samples that may suffer chemical alteration or contamination, *in situ* chemical sensors are being deployed on ship-based vertical profiling packages and more recently, moorings. One of these new chemical sensors is a field-deployable ultraviolet (UV) absorption spectrometer (Satlantic, Inc. In Situ, Ultraviolet Spectrometer, ISUS; Johnson and Coletti, 2002). The principle behind the development of the ISUS is optical in nature: nitrate, dissolved in seawater, exhibits a broad absorption maximum centered at ~210 nm. Nitrate absorption competes with the absorption of bromide, a conservative component of sea-salt, and to a lesser extent, the carbonate ion (Figure 4 in Chang et al., 2004). Advanced spectroscopic deconvolution techniques are utilized with the ISUS to isolate the nitrate absorption signal to make routine spectral measurements of nutrients (Johnson and Coletti, 2002). Another example of an *in situ* chemical sensor that utilizes spectrophotometric techniques is the SubChem, Inc. SubChemPak Analyzer. The SubChemPak Analyzer combines flow analytical methodologies of reagents with an absorption detector for rapid *in situ* measurements of dissolved nitrate, nitrite, iron, and other nutrients (http://www.subchem.com/). WS OCEANS

One of the main advantages of these *in situ* chemical analyzers is the ability to integrate quantification of ocean chemistry with other more commonly measured oceanographic parameters such as conductivity-temperature-depth (CTD), fluorometers, and optical sensors. Interdisciplinary sensor packages that carry chemical sensors may also be towed for underway sampling, profiled for high vertical resolution measurements, or deployed on autonomous platforms (e.g., moorings, bottom tripods, autonomous underwater vehicles (AUVs); see Section X.3.2 below). Measurements of nutrient concentrations are now possible at temporal and spatial scales relevant to HABs. Challenges with these instruments involve length of deployment, calibration, and storage of reagents (for instruments like the SubChemPak Analyzer).

X.3.2 Sensor platforms

Remote sensing systems

Remotely sensed measurements of oceanic properties from satellites or aircraft used for HAB research involve observations that rely on the sun for illumination of the ocean surface. These ocean color sensors measure the radiance entering the aperture of the sensor, e.g., SeaWiFS (satellite) and Portable Hyperspectral Imager for Low Light Spectroscopy (PHILLS; aircraft; Davis et al., 2002). A variety of scanning mechanisms are used to generate two-dimensional fields or images to provide nearly synoptic observations over the oceans (Yoder et al., 2001). Recent reports have summarized many of the salient principles, techniques, and applications of ocean color remote sensing (e.g., see IOCCG Reports 1-3, 1999, 2000, and 2001, respectively).

Figure X.8
(a) Moderate Resolution Imaging Spectroradiometer (MODIS) imagery of derived chlorophyll-*a* concentration showing a high biomass filament in the New York Bight on 14 July 2001 (the land mass on the left is coastal New Jersey just north of Cape Hatteras). Time series of (b) derived absorption at 443 nm at the location of the white box in the MODIS image and (c) derived chlorophyll-*a* concentration at the location of the white box in the MODIS image. The red X's