cy datasets (6 samples per second) and spectral analyses, short-term variations in PAR (with maxima at periods of 40 to 100 minutes) were evident with relatively high coherence among beam c, chlorophyll fluorescence, and dissolved oxygen. It is possible that this variability was caused by rapid (scales of minutes) photoadaptive responses in the phytoplankton. These responses could be caused by changes in fluorescence yield, photosynthesis rates, cellular absorption, cell size, or refractive index (e.g. Ackleson et al., 1993). The Biowatt II data set was also valuable because of its relatively long duration. For example, it was sufficient to do spectral and coherence analyses with statistical robustness as the time series spanned four orders of magnitude in frequency space. In particular, some of these analyses were able to characterize relationships including: 1) bio-optical properties as related to mesoscale features; 2) phytoplankton patchiness as related to the spring bloom; and 3) high frequency bio-optical variability due to interaction of the deep chlorophyll maximum with internal gravity waves. In addition, analyses showed relationships between downward propagation of near-inertial energy near a frontal feature and the enhancement of primary production and biomass, likely caused by nutrient fluxes into the euphotic layer. Also, the data set was used to test several different optical models for estimating biomass (including some designed for remote sensing algorithms) and coupled physical-biological models of seasonal transitions. Finally, the Biowatt II data, along with other open ocean data described below, were used to quantify the effects of undersampling and aliasing (Wiggert et al., 1994).

Marine Light in the Mixed Layer (MLML)

The Marine Light in the Mixed Layer (see Dickey, 2001a; Dickey et al., 1994) experiment was designed to study upper ocean bio-optical variability and bioluminescence as affected by physical forcing at a high latitude site (mooring location was south of Iceland at 59°N, 21°W, near Ocean Weather Station "I"). MLML was not explicitly part of JGOFS, however, several objectives were similar to those of the 1989 JGOFS North Atlantic Bloom Experiment. A focus of the MLML study was high resolution (sampling intervals at scales of minutes) time series observations of optical and bioluminescence variability. To this end, several optical systems were deployed during the periods of April-June 1989 and May-September 1991. MLML utilized the MVMS, BOMS, and other moored bioluminescence systems. The frequent sampling enabled examination of a variety of processes. For example, transient phytoplankton blooms were observed with even modest stratification events prior to the major springtime shoaling of the mixed layer (from approximately 550 m to approximately 50 m within five days!). It was demonstrated that these blooms contributed to the stratification by trapping heat near the surface. Variability of optical properties associated with diel cycles was also examined. The amplitudes (and statistical significance) of the daily cycles of beam c, chlorophyll fluorescence, and dissolved oxygen varied with the seasonal progression, being more pronounced during the spring. The fluorescence signals were clearly affected by the ambient light field.

JGOFS Regional Studies

A central objective of JGOFS has been to characterize, quantify, and improve understanding of ocean processes causing temporal and spatial variability in carbon inventories and carbon fluxes (see review articles in this issue and several *Deep-Sea Research II* volumes from 1993-present). Studies such as JGOFS rely heavily on interdisciplinary data sets because of the inter-relationships of physical, chemical, and biological processes (e.g. Dickey, 1991; Dickey and Falkowski, 2001). A major challenge to JGOFS (and future biogeochemical studies) has been to increase the variety and quantity of biogeochemical data. Further, these data need to be collected simultaneously (concept of synopticity) and span broad time (and space) scales to observe the relevant processes (Figure 2). JGOFS conducted a series of regional studies from 1989 to 2000, and time series programs near Bermuda (Bermuda Atlantic Time Series, [BATS]) and Hawaii (Hawaii Ocean Time-series, [HOT]) are still ongoing. Each of the following regional studies included a component devoted to time series observations. Several of the highlights relevant to biogeochemical cycling have been presented (Dickey, 2001a; Dickey and Falkowski, 2001), so the following summaries are brief.

The JGOFS equatorial Pacific process study took place in 1992-1993. The physical dynamics of the equatorial Pacific are quite well documented as meteorological and physical measurements have been made over the past two decades from the Tropical Atmosphere Ocean (TAO) mooring array (e.g., McPhaden, 1995). However, little was known of the region's optical or bio-optical variability prior to the JGOFS campaign. During JGOFS, the optics and biogeochemistry of the central equatorial pacific were studied using MVMSs (sampling intervals of a few minutes) that were deployed from a TAO physical mooring at 0°, 140°W for an eighteen-month period in 1992 and 1993 (see Foley et al., 1998; Dickey, 2001a). It was fortunate that the observations spanned both El Niño and "normal" phases. During the El Niño phase, the mixed layer, the thermocline, and a very weak equatorial undercurrent were deep and Kelvin waves (approximately 60 day period) propagated eastward past the site (see Figure 6 of Dickey, 2001a). Light levels were high, however, relatively high concentrations of nutrients including iron were deep. As a result, measured concentrations chlorophyll in the upper layer were low (less than 0.2 mg m^{-3}). However, as "normal conditions" returned, Kelvin waves ceased and the thermocline and the strong undercurrent shoaled