PREFACE

These thoughts on wide-scale studies of the ocean were presented in a manner as informal as possible before such a large group. The speakers used rough notes in some cases and finally edited manuscripts in others. The style of the presentations will be seen to vary. This variation reflects both the individual style of the speaker and the nature of the topic he was asked to discuss: some topics lent themselves to a precise discussion of data while others could be approached only through the necessarily coarse appraisals of future capabilities and future support.

Unfortunately it was not possible to record completely the discussions that followed. Rapid interchanges defied the traveling microphone as well as the scribbling chairman.

I regret that Lee Alverson has been unable, for various reasons, to prepare his paper "How an Ocean-Wide Survey of Adult Fish Might Be Carried Out, and What Might Be Gained From It" for publication at this time. It was presented as the sixth paper of the Symposium and would have been a valuable contribution.

On behalf of the participants in the Symposium I wish to thank those who made the Symposium possible:—to Dr. William A. Nierenberg, Director, and to the Scripps Institution of Oceanography for their sponsorship and their arrangements; to Mr. Julian G. Burnette, Chairman, and to the Marine Research Committee of the State of California, for their support and encouragement of the purposes of the Symposium; to the secretary and recorder, Mrs. Lorayne Buck and Miss Barbara Edwards and to Mrs. Ruth Ebey for her valuable assistance to the editor in preparing these proceedings.

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INTRODUCTORY STATEMENT

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The last few years have produced many new ideas and discoveries in oceanography and many new techniques and instruments for studying the ocean.

On the other hand, many of the discoveries may turn out to be discoveries of new problems, and many of the instruments and techniques, which were developed to solve older problems by making more precise and continuous measurements, have finished by revealing such complexity that we have to reformulate the original problem and start anew.

A classic example of an instrument that works beyond reproach, and measures just what we asked for is the GEK—it does indeed measure the surface velocity in the ocean remarkably well. Yet when we see the results we realize that for many, and perhaps most, purposes, this isn't what we wanted at all. The results show such complexity and such rapid fluctuation in both time and space, that a single observation, no matter how accurate, can tell us only what the average velocity was in one place during the 10 minutes required to make the observation. If we want the average flow during a day, or a week, or a year, we can get this from the GEK, but we have to continue the measurements for a day, a week, or a year to get these averages. This is not a practical instrument, then, for measuring the large-scale circulation of the ocean very economically, though it is extremely good for other purposes.

If we are to get at large-scale phenomena we must use instruments and methods which will provide data over large areas and over long periods, and we must consider very carefully whether the ideas and tools at hand can be used economically for the study of these phenomena.

At a recent meeting, the Scripps staff reported its immediate plans for research and I have chosen two or three examples of things mentioned there which bear upon or could be brought to bear upon large-scale phenomena.

One of the proposed tools was a modification of the Hardy plankton sampler to be towed vertically to reveal with one tow the stratification of various plankton. If the results constitute a usable integration in space so that some immediate quantification can be made, this may well be useful for large-area studies. On the other hand the results may show such a complexity in both time and space that the instrument can be used only to study this complexity.

Likewise, continuous records of nutrients and chlorophyll can be made. When a reasonable amount of data are at hand, we will have some notion of how close in space and time we need to measure these properties in order to quantify and study them, and how one ought to plan large-area studies of productivity in the ocean.

Quite a bit of development has been done in instruments to measure at abyssal depth the time variations of such properties as temperature, pressure and flow. Curiously, the first results of deep current measurements suggest that there is a reasonably large-area coherence of the deeper flow, and that perhaps we don't need 10,000 deep current meters each operating for 10 years to make a useful estimate of the deep circulation, but that a few dozen operating for a few months may reveal the major circulation. This is almost certain to be true for tides, of course, since they do have a very large-scale coherence.

For studies of longer-period fluctuations there are the sediments, which record in a more or less obscure form many aspects of the past environment. In areas of rapidly depositing and seasonally undisturbed sediments it may be possible to establish a great deal about the very recent past—perhaps details of fluctuations of populations and hence environmental conditions during the last 1500 years. This is especially exciting to physical oceanographers and to meteorologists. Most of us believe we could do something useful with a 1500-year record, since the fluctuations would probably be within a range we could compare with the last 30 years or so. We are not so sure how to use bits of information from 50 or 100 million years ago, when the ocean itself might have been very much different, and our present notions not at all applicable.

Of course, the CalCOFI program has itself contributed a great deal that can be used in planning the study of ocean-wide variations of many of the important items. Fish eggs and larvae, young and adult fish and general zooplankton studies in the California Current ought to give some useful time- and space-scale information about how to study the biology of the wider areas. The California Current temperature and flow measurements cover quite a large area and some 15 years of time, and during the last 10 years have been augmented with the eastern Pacific monthly surface temperature maps. These have been among the first series of reasonably large-scale synoptic data for the ocean and have led to some ideas about the relation between ocean and atmosphere. The Rancho Santa Fe symposium in 1958 (published as vol. 7 of these Reports in 1960) was called to describe and discuss one of the remarkable fluctuations in ocean temperature and populations and to try to relate this to the atmosphere.

The papers presented there and many others written since have dealt with large-scale matters in many fields, including trans-oceanic migration of fishes, zoogeography of the entire Pacific, and general studies of the ocean circulation of the Pacific and its relation to the atmosphere as only a few examples.

For this reason it has seemed appropriate to convene a symposium on wide-scale studies of the ocean at this CalCOFI meeting, and to invite these distinguished people to tell us about the newest developments and plans, or indeed to suggest a few plans, about how we might approach the broad problems in their fields in useful ways.