

- to introduce emerging interdisciplinary sensors and systems as well as data telemetry methods; and
- to discuss data dissemination and utilization issues.

Following the introductory section, each subtopic is subdivided into two components: present and near-future capabilities and a vision toward capabilities within the next two decades.

A brief summary of challenges for developing and utilizing new technologies concludes the chapter.

Because of the broad scope of the chapter, it is not possible to develop the ideas and concepts in detail, so several important observational tools can only be mentioned in passing, while others must be omitted. Further, the treatment is not exhaustive and the focus is deliberately on oceanographic instruments. Marine geology and geophysics are touched upon briefly, but not in depth; however, box 9.2 concerns seafloor observatories. Several recent review papers and reports are cited within the chapter, providing starting points for particular interest areas. A few are included in the Endnotes for Further Reading. Finally, an overarching goal of this chapter is to stimulate new and creative ideas concerning ocean technologies and their applications to societal problems.

OBSERVATIONAL CHALLENGES

Factors such as rapid population growth, expanding use and abuse of the oceans, and increasing awareness of environmental change have produced a sense of urgency to understand and minimize human impact on the oceans and atmosphere. In particular, it is vital to improve measurements of critical variables if we are to be able to distinguish natural from anthropogenic changes. It should be emphasized that virtually all important environmental problems require interdisciplinary approaches and necessarily atmospheric, physical, chemical, biological, optical, acoustical, and geological data sets. Ideally, these data should be collected simultaneously (concept of synopticity) and span broad time and space scales to observe the processes of interest (figure 9.1).

Detection limits, precision, and accuracy of ocean measurements are important. However, the oceans are naturally dynamic, with large-amplitude periodic and episodic variability, which is especially confounding for quantifying long-term trends and changes. Oceanography is confronted with challenges beyond those faced by laboratory scientists, in that it is important