1. PROCESSES AND SCALES

The oceans are naturally dynamic, with large amplitude periodic and episodic variability that confounds attempts to quantify long-term trends and changes. Oceanographers are confronted with challenges unlike those faced by laboratory scientists, as data must be obtained from an uncontrolled and often harsh, if not violent, environment. In addition, most oceanographic problems are interdisciplinary in nature and thus require a very large number of observational variables with relevant processes spanning over 10 orders of magnitude (Figure 3). Further, the processes are often nonlinear, turbulent, or chaotic, and biological and chemical aspects involve behavior and reactions that force the use of a large number of coupled nonlinear equations and empirical relations for models (see Matear, this volume). In addition, recent studies suggest that only a few strong episodic events can often be of far greater importance than more slowly varying relatively small amplitude variations. Despite these daunting challenges, recent biogeochemical studies have begun to characterize, quantify, and improve our understanding of ocean processes that cause biogeochemical variability in the form of carbon inventories and carbon fluxes However, it must be recognized at the outset that insufficient diversity of data and undersampling limit our ability to make further advances. Hence, a major challenge remains to greatly increase the variety and quantity of biogeochemical and other needed interdisciplinary data. Ideally, the relevant data should be collected simultaneously (concept of synopticity) and span broad time and space scales to observe the processes of interest (Figure 3). For global problems, this means sampling variability that extends well over ten orders of magnitude in space and much longer in time for climate problems. Next we review some sampling strategies, platforms, sensors, and systems that are presently being used or are planned for future biogeochemical research. Already, many measurements of several biogeochemical variables can be done on virtually the same time and space scales as physical variables. The optimal utilization of these platforms and measurement systems for regional and global studies is considered in the final section.

2. OBSERVATIONAL METHODS

2.1 PLATFORMS

Several major interdisciplinary oceanographic programs, including JGOFS, have adopted multi-platform approaches. The schematics shown in Figure 4