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4.4 COASTAL LAKES

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INTRODUCTION

Lacustrine freshwaters are an important component of the diversity of aquatic habitats in coastal KZN, with 13 coastal lakes in the province (Figure 4.7). These are standing bodies of open freshwater, often surrounded by vegetated wetlands and swamps, and are different from estuaries in that they have no surface water connection with the ocean. They differ in size, but commonly have low surface water inflows and are primarily fed by groundwater from primary aquifers. This has implications for the water chemistry and ecological characteristics of these lakes, the threats they face from surrounding land uses.

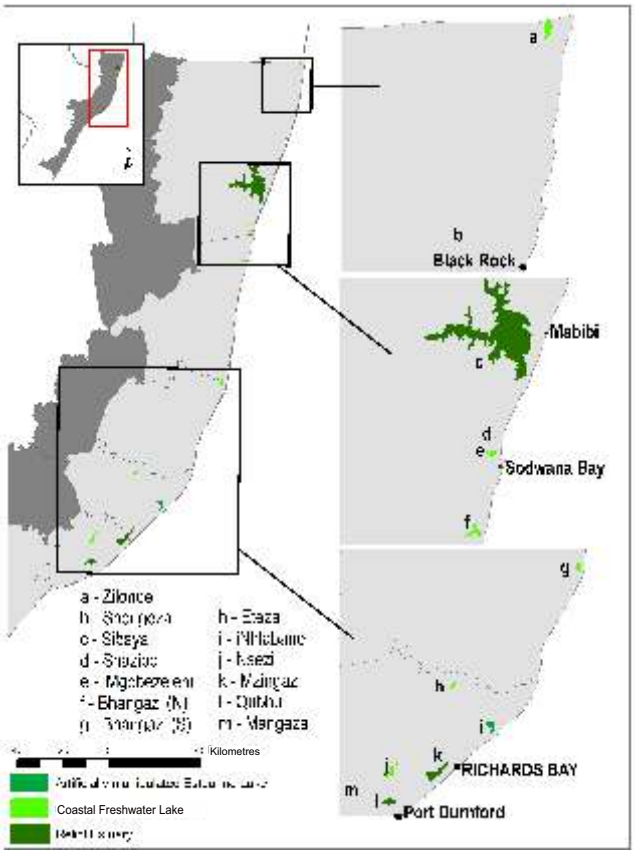

Figure 4.7: Locations of northern KZN coastal lakes around Richards Bay and in Maputaland.

LOCATIONS, ORIGINS AND CHARACTERISTICS

The arid climate and relatively short drainage systems mean that natural lakes are rare in South Africa (Whitfield *et al.* 2017). Coastal lakes in KZN occur to the north of the uThukela River (Figure 4.7), their formation promoted by the topography, porous sandy sediments and high-water table of the flat Mozambique peneplain. All but Shengeza, Nsezi and Mangeza were likely estuarine in the early stages of their evolution (MacKay *et al.* 2014) when during the Holocene, rising sea-level flooded coastal river valleys (Hill 1975). Lakes were separated from their original estuaries by segmentation (Qubhu, Mzingazi, Zilonde) or by sedimentation (iMgobezeleni, Shazibe, Eteza, Bhangazi South). In the case of Sibaya, Bhangazi North and iNhlabane, isolation of the entire former estuary from the marine environment took place through dune accumulation that provided a direct physical barrier between the lake and the ocean (MacKay *et al.* 2014). Around Richards Bay, coastal lakes separation from downstream estuaries has been expedited by anthropogenic activities. Berms and barrages have been constructed at the outlets of Qubhu, Mzingazi and iNhlabane to augment

domestic and mining water supplies (Weerts and Cyrus 2001). The lakes differ in morphology (depth ranges from <1 m to 40 m) and size (from 7 to >7 000 ha). Although they are freshwater lakes, their coastal location highly influences their hydrological and chemical characteristics and therefore their plant and animal communities are distinctly different from typical freshwater bodies (MacKay *et al.* 2014). Within these systems the different origins, hydrological and morphological characteristics creates a diversity of lake types and habitats with unique ecological characteristics.

ECOLOGY

With little surface water inflow, in their natural states most of these lakes are characterised by clear, oligotrophic water. Their food webs are based on autochthonous sources of primary production, mainly from reeds (*Phragmites*, *Typha*, *Scirpus*) and rooted submerged macrophytes (*Potamageton*, *Stuckenia*, *Myriophyllum*, *Ceratophyllum*) which all occur in the shallows. Connected swamp forests (and peatlands where present, Section 4.2) would have contributed to additional sources of dissolved and particulate organic matter, but these habitats have been destroyed around many systems. The dark, humic waters of Lake iMgobozeleni are an indication of the influence of surrounding drainage through swamp forests. The shallow littoral lake areas, with the greatest diversity of vegetated habitats, have the highest diversities of fauna. The estuarine origin of most of KZN coastal lakes is strongly reflected in their faunal communities with relict estuarine invertebrates (dominated by peracarid crustaceans) and fishes persistent in these disconnected freshwaters (Boltt 1969, MacKay and Cyrus 2000, Weerts and Cyrus 2001, Whitfield *et al.* 2017). It is these faunal components which make these systems biologically unique. They include IUCN endangered species, such as the barebreast goby *Silhouettea sibayi*, a small, cryptic species endemic to Southern Africa (discovered in Lake Sibaya). Other freshwater fishes that occur in these lakes such as the many-spined climbing perch *Ctenopoma multispine*, and the blackspot climbing perch *Microctenopoma intermedium,* are also rare and vulnerable partly because of their high specificity for standing coastal freshwaters. At the community level, fishes are considered unique to each lake as they represent the paleo-ecological history of connectivity and their evolved tolerances to wide salinity ranges and abilities to reproduce in lake environments (Whitfield *et al.* 2017). Larger invertebrates such as the catadromous paddler crab *Varuna litterata* make use of KZN coastal lakes that are still connected with the marine environment. Based on their relative abundance in these systems they appear to be a preferred habitat (Weerts *et al.* 2014).

DRIVERS

Expanding populations in urban and rural coastal KZN have increasingly placed pressures on the province's coastal lakes. This has resulted in state changes that impact the goods and services that people derive from these systems. Concomitant effects of climate change are especially important in the case of these coastal habitats, which are prone to impacts from drought. While these systems are appreciated as sources of freshwater and resources supporting various uses (including basic human needs), they are undervalued for their intrinsic contributions to biodiversity, ecosystem rarity and or as stepping-stone habitats for species that move across the floodplain via aquatic systems.

PRESSURES

WATER USE

Water use is the main pressure on these systems,

either through direct abstraction of surface water for domestic, agriculture, forestry and mining purposes, or indirectly through groundwater impacts, with forestry being especially problematic. The recent extreme low lake levels in Lake Sibaya were a result of prolonged drought (2001-2016) over much of Maputaland. However, this was exacerbated by water used by commercial forestry. Estimates are that 35% of the drop in lake levels since 2001 were caused by forestry which covers a quarter of the lake's catchment (Smithers *et al.* 2017). Domestic water use, dune mining and various industrial activities requiring water have placed similar pressure on coastal lakes in the south. Lake iNhlabane is adjacent to extensive dune mining activities and it was completely impounded in 1977 to provide water for dredge mining of heavy minerals (MacKay *et al.* 2014).

POLLUTION

Coastal lakes are sensitive to water quality impacts given their naturally clear, oligotrophic states but historically they have been subject to low loading of nutrients and other potential contaminants because they are predominantly groundwater rather than surface water fed. However, various land-use activities have increased the pollution pressures. In the Richards Bay area pollution from failing sewerage infrastructure, municipal wastewater and stormwater inflows are the most problematic sources of pollution in the lakes that occur there. Agrochemicals (herbicides and insecticides) for subsistence farming and agriculture are likely pollutants in lakes to the north. Concentrations of DDT in Sibaya are amongst the highest reported in South Africa (Humphries 2013).

HABITAT DESTRUCTION

In northern KZN, coastal lakes are largely restricted to rural areas with lower population densities, but they are subject to pressures from rural sprawl, forestry (including small-scale growers) and agriculture. Coastal and swamp forests and critically important peatlands have been cleared for small-scale food production (Van Deventer *et al.* 2018). Lakes Qubhu and Mzingazi are under greater pressure from habitat destruction from urban development, agriculture and forestry, all of which encroach onto the shores of these systems.

Lake Sibaya (2020) at critically low water levels due to drought and extreme water use pressures
Photo: Fiona MacKay

RESOURCE EXPLOITATION

Direct exploitation of freshwater lakes resources includes harvesting of reeds, sedges and other vegetation for various uses. Fishing is conducted, in some cases using sustainable traditional methods, but increasingly resorting to dip nets and gillnets. Productivity in these systems is not high and they are prone to the effects of over-exploitation.

ALIEN INVASIVE SPECIES

The freshwater lakes present an ideal environment for the coastal freshwater invasives, and a set of alien invasive species including plants, invertebrates and the vertebrates similar to those that are problematic in the freshwater reaches of KZN estuaries, occurs. The invasive gastropod *Tarebia granifera* is well established in all systems. Water hyacinth (*Pontederia crassipes*) almost completely covers Lake Nsezi. Vermiculated sailfin catfish (*Pterygoplichthys*

disjunctivus) has been found in Lake Mangeza, and carp (*Cyprinus* carpio) and bass (*Micropterus* spp.) are likely present in some systems outside of iSimangaliso Wetland Park. Largemouth bass (*Micropterus salmoides*) was introduced into Lake Sibaya in 1935 but subsequently has not been reported in scientific surveys of the system (Bruton 1979). Given the considerable effort spent by researchers sampling and studying the system in the 1970's, it is likely that this early introduction was unsuccessful.

STATE

Good historic information exists for Sibaya, based largely on research activities by the Institute for Freshwater Studies (Rhodes University) from 1965 to 1977, but for most KZN coastal lakes, basic information on lake levels and water quality are not available to assess present day, let alone historic conditions. In 2015, water-levels in Lake Sibaya dropped to the lowest level in living memory and the southern basin separated from the main lake. Similar low lake water levels were experience in the Richards Bay area, with Mzingazi dropping to its lowest levels in over 50 years and fragmenting into separated north and south basins. The catchments in both systems are heavily afforested, and in the case of Sibaya water use by deep-rooted commercial trees exacerbated drought impacts to the limits of non-sustainable use of groundwater.
Limited nutrient data from Lake Sibaya suggest that rural development and forestry have influenced conditions in the western arm and southern basin, especially in the shallower peripheral areas. While causality is difficult to prove, increased sediment nutrient concentrations in the western arm of the lake are coincident with human settlement and the development of Mseleni Town and forestry development (Humphries and Benitez-Nelson 2013). Nutrient loading in Lake Nseleni undoubtedly contributes to the invasion of that system by water hyacinth, and other pollution-tolerant biota. In addition to sources in stormwater and agricultural return flows, this lake is subjected to pollution from municipal wastewater. Bacteriological data from Lake Mzingazi indicate that this is not a new phenomenon (Van der Wateren, 1998) but there is also little doubt that levels and frequency of pollution are increasing in these systems.

The information and trends from these can be broadly extrapolated to other systems. A uniform set of indicators of ecosystem state, and a method of integrating these has not been developed nor applied to coastal lakes in South Africa. However, using methods developed for lentic systems and last collectively evaluated for the 2018 National Biodiversity Assessment, coastal lakes in KZN were considered Critically Endangered and under-protected. The ecological condition of Lake Sibaya was 'Heavily to Severely/Critically modified' under assessment criteria adopted (Van Deventer *et al.* 2018). Given the similarity in pressures faced, other KZN coastal lakes are likely also modified and those systems outside of formally protected areas can be considered heavily modified. Although the geophysical origins of lakes have permitted select estuarine macrobenthic taxa (isopods and amphipods) to maintain good populations (Mackay and Cyrus 2001), weirs at the outlets of most of these systems are barriers to natural movement and migrations between lakes, estuaries and the ocean. This has compromised the full range of biodiversity capacity of these unique ecosystems, their connectivity with downstream systems and reduced the ecological function of these systems (Weerts *et al.* 2014).

Current pressures on coastal lakes in KZN are all increasing, and without management response the state of these systems will continue to

decline. This will be exacerbated by climate change effects, especially widely fluctuating lake levels, and with an increasing threat of sea-level rise on the flat coastal topography. Ultimately rising sea levels will likely re-connect systems to the marine environment and re-establish many of them as estuaries. Along the way to this end point, salinisation by groundwater intrusion is likely to impact these freshwater bodies causing largescale and permanent changes to their ecology and capacity to deliver freshwater supply.

Currently, some lakes are apparently well protected, with several located in areas under the management and compliance control of conservation authorities (iSimangaliso and EKZNW). However, no work has been done to assess whether all, or what proportions of representative coastal lake types, habitats or biota are protected, and what is the *threat status of the ecosystem subtypes*? Lake Sibaya, the largest coastal lake in KZN, and South Africa, for example, is a designated RAMSAR site and forms part of the iSimangaliso Wetland Park. However, legal protection applies only to the lake surface and not the littoral and surrounding terrestrial components (Combrink *et al.* 2011).

IMPACT

Connectivity impacts (biodiversity and system function losses) caused by barriers to faunal migration at coastal lake outlets in KZN are now well understood (MacKay and Cyrus 2001, Weerts *et al.* 2014). Other forms of habitat alteration invariably cause loss of biodiversity and reduce systems resilience to future anthropogenic and natural (climate change) pressures. Falling lake water levels have already been shown to result in large losses of marginal habitats which are the most ecologically significant areas in these lakes. Extreme lake level reductions result in habitat fragmentation, with some lakes already seen to separate into isolated basins at low levels. This results in population fragmentation and increases the propensity for edge effects (resulting in increased pollution and erosion impacts and increasing the introduction of invasives species). While vegetation tends to follow lake levels down at a pace that support continued ecosystem function, this biomass is drowned when lake levels increase and widely fluctuating water levels can lead to high loads of decaying organic matter, with water quality impacts. Loss of supporting marginal habitats (wetlands, swamp forest and peatlands) contributes to this.

Low lake levels also exacerbate pollution threats as lower lake volumes have lower assimilation capacity. The oligotrophic nature of KZN coastal systems is easily impacted by nutrient inputs, and at the extreme eutrophication impacts are possible. Accumulation of DDT has been detected in the sediments of Lake Sibaya and other nearby water bodies (Buah-Kwofie *et al.* 2017) and is being passed in the food chain to higher trophic levels (Humphries 2013) and carried by groundwater seepage to coral reefs off Sodwana Bay (Porter *et al.* 2018). Pollution impacts not only have biodiversity and ecosystem function impacts, but also impact human health, particularly for communities that are reliant on coastal lakes as sources of drinking water, or for livestock waters and subsistence agriculture.

The impacts of resource exploitation in KZN coastal lakes are little studied, except for those associated with water use. Given the increase in population and the use of gillnets in these systems, it is highly likely that populations of larger fish species are declining. The crocodile population of Lake Sibaya has undergone marked decline since 1990, likely due to the perceived

threat posed to life and livestock, destruction of crocodile eggs, harvesting for medicinal/ economic purposes, gillnet mortalities and nest disturbance by livestock (Combrink *et al.* 2011). This is likely true for other large fauna (notably hippos) and at other coastal lakes outside of formally protected areas. Alien invasive plants are present in lakes around Richards Bay. Lake Nsezi is the most impacted with water hyacinth almost completely covering the water surface. This floating macrophyte has known long-term water quality impacts, reducing oxygen available for biota and, in Lake Nsezi, has a significantly negative impact on aquatic macroinvertebrate biodiversity (Coetzee *et al.* 2014). The invasive gastropod *Tarebia granifera* outcompetes local mollusc species in KZN coastal lakes and occurs in abundances high enough to be considered habitat altering. Dead shells dominate the sediments in shallow littoral areas of some systems, altering the sediment granulometry and benthic community composition.

RESPONSE

- Coastal lake water use, pollution, habitat destruction, resource exploitation and alien species can be summarily addressed by the *development and implementation of a set of integrative management tools* and *supporting monitoring programmes*. None exist, or are mandated, in specific legislation.
- As rare ecosystems in South Africa, *a strategic conservation plan* for coastal lakes needs to be developed and adopted. Many systems are in KZN, which has high development pressures and increasing socioeconomic issues.
- A protocol for developing *Lake Management Plans* (comparable with EMPs) must be established and implemented. For these to be effective, a method of *identifying and protecting buffer areas* around lakes will be needed (such as the EFZ and CMLs). These tools should be used to aid land use management and inform spatial development plans around coastal lakes.
- Plans must *address compliance and enforcement*, which at present is weak.
- *Environmental water requirement* studies have been conducted on some coastal lakes around Richards Bay and Lake Sibaya, but the protocols and methods for Resource Directed Measures (RDM) are better for rivers and estuaries. Lacustrine freshwater requirement methods are a priority.
- Underpinning all the above should be *systematic monitoring of lakes* to include abiotic and biotic components. This should include lake water levels and selected basic physico-chemical water quality parameters (continuous monitoring), as well as regular (monthly) discrete sampling for water quality parameters requiring laboratory analyses. Monitoring of sediments for metals and persistent organic pollutants can be done at much longer time intervals. Biological monitoring should include vegetation, diatoms, invertebrates, fishes and birds, with crocodile and hippo counts conducted on a regular basis in formally protected areas.

Data requirements
All lakes require morphology surveys to quantify lake volumes for lake water management and for predictive capabilities when considering climate change. Data should be collected and integrated with surveys that are conducted around neighbouring EFZs. There is a dearth of biological information on the lakes, even basic biodiversity inventories. Campaigns to collect specimens for species lists and genetic material may reinforce the rarity of these Critically Endangered ecosystem types. Associated vegetation and vegetated wetlands represent a possibly significant source of teal carbon. Climate change indicators are needed to use in risk evaluation, particularly given KZN's dependencies on coastal lakes. Lake-specific pressure assessments that evaluate e.g., harvesting, fishing, land-use are required to evaluate ecosystem state and impacts.