Overview

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The payoff in increase of knowledge often is greatest the more unconventional the idea, especially when it conflicts with collective wisdom.
—Henry Stommel (1989)

In his somewhat whimsical and futuristic article in a 1989 issue of *Oceanography*, the eminent oceanographer Henry Stommel describes what it might be like working in the Slocum Mission Control Center of the World Ocean Observing System. He describes a vision of a facility capable of monitoring the global ocean, using a fleet of small neutrally-buoyant floats dispersed throughout the oceans and transmitting back a variety of real-time oceanographic data to Mission Control Central. Stommel was a visionary and one of the first oceanographers to recognize and articulate the need to study the oceans on space and time scales that are appropriate to better understand their dynamic natural processes. Through recent technological advances and pressure from societal needs, a realization of Stommel's vision of the future is rapidly approaching.

As with most of the geophysical sciences, progress in ocean research has been driven strongly by the ability to make new observations—either located in new *places* (i.e. classical exploration-going to places on Earth that have not been observed before) or new *types* of measurements that permit natural phenomena or processes to be understood in different ways. The state of knowledge concerning our planet's oceans is built primarily upon this foundation of "spatial" exploration.

As our knowledge of the oceans has improved, observational oceanography has evolved to include "process studies"—where both location and observational strategies are chosen carefully to enhance the likelihood of gaining insight into the physics, chemistry, or biology of one particular active process. Simultaneously, the realization has grown that few characteristics of the ocean are in steady state—the ocean and the seafloor beneath are highly dynamic environments. If these processes are to be understood, if new insights are to be gained, if quantitative models are to be validated satisfactorily, then observations are needed over the time scales appropriate to the dynamics of these processes. We know enough today to realize that these time scales span milliseconds to decades, centuries and beyond—leading to a need for sustained time-series observations.

When investigators work to understand the ocean by making sustained time-series observations they are, in effect, *"exploring-in-time"*. Historically, oceanographers made great discoveries by conventional spatial exploration—they traveled to new places in the oceans and discovered unexpected phenomena that advanced our understanding of a particular process to a new level. Today, important and oftentimes unexpected discoveries result from the collection of long time-series data sets.

In parallel with this intellectual evolution that is yielding new insights into the dynamics of Earth and ocean systems, the technology that is needed to make the required measurements is evolving at a comparably rapid rate. A number of highly successful pilot experiments using seafloor cables have revolutionized measurement strategies by bringing continuous electrical power and data bandwidth to the seafloor. Profiling floats and gliders have been used in conjunction with seafloor observatories to provide a synoptic view, in real time, of basin-scale circulation of the upper ocean. Autonomous underwater vehicles with decision-making capability are making measurements on temporal and spatial scales never before possible.

This special issue of *Oceanography* is dedicated to the topic of ocean observations as a means of obtaining long-term or time-series measurements both for research purposes as well as for societally and economically motivated purposes. Becker and Gould provide historical perspectives on the scientific origins of two types of observing systems—one based on requirements for seafloor studies, the other for water column and climate research. D. Martin chronicles the development of a national ocean partnership dedicated to the provision of routine ocean measurements for a variety of end-users. Perry, Glenn, and Tunnicliffe, and their collaborators, describe the motivation, development, and implementation of three different types of observatories. Scavia et al. describe how the U.S. National Oceanic and Atmospheric Administration (NOAA) addresses a wide variety of ocean data requirements, and Altalo et al. provide one of the first economic analyses of an ocean observing system from a business perspective. And there is no question that new technologies and observational capabilities will provide new opportunities for educators and for public outreach concerning ocean matters as described by McDonnell, Geer, and M. Martin.

This special volume is certainly not intended to be an exhaustive analysis of the ongoing development of observatories as tools for conducting oceanography. But it may be a waypoint along the path of providing exciting new opportunities and capabilities for studying and monitoring the oceans.

References

Stommel, H., 1989: The Slocum Mission. *Oceanography*, 2(1), 22-25.

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