

# Food web (bio-)manipulation of South African reservoirs – viable eutrophication management prospect or illusory pipe dream? A reflective commentary and position paper

Rob C Hart

School of Biological and Conservation Sciences, University of KwaZulu-Natal, Pietermaritzburg 3201, South Africa

## Abstract

An overview of prospects and limitations for the application of 'classical' top-down biomanipulation as a management tool to ameliorate the consequences of eutrophication under the conditions applicable to reservoirs in South Africa is presented. This is structured by considering successive stages in reservoir food-web structure and function as far as can be generalised for South African biophysical conditions. Features and conditions that influence the potential vulnerability of local reservoirs to the effects of eutrophication, and prospects for its amelioration by biomanipulation intervention are examined. Physical factors linked to latitude (irradiation pattern and water-column stability) enhance the potential severity of eutrophication consequences in local reservoirs, although conversely, these are offset by suspended-clay turbidity. The predominance of *Microcystis* in local eutrophic waters is perceived as a primary major constraint in implementing 'classical' food-web manipulation. Intrinsic limitations on the ability of zooplankton grazers to control this cyanobacterium, and subsequent food-web linkages widely applicable in local reservoirs are discussed and evaluated accordingly. On balance, available evidence indicates a range of limitations that are likely to apply in respect of familiar contemporary approaches to biomanipulation in use today, although the uniqueness of each reservoir ecosystem is recognised. Some novel alternative management approaches are suggested, and a range of associated research requirements necessary to advance locally relevant scientific comprehension of 'biomanipulation' and its application are itemised. National revitalisation of reservoir limnology remains paramount.

**Keywords:** eutrophication, management constraints and options, warm-water reservoirs, biomanipulation, research needs.

## Introduction

Eutrophication – the enrichment of aquatic ecosystems by nitrogen and particularly phosphorus – is recognised as a serious and growing global threat to lakes, rivers and estuaries (OECD, 1982; Klapper, 1991; Moss, 1998; Straškraba and Tundisi, 1999; Holdren et al., 2001). The direct consequence of this nutrient 'pollution' is the excessive growth of autotrophic organisms in affected water-bodies. In standing waters, this manifests in blooms of generally undesirable planktonic 'algae' and/or prolific stands of rooted or floating vascular hydrophytes. The former commonly include 'harmful' toxic representatives, encapsulated as HABs (harmful algal blooms). (I use 'algae' as a collective term to include both conventional algae (photosynthetic eukaryote Protista), as well as photosynthetic prokaryote bacteria). Paradoxically, this elevated primary production is a major concern to the water quality of inland waters (OECD, 1982; Klapper, 1991; Moss, 1998; Straškraba and Tundisi, 1999; Holdren et al., 2001) in view of its profound and generally 'disruptive' impacts on ecosystem structure and functioning. Foremost amongst these are changes in the abundance and community structure of planktonic autotrophs, frequently resulting in nuisance 'algal' blooms. Planktonic eukaryote protistan algae (cryptophytes, dinoflagellates, chrysophytes and diatoms, green algae and euglenophytes) are commonly subjugated by prokaryotic blue-green algae – cyanobacteria, among whose members

toxic strains frequently arise, resulting in an array of subsequent changes in ecosystem functioning that are widely known today. The primary corrective measure for the control of eutrophication rests on reducing nutrient loading, principally through the integrated management of the drainage basin of the affected aquatic ecosystems. Globally, emphasis was initially directed at reducing nutrient loading rates (OECD, 1982), an approach that was (e.g. Walmsley and Butty, 1980; Grobler and Silberbauer, 1984), and indeed remains prominent in the South African context (e.g. Walmsley, 2000; Anon., 2004a, b). However, progressive recognition of ecological-biotic interactions spawned partly from long-term studies of Lake Washington (Edmondson and Litt, 1982; Edmondson, 1994; Edmondson et al., 2003), and thereafter in a range of shallow lakes in several densely populated lowland nations in Europe (e.g. Gulati et al., 1990; Moss, 1999; Kairesalo and Vakkilainen, 2004) brought widespread recognition to Shapiro's (1980) now familiar concept of food web or biomanipulation – schematically illustrated in Fig. 1. This 'classical' or 'traditional' approach focuses on enhancing or suppressing particular linkages within the trophic cascade: primary producer → primary consumer → secondary consumer → tertiary consumer ('algae' → grazing zooplankters → zooplanktivorous fish → piscivorous fish) in any manner consistent with maximising the grazing pressure exerted on the autotrophs.

Biomanipulation has been widely applied in north temperate waters, with results varying from spectacular success (especially in 'shallow' lakes) to dismal failure (often in deep lakes) and a range of outcomes between these extremes (e.g. Gulati et al., 1990; De Bernardi and Giussani, 1995; Mehner et al., 2002; Benndorf et al., 2002). Perhaps partly from desperation at the severity of eutrophication evident in various South African

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☎ +2733 260-5105; fax: +2733 260-5117;

e-mail: [hartr@ukzn.ac.za](mailto:hartr@ukzn.ac.za)

Received 19 April 2006; accepted in revised form 29 June 2006.