

Derivation of quantitative management objectives for annual instream water temperatures in the Sabie River using a biological index

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Abstract

Adaptive management of river systems assumes uncertainty and makes provision for system variability. Inherent within this management approach is that perceived limits of 'acceptable' system variability are regarded not only as testable hypotheses, but also as playing a central role in maintaining biodiversity. While the Kruger National Park currently functions as a flagship conservation area in South Africa, projected increases in air temperatures as a consequence of global climate change present challenges in conserving this biodiversity inside the established land boundaries. Within the rivers of the Kruger National Park, a management goal of maintaining biodiversity requires a clearer understanding of system variability. One component of this is water temperature, an important water quality parameter defining the distribution patterns of aquatic organisms. In this study, *Chiloglanis anoterus* Crass (1960) (Pisces: Mochokidae) was selected as a biological indicator of changes in annual water temperatures within the Sabie River in the southern Kruger National Park. Relative abundances of *C. anoterus* were determined using standard electro-fishing surveys. The presence or absence of *C. anoterus* was linked to cumulative annual heat units using a logistic regression model, and a critical annual cumulative water temperature threshold estimated. A correlative relationship between this temperature threshold and a biological index using a *C. anoterus* condition factor provides river ecologists with a tool to assess ecologically significant warming trends in Sabie River water temperatures. A similar approach could be applied with relative ease to other Southern African river systems. Further testing of this hypothesis is suggested, as part of the adaptive management cycle.

Keywords: Sabie River; daily maximum water temperature; *Chiloglanis anoterus*; condition factor index; adaptive management

Introduction

The importance of water temperatures to aquatic biota has been well-documented (for example Elliott, 1994; Eaton and Scheller, 1996; Claska and Gilbert, 1998; Sullivan et al., 2000). Furthermore, the accumulation of daily maximum temperatures above a critical threshold has been shown to have the greatest effect on the distribution and condition of aquatic species (Armour, 1991; Essig, 1998; Hines and Ambrose, 1998; Robison et al., 1999; Sullivan et al., 2000; Caissie et al., 2001). Biologically, daily maximum water temperatures are significant to fish, and in particular cold-water species, which show signs of acute stress at warm (>22°C) water temperatures (Dunham et al., 2003). For example, Hines and Ambrose (1998) found that the best predictor for the presence or absence of coho salmon *Oncorhynchus kisutch* (Walbaum, 1792) was the number of days a site exceeded a critical temperature threshold, and that single temperature values correlated poorly with fish presence and absence.

However, fish presence is only one measure of individual success in an environment. While fish may persist, temperature conditions may be contributing to their decline, which will be manifested as a change in condition, reflecting responses to environmental stress (Hines and Ambrose, 1998). Thus, repeated

and lasting exposure to sub-optimal thermal conditions leads to deterioration in condition. Hines and Ambrose (1998) proposed that a condition 'factor' could be linked to the number of days a threshold water temperature was exceeded. Such condition 'factors' are commonly used in biological studies to investigate seasonal and habitat differences in 'condition' or general 'well-being' (Ricker, 1968). Setting a water temperature threshold value based on the average condition of a population present at a site provides one method of determining 'unacceptable' water temperature conditions.

An approach such as this can provide river managers with a predictive tool when biotic responses to abiotic drivers are linked (Rivers-Moore, 2003), and have a degree of confidence in deciding when limits of natural variability are being exceeded. According to Rogers and Bestbier (1997), a 'primary problem facing scientists and managers in the Kruger National Park has been to develop the potential to predict and monitor the response of biodiversity in specific river sections (i.e. within the park) to modifications in hydrology, sediment supply and water quality originating at the catchment scale'. A key management challenge is to gain insight into change in complex natural systems, and to manage this change within so-called 'natural limits'. Adaptive management, based on managing natural systems through a process of careful testing of hypotheses rather than a reactive trial and error process (Walters, 1997), has been asserted as an approach to meeting this challenge.

Rogers and Bestbier (1997) provide a protocol for an adaptive management programme being implemented in the Kruger

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