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Investigation into the mortality of mangroves at St. Lucia Estuary

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ABSTRACT

Lake St. Lucia is the largest estuarine lake in South Africa and is a UNESCO World Heritage Site. The St. Lucia Estuary resides in a poor state due to drought and human impacts which have resulted in the closure of the mouth to the sea since 2002 and changes in freshwater inflow particularly from the Mfolozi River. This provides a unique opportunity to study the responses of the mangroves that usually grow in an intertidal environment. High water levels and inundation caused mangroves to die in The Narrows in 2013/2014 which caused concern. The aim of this study was to investigate the response of the mangroves to fluctuating environmental conditions. This was done by measuring the population structure and sediment characteristics at four sites in 2010, 2013 and 2014. The reconnection of the Mfolozi River to St. Lucia in 2013 via the Beach Canal and Back Channel as well as good rains led to an increase in water level which caused permanent inundation of pneumatophores (aerial roots of the white mangrove *Avicennia marina*) and anoxic conditions resulting in the mortality of mangroves fringing the main estuary channel (Site 3 on The Narrows). Self-thinning is a natural process that has occurred at Sites 1 and 2 while Site 4, which was previously considered a dying population, had a recruitment of a new seedling cohort in 2014. The dieback of mangroves along the water's edge is part of the natural dynamics because this would have occurred under the natural state for this system when the mouth closed to the sea, water level was high and the estuary was fresher. This study has shown that site-specific differences will allow for recruitment and overall survival of mangroves at St. Lucia Estuary.

1. Introduction

Lake St. Lucia is the largest estuarine lake in South Africa and has also been classified as a UNESCO World Heritage Site. Even though this lake falls within the iSimangaliso Wetland Park, the National Biodiversity Assessment of 2012 indicated that St. Lucia Estuary resides in a poor state (van Niekerk and Turpie, 2012). This is mainly due to a history of human impacts and management decisions that have resulted in alterations in the mouth status of the lake and freshwater inflow. A chronology of the important events that would influence the mangroves is provided in Table 1. Among the many macrophyte habitats that St. Lucia Estuary provides (described in detail in Taylor et al., 2006 and Adams et al., 2013) are mangrove forests. Dominant species are *Avicennia marina* (Forsk.) Vierh. (white or grey mangrove), *Bruguiera gymnorrhiza* (L.) Lam. (black mangrove) and *Acrostichum aureum* L. (a mangrove-associated fern as it lacks true mangrove features such as pneumatophores and vivipary) (Taylor et al., 2006). These unique forests are situated between the spring high tide and mean sea level. However, at St. Lucia, the mouth has been closed to the sea since 2002, resulting in non-tidal conditions with fluctuating water levels. Now, water level changes in response to rainfall, river inflow, linking of the Mfolozi River with St. Lucia via the Beach Channel and the Back Channel which introduces either freshwater or seawater depending on the state of the Mfolozi mouth (Fig. 1).

Because mangrove trees grow in the intertidal zone, changes in salinity, water level and anoxia are relatively common, and mangroves must be able to withstand these conditions. *Avicennia marina* (the dominant species at St. Lucia) has developed a specialised root system, pneumatophores, which are pencil-like roots with corky textures that grow vertically upwards from cable roots. Lenticels and the aerenchymatous cortex of these roots allow for gas exchange and the storage of oxygen under submerged conditions (Steinke, 1999; Purnobasuki and Suzuki, 2005). *Avicennia marina* is known to tolerate a wide range of conditions and has been described as a pioneer species (Steinke, 1999). *Bruguiera gymnorrhiza* is not a pioneer species and is found to establish at higher elevations of the middle and upper intertidal zones where inundation occurs at spring high tides (Steinke, 1999; Duke and Allen, 2006). Similar to *A. marina*, this mangrove has a specialised root system that winds into and out of the sediment forming knee roots (buttress roots) that aid in gaseous exchange. A comparison of the sediment characteristics in the mangrove forests of northern KwaZulu-Natal (Rajkaran and Adams, 2011) confirmed that *B. gymnorrhiza* occurred in drier habitats than *A. marina*. Tree density was negatively correlated with sediment moisture content whereas the density of *A. marina* was not significantly

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Table 1
Summary of historical events influencing environmental conditions and mangroves in the St. Lucia Estuary.

Date	Event
1952–2012	St. Lucia dredged to keep the mouth open to the sea and separate from the Mfolozi Estuary
2002–2012	A decade of drought with permanent mouth closure, low water level and high salinity in the lakes. Mfolozi mouth actively kept separate from St. Lucia
2011	Backchannel dredged to allow flow from Mfolozi into St. Lucia
July 2012	Beach channel excavated to connect Mfolozi Estuary and St. Lucia Estuary at the mouth
2012–2013	High rainfall in September 2012 broke the drought. Strong freshwater inflow in December 2012/January 2013 resulted in input from Mfolozi River into St. Lucia Narrows via the link canal causing an increase in water level and decrease in salinity in The Narrows

correlated with any sediment parameter confirming its pioneer status and tolerance to a wide range of environmental conditions.

Stands of mangroves grow along the banks of The Narrows of the St. Lucia Estuary (Fig. 1). The mangrove species *A. marina* and *B. gymnorrhiza* covered a total area of 304 ha. in 2008 (Adams et al., 2013); they fringe the main channel from the mouth of the St. Lucia Estuary inland over a distance of approximately 19 km and also occur between the Mfolozi and St. Lucia systems and along the lower parts of the Mpate River, which drains into St. Lucia from the west (Hoppe-Speer et al., 2012). Under natural conditions, when St. Lucia and Mfolozi estuaries shared a common mouth, mangrove distribution would have been restricted as the mouth would have closed periodically, increasing water level. Additionally, salinity would have been low due to freshwater flow from the Mfolozi River. However, the Mfolozi River was diverted away from St. Lucia because of high silt loads and from 1952 to 2002, the separate St. Lucia Estuary mouth was kept open to the sea by dredging, resulting in saline tidal conditions which would have encouraged the spread of mangroves. Aerial photograph analysis shows that the area covered by mangroves doubled since 1937 (Adams et al., 2013).

The decade of drought in St. Lucia, when the mouth was closed to the sea, occurred from 2002 to 2012 (Table 1). At this time, the management decision was to keep the mouth closed to prevent seawater input and hypersaline conditions (Taylor, 2013). In 2012/2013, the drought was broken, St. Lucia remained closed to the sea but received flow from the Mfolozi River via the Beach Canal, Back Channel and Link Canal. This study traverses this time period measuring the response of mangroves in 2010, 2013 and 2014 over a period of increasing water level and fluctuating salinity. Salinity increased in The Narrows due to inputs from the Mfolozi River, when it was open to the sea and decreased in response to high rainfall and freshwater input from the Mfolozi River via the Link Canal and Back Channel (Fig. 1). In December 2013/January 2014 there was a die off of patches of the *A. marina* mangroves in The Narrows with the largest patches at Oxbow and downstream of the Mpate River (R. Taylor, pers. comm.). The aim of this study was to assess the responses of mangroves at St. Lucia Estuary to fluctuating environmental conditions and to determine why stands of mangroves died in 2013/2014. The non-tidal conditions in The Narrows of St. Lucia provide an opportunity to study the responses of mangroves to these extreme conditions. The results from this study will contribute to a global understanding of the response of mangroves to stress.

1.1. Study site description

Four mangrove sites were sampled in May 2010 by Hoppe-Speer et al. (2012), and in May 2013 (Rautenbach, 2015) and 2014 (this study) (Fig. 1). The sites were chosen in 2010 to represent a range of salinity and moisture conditions. *A. marina* was present at all four sites, and *B. gymnorrhiza* was present at Site 2. When Hoppe-Speer et al. (2012) conducted the study on the mangroves in 2010, water level was lower

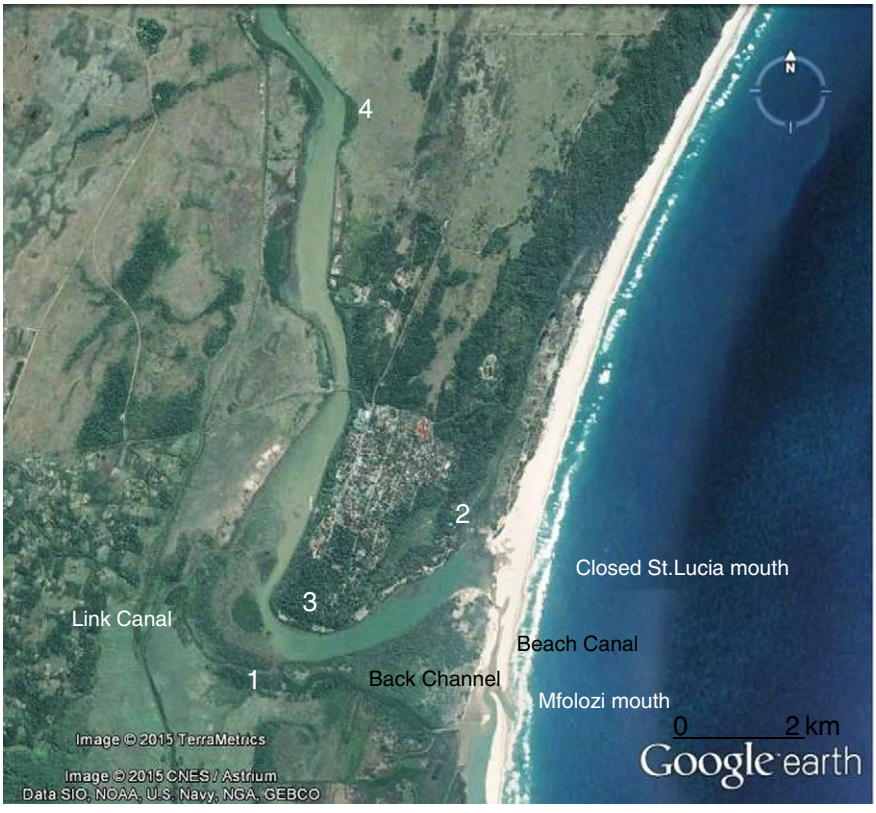

Fig. 1. Mangrove study Sites 1 to 4 along The Narrows in Lake St. Lucia.

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