western Equatorial Atlantic basin, together with seasonal-to-interannual variability in SST in the central and eastern basins. The meridional arrays cover the regions of high SST variability associated with the SST dipole mode. A set of spectroradiometers and fluorometers have been deployed at the *Lambada* mooring (8N, 38W) in the PIRATA array to add a biogeochemical component to the program and to study the effect of the Amazon River/North Equatorial Counter Current, tropical instability vortices, the effect of dust on phytoplankton productivity and carbon cycling in this region. This bio-optical mooring addresses the following three specific objectives:

1. Provide high temporal resolution (6 times daily) in-situ spectroradiometric measurements to fill missing satellite measurements due to dust, clouds, and gaps due to satellite orbit patterns, sun glint avoidance and tilt maneuvers.
2. Use the in-situ measurements to evaluate atmospheric correction algorithms by comparing the in-situ and satellite derived normalized water leaving radiance estimates.
3. Use the combination of the chlorophyll concentrations derived from the in-situ spectroradiometric measurements and fluorometric measurements to study both temporally short events, such as tropical instability waves and the effect of aeolian dust deposition on marine productivity (including the time lag between dust deposition and increased chlorophyll biomass), as well as long-term trends in primary production and biogeochemical cycles in this region.

***JGOFS EQPAC Drifter Studies*:** The first deployment of a drifting buoy with high precision optics (McLean and Lewis, 1991) was carried out in 1994, in association with the JGOFS Equatorial Pacific Process Study. The drifters were air-launched from a NASA P-3 low altitude aircraft, which was carrying out remote sensing support of the seagoing mission. The buoy was a modified Compact Meteorological and Oceanographic Drifter (CMOD) manufactured by MetOcean Data Systems. A seven channel (450, 492, 532, 562, 656, 683, 700 nm) downlooking radiance sensor (Satlantic) was deployed on the buoy approximately 0.5 meters below the sea-surface and a single uplooking irradiance sensor (490 nm) was deployed on the extendable mast above the surface. Raw data was communicated via the ARGOS system. Radiances were propagated to and through the sea-surface using empirical algorithms for spectral attenuation, and normalized by the spectral downwelling irradiance inferred from the measured value at 490 nm and a model for spectral sun and sky irradiance. Two buoys were successfully deployed during this experiment and operated for several months. The resulting normalized water-leaving radiances were used to estimate chlorophyll concentrations. Based on these data, several novel syntheses resulted, ranging from a means to integrate shipboard estimates of primary production and grazing over the larger scale (Landry *et al*., 1997), and an improved understanding of the role of tropical instability waves in the production dynamics of this region (Foley *et al*., 1997). These first drifting buoys were the predecessors for subsequent optical deployments on several platforms, notably the surface WOCE/OCM drifters used extensively by Oregon State University (Abbott and Letelier, 1998).

Oceanographic Processes in Oligotrophic Water Masses

BATS/BTM: The Bermuda Testbed Mooring (BTM) was first deployed in 1994 and continues in operation today (Dickey *et al*., 1998b, 2001a). High frequency, long-term data measured by the BTM instruments are used for studies and models of upper ocean biogeochemistry and physics, to develop and test new multi-disciplinary sensors and systems, and to provide validation data for satellite ocean color imagers including SeaWiFS. The complementary Bermuda Atlantic Time-series Study (BATS) was established in 1988 as part of the U.S. JGOFS program, to characterize, quantify, and understand processes in the Sargasso Sea that control ocean biogeochemistry, especially carbon, on seasonal to decadal time scales. BATS ship sampling is done monthly and every two weeks during the springtime. Ship-based bio-optical profiles (sampling in concert with BATS) and remotely-sensed ocean color data have been obtained at the BATS site (Fig. 3.2) since 1992 by the Bermuda Bio-Optics Program (BBOP; Siegel *et al*. 2001). BTM measurements were an important addition as processes with time scales of less than a few weeks (*e.g.*, eddies, wind-events, and transient blooms) cannot be resolved with monthly or bi-weekly shipboard observations. The BTM program has tested and utilized a broad range of autonomous sampling sensors and systems. These include new measurements of pCO2, dissolved oxygen, nitrate, trace elements (*e.g.*, iron and lead), several spectral inherent and apparent bio-optical properties, ^{14}C for primary production, and currents (Dickey *et al*., 1998a, 2001). Several bio-optical systems designed to measure IOP and AOP have been tested using the BTM (Figure 3.6). The bio-optical instuments (placed on the surface buoy and at 2 to 4 different depths) are used to determine relevant remote sensing parameters such as remote sensing reflectance (*e.g.*, Dickey *et al*., 2001; Zheng *et al*., 2002, 2003). The depths are optimally selected to enable extrapolation of subsurface radiance to the