and primary production and show that aliasing can be problematic for coarse (monthly) sampling (e.g., Wiggert et al., 1994). As described earlier, short time-scale variations in phytoplankton populations are caused by passages of clouds and the diel solar cycle. In addition, short-lived blooms and busts (cessations of blooms) are especially evident in the springtime when shallow mixed layers are often formed and then erased because of wind events (e.g., Dickey et al., 1991, 1993a, 1998a), as shown in Figure 10.7. In particular, a set of observations in the open ocean south of Iceland (Dickey et al., 1994) showed that even modest near-surface stratification, preceding formation of the seasonal thermocline, can be sufficient to initiate shallow phytoplankton blooms, which can in turn intensify near-surface heating rates and stratification (Stramska and Dickey, 1993, 1994). These types of observations and sequences of ocean color observations from space suggest that the integrated effect of the phytoplankton seasonal cycle and its poleward march are built on many cumulative events driven by short time- and space-scale forcing as well as the periodic seasonal solar insolation.

Energetic mesoscale features (e.g., fronts, eddies, and rings) further complicate a simple seasonal description and modeling of phytoplankton. In particular, eddies can introduce nutrient-rich waters into the euphotic layer, where they can drive phytoplankton productivity (e.g., Falkowski et al., 1991; Dickey et al., 1993a). In the Sargasso Sea, the influence of eddies on new production (i.e., the fraction of total primary production in surface waters fueled by externally supplied nutrients) is well documented (McGillicuddy et al., 1998; McNeil et al., 1999). This problem was attacked using high-resolution physical, bio-optical, and chemical measurements from a mooring, ship survey data, satellite altimetry data, and eddy-resolving model simulations. The vertical transport of nutrients into the euphotic layer, along with elevated levels of chlorophyll, are apparent in the time series shown in Fig. 10.7 as a second baroclinic mode eddy passed the Bermuda Testbed Mooring (BTM) in July 1995. It is interesting to note that near-inertial oscillations (inertial period of about 22.8 h) are superimposed on the dominant eddy signature. These observations suggest that in addition to seasonal convection, mesoscale eddies can make major contributions to the vertical flux of nutrients into the euphotic zone and may be sufficient to balance the annual nutrient budget of the region and account for discrepancies in regional estimates of new production (McGillicuddy et al., 1998; McNeil et al., 1999). In separate but related work, Granata et al. (1995) have reported increased subsurface chlorophyll concentrations, which were observed as near-inertial waves propagated along a front in the Sargasso Sea, suggesting that shear instabilities associated with the wave packets stimulated new production.

The seasonal cycle of bio-optical properties of the coastal ocean has been observed to follow a pattern similar to that of the open ocean by several studies (e.g., Chang and Dickey, 2001). However, the coastal environment is far more complex because of several factors, such as terrigenous input of materials as described earlier, bottom boundary layer effects, resuspension of bottom materials, greater roles of tides and internal solitary waves, topographically related fronts, and water mass intrusions (e.g., from impinging eddies). In addition, major events such as hurricanes can rapidly modify the ecosystem and optical properties (e.g., Dickey et al., 1998c, d). It is interesting to note that bottom sediments were suspended more than 30 m above the ocean bottom (about 70 m depth) during the passage of Hurricane Edouard at a mooring site located about 110 km south of Cape Cod, Massachusetts. A time series of spectral