Given the world's expanding human population, it is important to evaluate the net primary production of different ecosystems that can provide food. The inland aquatic ecosystems comprise less than 1% of the Earth's surface, but often are among the most productive areas. Many of these aquatic ecosystems have undergone dramatic changes in recent years as a result of man's activities. In some cases the change has been beneficial to man's short-term desires and requirements, but often the changes have been detrimental (e.g., polluted water supplies) because man has used water bodies widely as an inexpensive receptacle for waste products. Other responses and their implications were initially less obvious; for example, even though some aquatic ecosystems have been fertilized artificially by man's activities, thereby increasing productivity (cultural eutrophication), in many cases this productivity has been shifted to species less suitable for human consumption (e.g., Beeton, 1969; Beeton and Edmondson, 1972).

Inland Water Bodies

Among the inland bodies of water are an infinite variety of fresh and saline lakes, ponds, rivers, brooks, swamps, and marshes. This chapter groups the inland seas (e.g., Caspian) with the fresh and saline lakes in the treatment of productivity of inland aquatic ecosystems.

The dimensions of the surface inland waters of the Earth are not known precisely (cf. Hutchinson, 1957; Nace, 1960; Penman, 1970). Most of the

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surface freshwater exists as ice and snow in glaciers and polar ice caps (some \[25.5 \times 10^6 \text{ km}^3\]). Freshwater lakes and streams cover some 0.2% of the Earth's surface and have a volume of at least \[2.04 \times 10^6 \text{ km}^3\]. A few lakes may be exceedingly deep (Lake Baikal, U.S.S.R., 1741 m), but the average depth of lakes of the world is only about 10 m. Lake Baikal contains 11% of the Earth's surface freshwaters; and as such represents the largest single reservoir of liquid freshwater. In addition, some 20% of the liquid-surface freshwaters are held by the five Laurentian Great Lakes of North America.

Saline lakes and inland seas have a somewhat smaller area and volume than freshwater lakes, but the order of magnitude is the same. A total area for inland waters of \[2 \times 10^6 \text{ km}^2\] is assumed. Freshwater marshes and swamps comprise an additional area of about \[2 \times 10^6 \text{ km}^2\].

Carbon Fixation

Man's attention usually has focused on the open water of lakes and rivers for his commercial harvest of food; however, weedy shorelines, swamps, and marshes may be the sites of greatest primary productivity. Herein lies a major difficulty when one attempts to assess the primary production of inland aquatic ecosystems. Most studies have estimated primary productivity solely from measures of phytoplanktonic photosynthesis. Even in purported studies of lake ecosystems, the primary production contributed by periphyton and rooted macrophytes often is not measured or included.

Photosynthetic fixation of carbon in inland aquatic ecosystems may occur by various communities (Fig. 9-1). These communities may be grouped and identified conveniently by the type of producer organism, that is, phytoplankton, macrophytes, and periphyton. The phytoplankton represents the algal community of the open water; macrophytes are macroscopic vascular plants that are submerged or emergent, rooted or floating; and periphyton is the community of plants, other than macrophytes, that grows on submerged substrates. In many cases diatoms are dominant in the periphyton, and with other microorganisms they form a film on the surface of mud, rocks, or sand (and also on the surfaces of the macrophytes).

In the majority of aquatic ecosystems carbon is most abundant in the inorganic form: \([\Sigma \text{ CO}_2] \gg \text{DOC} + \text{POC detritus} > \text{POC living}\) (Wetzel and Rich, 1973). Of the detrital fraction, the dissolved organic carbon (DOC) is usually an order of magnitude more abundant than the particulate organic carbon (POC). Only a small fraction of the total organic carbon pool is incorporated into living organisms at any given time; but this small fraction creates the organic carbon that accumulates in other fractions and determines the functional characteristics of the ecosystem.

Very few good quantitative studies have been done on the photosynthetic and respiratory rates of the macrophyte and periphyton communities. Yet from data recently summarized by Westlake (1963, 1966), it is apparent that rooted aquatic macrophytes are particularly productive on fertile sites (Table 9-1). Apparently, as rooted emergent macrophytes colonize the sediments of a shallow