Moorings and bottom tripods

Moorings and bottom tripods are ideal for HAB monitoring and characterization because these platforms can be used to study environmental changes in the ocean on timescales from minutes to decades. An increasing number of optical, chemical, biological, and physical parameters are being measured from these platforms at multiple depths. In addition, researchers are currently developing automatic profiling moorings for high vertical and temporal resolution observations (Donaghay et al., 2003). Another advantage of moorings and tripods is the ability to sample during times of inclement weather and high sea-states. One of the limiting factors for these types of platforms is the great size and weight of moorings along with the high cost of implementation and deployment. Additional future technological advances will allow measurement systems to be more compact and lightweight, less power-hungry, and lower in cost (Kaku, 1997; Tokar and Dickey, 2000; Bishop et al., 2001). The greatest disadvantage of these platforms is biofouling of sensors (Lehaitre and Compère, 2005). Useful data, particularly optical data, from moorings have often been limited to a few months in the open ocean and less in coastal waters (Davis et al., 2000). However, work is progressing to mitigate this problem (Chavez et al., 2000; Manov et al., 2004; Figure X.9).

Anti-biofouling techniques for optical instrument packages have been effectively implemented (Chavez et al., 2000; Manov et al., 2004). Some of the most useful techniques involve the use of copper and are necessary for long-term deployments of optical sensors (Figure X.10). Copper significantly reduces marine fouling for long-term bio-optical sensor deployments in the coastal ocean and can effectively replace highly toxic and problematic chemical anti-foulants, e.g., tributyl tin (TBT), bromine, and chlorine (reviewed by Manov et al., 2004). Copper shutters that open during sampling and close over radiometric sensors, fluorometers, and other optical windows during idle periods, successfully mitigate biofouling on coastal moorings (Chavez et al., 2000; Manov et al., 2004, Figures X.9 and X.10). Many optical instruments utilize a flow-thru system, thus copper tubing to prevent biological growth in optical systems have been effectively employed. These anti-fouling methods have been shown to increase useful deployment times of moorings from ~1 month to as long as 4 months in the coastal ocean (see Chang et al., 2001; Chang et al., 2002). Another simple method of reducing biofouling on nearshore coastal moorings is diver servicing or retrieval of optics chains to the deck for cleaning. Many HAB monitoring moorings are or will be deployed within a few km of shore, allowing easy access for regular cleaning of optical windows.

Figure X.9
Time series of over 1 year (406 days) of continuous, autonomously collected (a) chlorophyll-*a* concentration derived from a fluorometer and (b) downwelling irradiance at 555 nm measured by a spectral radiometer. Both instruments were equipped with copper shutters to mitigate biofouling. Data were collected at 35 m on a mooring deployed in the Sea of Japan. This long time series captures the spring-bloom in late-March through late-April [starting near Year Day 90 and ending around Year Day 120 in (a)] and the seasonal variability in solar insolation [low irradiance in winter and high light levels in summer in (b)].