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Integrating vertical and horizontal approaches for management of shallow lakes and wetlands

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Abstract

Most lake restoration/rehabilitation schemes are biased toward vertical lake management practices generally applicable to deep lakes. Unfortunately, most schemes fail to or inadequately consider their actions within the context of horizontal lake management, an especially critical component when considering shallow lakes. Two Greek lakes, phytoplankton-dominated Koronia and macrophyte-dominated Chimaditida, are used to illustrate the importance of integrating vertical and horizontal considerations in the management of shallow lakes experiencing pronounced water level reduction. Attempting to manage the structure and function of fringing wetlands via vertical manipulations of the water column are doomed to failure without consideration of changes in physical and chemical aspects of the "memory" (sediments, soils). Fringing wetlands must not be considered as monotypic habitats interacting with lakes in direct proportion to their aerial extent. A predominately vertical lake management approach is probably valid for systems such as Lake Koronia without a history of significant submersed or emergent macrophytes. For those lakes embedded within significant wetlands like Lake Chimaditida, however, failure to consider horizontal lake management as a significant component of the overall system rehabilitation will likely diminish its successful outcome. Finally, definitions of wetlands currently used by Ramsar and aquatic scientists based primarily on structural aspects of ecosystems need to be modified to recognize the overriding importance of aerially differentiated functional aspects within vegetated communities as well as fundamental differences between vegetated and open-water habitats.

Keywords: Chimaditida; Koronia; Phytoplankton-dominated systems; Lake management

1. Introduction

The world is facing a fresh water crisis. What historically has been a problem of water quality is fast becoming a double-faceted problem of quality and quantity. In many regions, centers of population growth

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and water resources do not overlap, leading governments to consider elaborate schemes both for water transfer across political and catchment boundaries and for over exploitation of groundwater resources. The World Summit on Sustainable Development in Johannesburg, South Africa, during 2002 recognized that improving the economic and health status of most people on earth is linked to critical shortages of fresh water resource quantity and quality and that this problem is rapidly expanding into a worldwide concern that is independent of economic status (United Nations, 2003).

Current and projected problems with the quality and quantity of surface freshwater resources are profound for shallow lakes and wetlands of arid and semi-arid areas of Africa (Crisman et al., 2003b), Southern Balkans (Loeffler et al., 1998; Mitrakı et al., 2004), Near East (Bayar et al., 1997; Beklioglu and Moss, 1996; Green et al., 1996; Hovhanissian and Gabrielyan, 2000) and Middle East (Gophen, 2000). Many of these sites are of paramount importance for migrating and overwintering bird species and have been designated as Wetlands of International Importance (Frazier, 1996).

Both the number and magnitude of environmental perturbations to these lakes and wetlands have increased dramatically in the past two decades. Many systems have displayed progressive and profound reduction in water level due to over extraction of ground water for domestic and agricultural purposes (Mitrakı et al., 2004), landscape alterations (Chapman and Chapman, 2003; Crisman et al., 2003a) and climate change (Hollis and Stevenson, 1997). Such perturbations are not limited to arid and semi-arid regions. Shallow lakes and wetlands in west-central Florida, an area of moderately high rainfall, have undergone progressive water level reductions often leading to complete dessication due to overextraction of groundwater to meet domestic demands of cities surrounding Tampa Bay (Wiley, 1997).

Even slight reduction in lake depth can produce significant changes in the structure and function of shallow lakes. Responses are complex and dictated principally by basin morphology, prior trophic state, and the balance between phytoplankton and macrophyte biomass. Littoral zones of low to moderately productive lakes with well-established macrophyte communities prior to water level reduction often expand to dominate autotrophic production in response to increased light availability, while moderately productive lakes characterized by either co-dominance of phytoplankton and macrophytes or dominance by phytoplankton tend to become completely dominated by phytoplankton following water level reduction due to increased nutrient cycling via resuspension of sediments leading to decreased light penetration and increased flocculence of sediments. Pronounced reduction in lake level in phytoplankton-dominated systems can shift the overall metabolism of the system from autotrophy to heterotrophy in spite of a progressive increase of cultural eutrophication (Mitrakı et al., 2004). Such shifts to complete dominance by phytoplankton or macrophytes can result in extremely stable autotrophic conditions of low habitat diversity (Scheffer, 1998).

Limnologists have long recognized that deep lakes are inherently different from shallow systems due to their pronounced physical, chemical and biological stratification and seasonally restricted water column mixing (Wetzel, 2001), but the distinction between shallow lakes and wetlands remains unclear. While the Ramsar Convention on wetlands in 1971 defined wetlands as water bodies less than 6 m depth, it is understood that lakes and rivers of greater depth are covered entirely by the intent of the convention (Ramsar Convention and Secretariat, 2004). Such a purposefully broad definition of wetlands ignores intrinsic differences in structural and functional properties among shallow systems reflecting basin morphology, water depth, and the balance between open-water and vegetation cover. Such a definition lends confusion to any attempts to differentiate among shallow lakes, deep lakes, and wetlands to recognize the importance of water depth for inherent differences in structural and functional aspects of these three systems.

Ramsar was correct in recognizing that adjacent deep and shallow systems should be considered as a single functional unit. It is inherent in such an approach that wetlands are critical for the transformation and storage of watershed physical/chemical exports (hydrology, sediments, nutrients), thereby regulating structural and functional aspects of adjacent deep water systems. Until recently, lake management considered only the linkage between point/non-point exports from uplands and responses of open-water foodwebs, and ignored the role of vegetated aquatic ecotones as a driving factor. In marked contrast, lotic ecologists have recognized the importance of horizontal linkages with the floodplain, including the nutrient spiraling (Newbold-