as short as a few hours to the seasonal cycle and spatial scales covering the extent of the HABs out to beyond the continental shelf break. Real-time data telemetry will be essential for early warning of HABs to researchers and responsible authorities. Some important objectives of designing HAB sampling strategies are to: (1) develop and implement *in situ* detection and monitoring techniques using a variety of novel interdisciplinary instrumentation and platforms; (2) engineer anti-biofouling techniques for long-term deployment of HAB sensors; (3) develop and implement real-time telemetry of key data; (4) develop and implement web-based adaptive sampling networks, including two-way communication with instrumentation; (5) determine threshold values of key HAB parameters to be used for a rapid response alert system prior to HAB formation; (6) determine the factors (environmental and anthropogenic, physical, chemical and biological) causing formation, persistence, and cessation of HABs; (7) monitor the frequency, intensity, and duration of HABs; and (8) provide data for the development of models to predict the occurrence of HABs. The following suggested techniques would complement existing ship-based and volunteer HAB monitoring efforts, providing shorter temporal scale measurements and more timely and adaptive sampling strategies.

X.4.1 HAB systems and sensors

We advise the use of small, lightweight, re-locatable moorings and bottom tripods with interdisciplinary instrument packages deployed in regions of known HAB occurrences (Figures X.11-13). These autonomous measurements should be complemented with synoptic measurements (e.g., ocean color satellite images) and high spatial resolution measurements to resolve processes associated with HAB development, persistence, and cessation (further described below). Bio-optical instruments equipped with anti-biofouling devices on the moorings will be necessary for detection of HABs and ideally, will include: (hyper)spectral absorption-attenuation meters, fluorometers, backscattering sensors, and radiometers, and bioluminescence sensors (e.g., marine bioluminescence bathyphotometer, MBBP) (Figures X.12). New *in situ* optical-based chemical sensors will be necessary for obtaining information about micro- and macronutrients. Dissolved oxygen sensors will be essential for investigating the variability of biological processes in many coastal environments (not everywhere, e.g., Gulf of Maine). Complementary hydrographic data should be collected using temperature and conductivity sensors, and meteorological systems and HF-radar and current meters will be deployed for physical data. The sampling rates for all instruments should be hourly or faster with potential for adaptive sampling rates up to several times per minute. Instrumentation packages should be interfaced through a data logger and communication system for data transfer to shore-based computing assets (Figure X.13).

Figure X.11
Schematic diagram of an *ideal* interdisciplinary coastal sampling network for harmful algal bloom detection, identification, and characterization.

Figure X.12