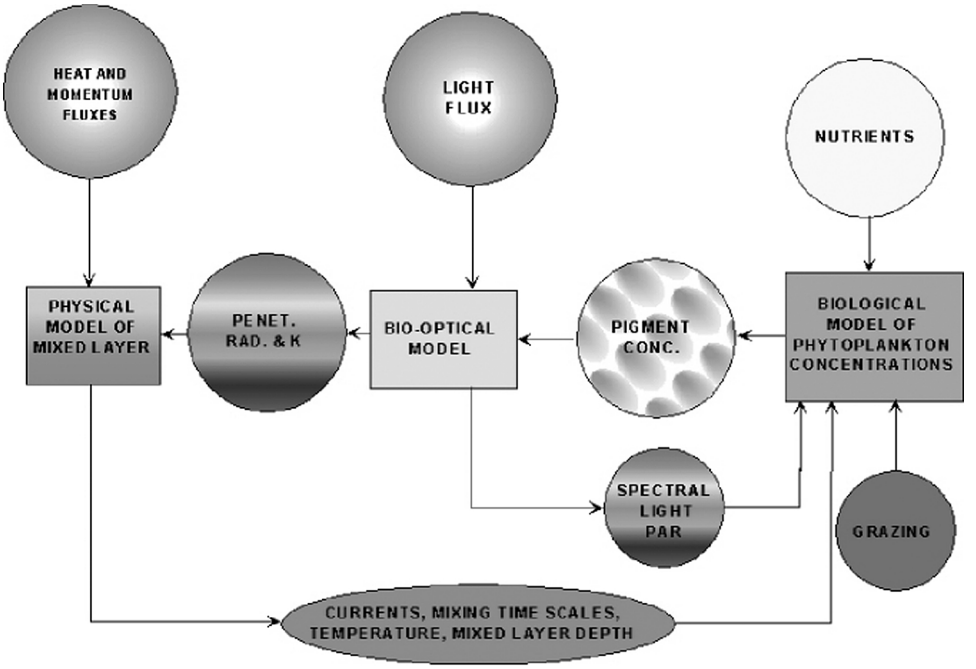

Fig. 10.2. Conceptual model illustrating coupling of physical and biological processes through optical processes. PENET. RAD. and K represent the penetrative component of solar radiation and the diffuse attenuation coefficient of solar radiation. (After Dickey, 1991.)

As in the atmosphere, the direct physical interactions between solar radiation and the ocean are wavelength dependent. Water itself effectively absorbs all incident infrared solar radiation (e.g., Morel and Antoine, 1994), and this direct radiative transfer process provides roughly half of the heat to the ocean surface waters. An example of potential interactions between solar radiation and physical and biological processes is depicted in Fig. 10.2, where the following sequence is illustrated: (1) forcing of the upper ocean physical condition through the input of solar radiation, including light, heat, and indirectly momentum at the ocean surface; (2) upper ocean physical responses, including stratification and turbulent mixing that result in (3) phytoplankton vertical and horizontal motions, which, in turn, lead to (4) feedbacks on distributions of pigments and photosynthetic available radiation (PAR), and (5) modulation of the upper ocean heating via phytoplankton and their associated optical properties. The balance between primary production and grazing determine the concentration of phytoplankton at any moment in time and both processes must be considered in biological–physical interactions.

The interactions among these processes occur on many time and space scales. Long-term changes (millennia to millions of years) in ocean circulation are driven by changes in radiative forcing resulting from orbital variations, albedo feedbacks, and continental configuration (Fig. 10.3). Short-term changes (seconds to decades) are driven by atmospheric conditions (e.g., aerosols, cloud cover, albedo, and ozone concentration) and thermal contrasts between continents and the oceans and from the equator to the poles. Together, both long- and short-term variations in radiative