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The benthic macrofauna of the St. Lucia Estuary during the 2005 drought year

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Abstract

The St. Lucia Estuary is the largest estuarine system in Africa. The estuary is part of the Greater St. Lucia Wetland Park, which has been declared a World Heritage Site. This ecosystem has been subjected to severe drought conditions over the last four to five years, resulting in its mouth being closed off from the ocean in June 2002 for a period of over four years. The main aim of this study was to document the effects of the prevailing drought on the macrofauna of the system, since the last work on this benthic component had been undertaken over a decade ago, during a normal-to-wet phase. Macrofauna samples together with physico-chemical data were collected at representative sites in the Narrows, and the South and North lakes in February, April, August and October 2005. The drought exerted a strong influence on the system, leading to hypersaline conditions developing in its northern regions (maximum of 126 at Hell's Gate), and to the loss of aquatic habitat. Ordinations and clustering indicated that the macrofauna of the system could generally be separated into three clusters viz. (1) the Narrows and the southern portion of South Lake, (2) the northern half of South Lake, and (3) the North Lake–False Bay complex. Multivariate correlations indicated weak relationships between macrofaunal community structure and physico-chemical parameters. The distinction in macrofaunal assemblages between these clusters was probably caused by these habitats being physically separated at the peak of the drought, with no water flow between them, thereby preventing exchange of planktonic larvae and retarding colonisation of habitats. There was a northward decline in taxonomic richness and diversity of macrofauna in the system, which correlated positively with water depth and negatively with the biomass of microphytobenthos. It is evident that the drought structured macrofauna communities primarily through its effects on water depth and habitat fragmentation. The results of this investigation provide valuable information regarding the effects of droughts on estuarine–lake systems and the possible mechanisms by which they occur.

Keywords: drought; hypersalinity; habitat fragmentation; macrofauna; estuarine lake; South Africa

1. Introduction

The St. Lucia estuarine lake (hereafter referred to as the St. Lucia Estuary) is the largest estuarine system in Africa (Fielding et al., 1991; Cyrus and Vivier, 2006a) and makes up roughly 80% of the overall estuarine area in the province of KwaZulu-Natal (Begg, 1978). The St. Lucia Estuary forms part of the Greater St. Lucia Wetland Park, which was declared a RAMSAR site in 1991, and granted World Heritage status in 1999, in view of the biological diversity and richness of this ecosystem.

Ecologically, the St. Lucia Estuary functions as a nursery for many fish (Wallace and van der Elst, 1975) and invertebrate species (Begg, 1978; Benfield et al., 1989). From a commercial and socio-economic point of view, the estuary has also supported a commercial prawn bait fishery since 1952 (Fielding et al., 1990), as well as other subsistence and recreational fisheries (Mann, 1995).

The St. Lucia Estuary is a naturally variable system, as large-scale spatial and temporal variations in physical and chemical parameters have been documented through its history (Begg, 1978; Fielding et al., 1991). The system has been typified by intermittent periods of flooding, droughts and mouth closure, but in spite of such disturbances, the system has nevertheless

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supported rich and diverse fauna and flora (Fielding et al., 1991). Such unpredictability in the physico-chemical habitat, allied with the diversity of biota has resulted in the system being well researched relative to other systems in South Africa. Studies on phytoplankton (Fielding et al., 1991), zooplankton (Grindley and Heydorn, 1970), fish (Blaber, 1979; Cyrus and Vivier, 2006a,b) and macrofauna (Forbes and Cyrus, 1992; Owen and Forbes, 1997) have been undertaken in the system.

However, the St. Lucia Estuary has been subjected to severe drought conditions over the last four to five years, which have resulted in the mouth of the estuary being permanently cut off from the Indian Ocean in June 2002 (Cyrus and Vivier, 2006a). Since then, the only link the estuary has had with the ocean is via the adjacent Mfolozi River during a flood event (Cyrus and Vivier, 2006a). Due to high evaporation rates and reduced fresh water inflow into the system, parts of the estuary have became hypersaline, with salinities of 200 and 90 being recorded in the North and South lakes, respectively (Cyrus and Vivier, 2006a).

So far, the only published work documenting the biological effects of this drought has dealt with the fish community, but there is as yet no information available on its effects on invertebrates, specifically macrofauna. The primary aim of this investigation was, therefore, to examine the effects of the prevalent drought conditions on the macrofauna of the St. Lucia system, as no study has specifically addressed this issue. The secondary aim was to update knowledge of benthic macrofauna in the St Lucia Estuary, since the last published work on macrofauna was undertaken roughly a decade ago. From a global perspective, literature regarding the effects of droughts on estuaries and estuarine lakes is scarce, and the mechanisms by which they influence these ecosystems are poorly understood (e.g. Hastie and Smith, 2006). The present study was intended to add to current knowledge of drought effects on estuarine systems, and to understand the fundamental causative mechanisms.

2. Materials and methods

2.1. Study area

The St. Lucia Estuary is situated in northern Kwazulu-Natal and lies between 27° 52′S to 28° 24′S and 32° 21′E to 32° 34′E. The system is made up of three shallow lakes connected to the Indian Ocean by a 21 km meandering channel referred to as the Narrows (Fig. 1). In total, the St. Lucia Estuary and lake system cover an area between 300 and 350 km^2, depending on water levels (Begg, 1978). The system is subdivided into the Mouth, Narrows, South Lake, North Lake and False Bay (Fig. 1).

2.2. Sampling procedure

Samples were collected in February, May, August and October 2005. Thirteen representative sites were sampled during each season (Fig. 1). An additional four sites were sampled in the North Lake only in December 2006 (Sites H1–H4). The drought conditions prevented access to these four sites by boat, and could only be accessed by a helicopter. The expense incurred in chartering the helicopter prevented sampling these sites more regularly.

2.2.1. Physico-chemical parameters

A portable YSI 556 multiprobe system was used to measure in situ physico-chemical variables such as salinity, temperature and dissolved oxygen. Measurements were made at the sediment–water interface at all sites. For sediment particle size analyses, pre-weighed (dry-weight) sediment was passed through a 2000 μm sieve. The sediment that passed through this sieve was then analysed by a Malvern Analyser, which could detect fractions between 2 and 2000 μm. Sediments retained by the 2000 μm sieve were weighed and incorporated with the data obtained from the Malvern Analyser to determine median particle sizes. Sediments were classified according to the Wentworth classification system (Morgans, 1956). Silt (<63 μm) content was determined from data obtained from the Malvern Analyser.

2.2.2. Benthic macrofauna

In February 2005, macrofauna samples were collected using a stainless steel corer (sampling area 0.00442 m^2; depth 20 cm). The corer proved difficult to operate in very muddy substrates and resulted in considerable delays in extracting cores. To overcome this problem, benthic samples were subsequently collected using a Zabalocki-type Ekman grab (sampling area 0.0236 m^2; depth 15 cm) for the rest of the survey and proved more efficient in muddy substrata. In February, single samples comprising three cores were collected at each site. For the remaining sampling trips, three replicate samples were collected at each site, with each sample comprising three grabs. Replicate sediment samples were emptied into buckets to which water was added and stirred vigorously, thereby suspending benthic invertebrates. The supernatant was then washed through a 500 μm sieve. This process of adding water, stirring and sieving was repeated five times, and any material retained on the sieve was emptied into a plastic jar. This procedure has been shown to extract more than 95% of the macrofauna in each sample (Cyrus and Martin, 1988). The remaining sediment was washed through a 2000 μm sieve in order to collect larger macrofauna such as bivalves, gastropods or crustaceans (Cyrus and Martin, 1988). All the macrofauna samples were preserved in 4% formaldehyde solution and stained with Phloxin-B. In the laboratory, organisms were sorted and identified to the lowest possible taxon.

2.2.3. Microphytobenthos

Sediment surface samples were collected using a corer (internal diameter 2 cm; depth 1 cm; $n = 3$) and placed into 50 ml polyethylene bottles containing 30 ml of 90% acetone. Microphytobenthic biomass was measured as chlorophyll-*a* (chl-*a*) concentration using a 10-AU Turner Designs fluorometer fitted with the narrow-band, non acidification system of Welschmeyer (1994) (Nozais et al., 2001).