different phytoplankton groups, including those associated with red tides or harmful algal blooms (HABs) (e.g., Carder and Steward 1985).

Remote sensing of many important chemical and biological variables (e.g., zooplankton and fish) remains as a major research challenge. Regular observations of organisms from satellite platforms are not presently feasible. However, ocean color, temperature, and current data can be valuable for identifying features (e.g., fronts, eddies, upwelling areas, red tide blooms, etc.) where high biological activity may be located. Further, extremely high-resolution imagery may eventually be available for sensing surfacing mammals and large schools of fish. Also, studies of larger organisms, such as marine mammals, have used satellite radio tracking, but this approach requires initial tagging. In some cases, tagging instrument packages have included sensors for temperature and depth as well as positioning.

Possibilities for event-triggered sampling using sensors placed on special satellite platforms (e.g., steerable instruments in geostationary orbit) are being considered. This approach is most attractive for responses to disasters, directing field and other remote sensing observations to key locations and providing data, which would otherwise be unattainable. Advanced analytical and modeling activities will be required to optimize the use of present and future remote sensing data sets. Examples include removal of tides from altimeter data and incorporation of remote sensing and in situ data into models for three-dimensional spatial descriptions and predictions.

IN SITU SENSORS AND SYSTEMS

The emergence of more capable sensors and systems for oceanographic applications can be attributed to several factors. These include:

- technology transfer in the areas of measurement and analysis techniques originating in the medical, engineering, microelectronics, microprocessor, data communication, and global positioning research communities;
- support of projects devoted to development of both fundamental and societally relevant ocean technologies; and
- the formation of functional partnerships among academia, government laboratories, and private industry (e.g., Dickey et al. 2001b). Many of the requirements for deep-space measurement systems are similar in nature to those of oceanographic studies, so future synergistic partnerships between ocean and space technologists are attractive.