Effects of Water Level Fluctuation on the Structure and Function of the Littoral Zone

Avital Gasith and Sarig Gafny

Abstract Water level fluctuations (WLFs) are most pronounced in impoundments, but are also observed in natural lakes over a wide size range, both on a seasonal and on an interannual time scale. In small and/or shallow lakes, WLFs can affect the metabolism and structure of the entire lake system. In most cases of large deep lakes, only the littoral region is affected. The effects on the biota, either beneficial or adverse, depend on local conditions.

In Section 8.1, effects of WLFs on the physical and chemical environment and on the community of the littoral are described in general. Thereafter, we examine the effects of long-term WLFs in Lake Kinneret, Israel. The relatively large amplitude of WLFs in this lake results in periodic changes of the littoral slope and of the substrate composition. This latter factor affects the breeding of the dominant fish species of the lake. At lower water levels, semi-aquatic vegetation that grows well in the exposed littoral provides vegetative habitats after it is inundated.

WLFs should be looked at as an environmental disturbance maintaining the temporal and spatial heterogeneity, which, in general, is characteristic of the littoral zone.

8.1 Introduction

The littoral zone of lakes is most commonly defined as the lakeward region of macrophyte vegetation (Wetzel, 1983). To include cases where benthic algae replace macrophytes, the littoral zone can be more generally defined as the shallow region extending from the shoreline to the lower limit of the euphotic zone. The latter approach underscores aspects of the metabolic significance of the littoral zone but neglects other functions, such as fish-habitat availability for colonization, foraging, spawning, and cover.
WLF is a natural phenomenon of inland waters resulting from periodic imbalances between water inputs (inflow, precipitation) and outputs (outflow, evaporation). Seasonal WLFs are most pronounced in lakes and reservoirs with relatively short retention times in conjunction with seasonal precipitation patterns. Long-term irregular WLFs mainly occur in semi-arid and dry tropical regions with distinct wet and dry seasons (e.g., John, 1986). Water use for drinking and irrigation, and more often, for power generation and flood control, are additional causes of water level fluctuations in man-made, as well as in natural lakes.

In the following, effects of WLF on structural and functional properties of the littoral environment are examined. As a case study, WLFs in Lake Kinneret, Israel, are described.

8.2 Effects of WLF on the Littoral Environment

The effects of WLFs on the structure and function of the littoral zone in lakes have not been extensively studied. Most of the information originates from studies of water level manipulation in ponds and reservoirs (Frazer, 1972).

Littoral Features Affected by WLFs

Physiography   Shallow systems with gradually sloping shorelines are more affected than lakes with steep littoral slopes, since larger areas are flooded or exposed, respectively (Frey, 1967; Moss and Moss, 1969; McLachlan, 1970; Howard-Williams and Lenton, 1975; Herdendorf and Fay, 1988). Two physiographic parameters are modified by WLF:

1. Shoreline morphometry, especially in convoluted shorelines where changes of water level can significantly modify the area of lagoons and consequently change habitat availability and affect biomass production (Monro and Larkin, 1950; Pieczynska, 1972; Mitchell and Rogers, 1985; Osborne et al., 1987).

2. Littoral slope and substrate composition (Piecynska, 1972). In general, gentler slopes and softer substrates are associated with falling water levels and vice versa.

Water Quality   Water quality can be greatly affected by WLFs, as a result of the introduction of organic matter and nutrients from re-flooded terrestrial areas (Nees, 1964; Cooper, 1966; McLachlan, 1970; Hestand et al., 1973; Osborne et al., 1987), the increased concentration of dissolved materials due to water loss by evaporation (McLachlan et al., 1972), and the increased turbidity due to shoreline erosion and resuspension of bottom sediment (e.g., Grimas, 1962; Swanson, 1967; Geen, 1974; Walker and Tyler, 1984; Mitchell and Rogers, 1985; Osborne et al., 1987), or to rapid re-flooding of shallow lakes (Hestand and Carter, 1974).