



Figure 6. (a) Absorption (thin), scattering (dashed), and beam attenuation (thick) coefficients for eight wavelengths (412, 440, 488, 510, 630, 650, 676, and 715 nm) at 10 m (circles) and 50 m (asterisks) depths. (b) Absorption coefficient (same wavelengths as Figure 6a) versus depth. (c) Same as Figure 6b for beam attenuation coefficient. All data shown are for cast 9.

scattering and beam attenuation spectra did not contain any peculiar peaks and had steep slopes (with a break in the shape around 500 nm), decreasing with increasing wavelength (Figures 6a and 6c). Between 412 and 715 nm, scattering spectra were fit by $\lambda^{-1.0}$ ($r^2 = 0.99$) in the sewage plume compared to $\lambda^{-0.3}$ ($r^2 = 0.77$) at 10 m, and attenuation spectra by $\lambda^{-1.4}$ ($r^2 = 0.99$) in the sewage plume compared to $\lambda^{-0.8}$ ($r^2 = 0.97$) at 10 m. In the plume the relative contributions of scattering to attenuation increased from 80% at 412 nm to 92% at 650 nm.

3.3. Fluorescence

Throughout the plume, the chlorophyll fluorescence either increased with depth as if the plume was not present (e.g., cast 13; Figure 7), or increased noticeably, peaking at the maximum concentration of the sewage plume (e.g., cast 9; Figure 3).

SAFire fluorescence data were analyzed to determine which Ex/Em wavelength pairs had the strongest and most reliable

signals in the presence of sewage plume waters. Ex/Em = 228/340 nm was the best indicator of both new and old sewage plumes, since it increased in the presence of sewage waters but not phytoplankton (Figure 2). Ex/Em = 435/540 nm detected new plume but also the shallow phytoplankton layer when its signature was very strong (Figure 2). Ex/Em = 435/540 nm showed a slight increase in fluorescence in the old sewage plume.

3.4. Nutrient and Particle Characterization

3.4.1. Nutrients. Outside of the sewage plume, nutrient concentrations were typical of oligotrophic waters (Figure 8). Ammonium, silicate, and phosphate concentrations in the sewage plume were at least 2 times greater than in background waters. SITP wastewater was shown to contain high concentrations of phosphate (57 μM), nitrate (2.7 μM), and silicate (556 μM) [Fujioka and Loh, 1995]. Dilutions, calculated from wastewater concentrations and nutrient