water [*Sosik et al*., this issue]. Our statistical analyses support this interpretation.

Following the spring bloom, mean current speeds decreased to their lowest levels of the 11 month time series record (Table 4; Figure 4). Peaks at the semidiurnal tidal period were observed in temperature data at the 35 m depth, most likely because of tidal oscillation of the thermocline (not shown). Low salinities observed in the upper layer thick starting May 15, 1997 (Plate 1, SR, and Figure 7, SR), were due in part to springtime warming and subsequent runoff. This phenomenon has been observed by *Flagg* [1987] to flow south and west along the coast of Cape Cod in a layer typically <20 m thick.

## 4. Discussion

Statistical analyses were used to establish the relationships between physical and bio-optical processes at several timescales. The most dominant signal was the seasonal evolution, including stratification, mixing, and restratification of hydrographic properties and associated blooms and death of phytoplankton. The semidiurnal tidal period was prominent in current speed data, sometimes resulting in the generation of ISWs, which have the potential to mix nutrients and phytoplankton. However, phytoplankton was apparently only temporarily vertically displaced past our instruments on the CMO mooring during the passage of ISWs in summer/fall. This led to significant coherence between PAR and [Chl *a*] at high frequencies during highly stratified conditions (summer/fall). At the CMO site, light and nutrient conditions were greatly affected by episodic events that were observed throughout the 11 month time series record: storms, hurricanes, and water mass intrusions induced by mesoscale variability. Mesoscale variability, in particular, shelf-slope frontal intrusions and Gulf Stream eddies, caused advection of high concentrations of nutrients and possibly high biomass waters past the CMO site. These intrusions occurred at timescales as short as 1 day to as long as 45 days, resulting in high coherence between temperature and [Chl *a*] at the near-bottom depths. The advected water masses often resulted in increased [Chl *a*] and changes in the shape of phytoplankton spectral absorption. Intense atmospheric forcing during storms and hurricanes at timescales of ~3 days mixed the water column and particles, bringing nutrients up from the ocean bottom into the euphotic layer as well as resuspended sediments and relict pigments, increasing the attenuation of light. This is evidenced in the significant coherence between beam c and [Chl *a*] at 68 m during periods of intense storms and partitioned spectral absorption as well as in the scatterplots of [Chl *a*] versus beam c (Figure 10). Therefore bottom boundary layer processes were very important to bio-optical properties. Inertial periods did not appear to be important at the CMO site, except perhaps following major storms or hurricanes.

The relatively short timescales of variability (~5 days) associated with wind and current speeds at all depths and time periods were expected in autocovariance analyses. Variability in wind speed was primarily associated with passing atmospheric pressure systems, and current speed variability was generally the result of atmospheric forcing, surface and internal waves, tides, and mesoscale advection events. Beam c exhibited relatively short temporal lag as well (<10 days) at 12, 30, and 68 m depths. High variability existed in beam c because of fluctuations in all components of attenuation (phytoplankton, detritus, and dissolved matter). Relatively low concentrations of phytoplankton and dissolved matter at 50 m likely resulted in a longer temporal lag or less variability in beam c seen at this depth. Autocovariance spectra for temperature were generally similar at each depth; the temporal decorrelation scale was relatively long (>20 days). Temperature decorrelation timescales were dependent on mixing, advection, and water mass movements through mesoscale activity. Chlorophyll *a* concentration autocovariance, a result of biological processes, was highly variable with depth and season (discussed in section 3.2).

Our results allow us to compare important mixing processes (wind mixing, surface and internal gravity waves, tides, storms, hurricanes, eddy-induced advection and mixing, and turbulent mixing associated with internal solitary waves) relevant to bio-optical variability on a continental shelf versus those of the open ocean. Analogous measurements of physical and bio-optical variability in the Sargasso Sea, the subarctic North Atlantic Ocean, and the Arabian Sea have been reported by *Dickey et al*. [1993, 1998b], *Dickey et al*. [1994], and *Dickey et al*. [1998c], respectively. Some timescales of mixing that are important to bio-optics in the open ocean are similar to those of the coastal ocean (seasonal, tidal, and episodic), except for the inertial period, which was less important at the CMO site than was reported by open ocean studies. Mixing processes important to bio-optics in the open ocean include inertial eddies, storms and hurricanes, and shear instabilities. Other than storms and hurricanes, these mixing processes are quite different from the results of the CMO experiment; water mass variability (except eddies), advection, frontal gradients, and internal solitary waves are less relevant mixing processes in the open than in the coastal ocean. The bottom boundary layer and associated processes (resuspension of sediments and nutrients) are not at all important in the open ocean. *Sosik et al*. [this issue] report that more diverse assemblages of optically important material are present on and near continental shelves as compared to the open ocean. Differences in biological processes between the open and coastal ocean are well known [*Mann and Lazier*, 1991], for example, light levels and attenuation and mixing of nutrients versus recycling. A summary of the differences between open ocean and coastal ocean processes is found in Table 5.

## 5. Conclusions

The CMO experiment was unique in that an extensive data set of concurrent high-frequency temporal resolution physical and bio-optical parameters was collected with newly developed oceanographic instruments on a mooring and a bottom tripod, and our study was coordinated with studies by other CMO investigators to complement our measurements. We identified several processes that were important to bio-optics on the southern New England continental shelf during the CMO experiment. The most prominent physical and bio-optical signals observed during the experiment were associated with the seasonal variability. However, several important episodic events interrupted the seasonal cycle. These episodic events (e.g., hurricanes, storms, and water mass intrusions) appear to have had a great impact on biogenic and nonbiogenic matter. Because of these major transient events, there is likely considerable interannual variability in the seasonal cycles of the physical and bio-optical properties on the MAB continental shelf. In addition to episodic events, the semidiurnal, and to a lesser extent, the diurnal tides were significant for the bio-optical as