It is now generally thought that the world oceans primarily control the atmospheric concentration of CO_2 on very long geological time scales (see other chapters in this volume). Higher concentrations of dissolved inorganic carbon (DIC) are found below the surface mixed layer of the ocean. Yet, the upper portion of the water column is in equilibrium with the atmosphere to first order. This gradient is maintained by two carbon "pumps," the "solubility pump" and the "biological pump." The solubility pump involves the thermal contrast between the upper ocean and the ocean interior with the solubilities of cold waters of the deep ocean being on the order of twice as great as some of the warmer near surface waters. Thus, the net effect of sinking high latitude surface waters, via deep ocean thermohaline circulation, is to enrich deeper waters in carbon.

The present chapter focuses primarily on processes, observations, and recent studies related to the second type of carbon pump, the biological pump (see reviews by Bishop, 1989; Ducklow et al., 2001; and other chapters in this volume). Quantification and understanding of this process drive much carbon research. We emphasize *in situ* methodologies in this contribution as remote sensing aspects are covered by Korotaev in this volume). A brief description of the biological pump concept follows for completeness (see Figure 1; more in-depth discussions are presented in this volume by Anderson and Toterdell. Phytoplankton living in the euphotic layer of the ocean use carbon dioxide to form organic matter. A high percentage of the organic matter is metabolized (used for maintaining life functions); however, a significant portion (roughly 20%, but highly variable in terms of location and time) sinks to the deep sea. There it is converted back to carbon dioxide (through a process called remineralization; e.g., via bacteria). Physical transport processes later bring the carbon dioxide back to the surface (e.g., through upwelling in various forms or advection of water masses and mixing from depth, Anderson and Toterdell, this volume). The biological pump also includes pathways for getting carbon to the deeper layers through dissolved organic carbon (DOC) molecules (e.g., Kirchman, this volume; Hansell and Carlson, 2001) and particulate organic carbon (POC) matter. Importantly, the overall effect is to transport carbon to the deep ocean. The determination of primary productivity, the rate of plant tissue build up through photosynthesis, in the upper ocean is a vital step in quantifying the carbon flux associated with the biological pump. Primary producers, predominantly phytoplankton, convert inorganic materials like nitrate, phosphate, and silicate into organic compounds such as lipids and proteins through the process of photosynthesis (e.g., Lalli and Parsons, 1993). Secondary producers, mainly zooplankton (small generally drifting, but some mobile, animal organisms), are important players also as they excrete ammonia (another nutrient), graze phytoplankton, and contribute to