2001). These bioluminescent organisms can be detected *in situ* with bioluminescence sensors (Herren, 2002; Herren et al., 2004). These sensors usually pump water through a baffle, mechanically stimulating the organisms to generate bioluminescence. Optical sensors inside the instrument's chamber then detect the amount of light produced by the organisms. Baffled bioluminescence instruments can operate 24 hours a day, although they are most effective at night, when most bioluminescent species are photo-inhibited and reach peak bioluminescence intensities. A major limitation of *in situ* measurements of bioluminescence lies in the separation of phytoplankton bioluminescence signals; these signals can be confounded by bioluminescent bacteria, zooplankton, or jellyfish.

The first generation of bioluminescence sensors were quite large (about the size of an automobile) and could only be utilized as shipboard samplers (Widder et al., 1993 and references therein). Currently, scientists and engineers are developing portable, lightweight, reduced-power, and relatively low-cost optical sensors for oceanographic research. The movement toward smaller sensors coincides with the advancement of autonomous sampling platforms for high spatial and temporal resolution ocean monitoring (see section X.3.2).

Biological sensors

Many new biological sensors (instruments that measure biological quantities) that are currently transitioning to the operational phase rely on optical principles or techniques. Jaffe (2005) provides an extensive review of optical imaging of plankton. Another example of a biological sensor that employs optics is the flow cytometer. In the flow cytometer, several optical measurements are made as each particle in a water sample passes through a focused laser beam. Light scattering signals provide information about the distributions of particle size and composition, while fluorescence data allow discrimination between phytoplankton and other particles and identification of major phytoplankton groups, e.g., *Synechococcus*, crytophytes, and eukaryotes. Researchers are now deploying flow cytometers for rapid and quantitative measurements of individual suspended microscopic particles for cells in the size range ~0.5 to ~30 μm . Time series of flow cytometric measurements have contributed to a greater understanding of phytoplankton species succession and growth processes , which have important implications for HAB research.

Other types of biological sensors that are gaining considerable interest for HAB research are molecular, e.g., deoxyribonucleic acid (DNA), probes (see Scholin et al., 2005). Previous molecular analyses of HABs involved several days of cell preparation and high-powered electron microscopy analyses to identify toxic algae. With the advent of *in situ* molecular probes, HAB species can be determined within 4 hours of seawater sample collection. These probes can sequence the DNA of a selected phytoplankton and compare its genetic code sequence of nucleotides with that of other related algae. Scholin et al. (1998) are currently developing real-time HAB data collection methods using DNA probes on moorings. More information about molecular probes for HAB research can be found in Scholin et al. (2005).

Chemical sensors

Chemical measurements have greatly improved with technology (e.g., Tokar and Dickey, 2000; Dickey et al., 2000). Rather than relying on untimely laboratory analyses of bottle