish.

Enclosed with this set of documents are the transparencies donated by some of the authors who made presentations at the meeting. They are by no means complete, however are quite representative of the presentations that took place at the meeting. Several articles are also enclosed. These were submitted by several of the attendees and felt to be of particular relevance to the topics discussed at the meeting.

Finally, our impressions of the answers to the basic questions asked by Dr. Ausubel, that is: Is a census of fishes interesting from a scientific point of view? and, are the technological opportunities to make such a census feasible worth pursuing, are yes, and yes. Certainly, all of the participants to the meeting, including the authors of this document went away from the meeting with the definite impression that there was much to learn that is new and that advances in technology make such an effort a feasible endeavor.

Appendix A: List of Attendees

Jesse Ausubel, The Sloan Foundation, New York, NY

Jules S. Jaffe, Scripps Institution of Oceanography, La Jolla, CA

William Nierenberg, Scripps Institution of Oceanography, La Jolla, CA

Duncan McGehee, Tracor, San Diego, CA

D. Van Holliday, Tracor, San Diego, CA

Carla Scalabrin, IFREMER Centre de Brest, Plouzane, France

Paul E. Smith, La Jolla, CA

E. John Simmonds, Marine Laboratory, Aberdeen, Scotland

James H. Churnside, Chief, Ocean Remote Sensing, NOAA Environmental Technology Laboratory, Boulder, CO

M. Trevorrow, Institute of Ocean Sciences, Sidney, Canada BC

Stephen B. Brandt, Director, NOAA - Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan

Kim Holland, Associate Researcher, University of Hawaii at Manoa, HI

M. Furusawa, National Research Institute of Fisheries Eng., Kashima Ibaraki, Japan

Orest Diachock, NRL, Washington, DC

M. Elizabeth Clarke, Associate Director, Ocean Studies Board, National Academy of Sciences, Washington, DC

Amatzia Genin, H. Steinitz Marine Biology Lab, The Hebrew University of Jerusalem, Eilat, Israel

Julia Parrish, University of Washington, Dept. of Zoology, Seattle, WA

Ken Smith, Scripps Institution of Oceanography, MBRD, La Jolla, CA

Anne Bucklin, University of New Hampshire, OPAL, Durham, New Hampshire

Clarence Clay, Prof. Emeritus, University of Wisconsin, Dept. of Geology & Geophysics, Middleton, Wisconsin

Dan Walker, Ocean Studies Board, National Academy of Sciences, Washington, DC

Edith Widder, Div. Ocean Marine Sciences, Harbor Branch Oceanographic Institution, Fort Pierce, FL

Waldo Wakefield, Rutgers University, New Brunswick, NJ

Manell E. Zakharia, Laboratoire d'Acoustique,Systemes, Signaux et Sonar, Villeurbanne, France

G.F. (Skip) Denny, Scientific Fishery Systems, Inc., Anchorage AK

John Meyer, President, Meyer Sound Laboratories Inc., Berkeley, CA