



Lake St Lucia Estuary Management Plan



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Glossary and Abbreviations

Amsl	above mean sea level
Anthropogenic	Having to do with people, or caused by humans
Benthic Macroinvertebrates	Or benthos, refers to invertebrates attached to, living on (epifauna) or in (infauna) the substratum, that can be captured by a 500 µm net or sieve
BGIS	Biodiversity Geographic Information System (GIS) developed and managed by the South African National Biodiversity Institute and accessed at http://www.bgis.sanbi.org/
Biodiversity	The variability among living organisms from all sources including, <i>inter alia</i> , terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems
Catchment	In relation to a watercourse or watercourses or part of a watercourse, this term means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points
Community	Assemblage of organisms characterised by a distinctive combination of species that occupy a common environment and interact with one another
Community composition	All taxa, plants and animals, present in a community
Cumulative impact	Impact on the environment which results from the incremental or combined effects of one or more developmental activities in a specified area over a particular time period, which may occur simultaneously, sequentially, or in an interactive manner
CWDP	Coastal Waters Discharge Permit under the National Environmental Management: Integrated Coastal Management Act No. 24 of 2008
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs (National)
DEDTEA	Department of Economic Development, Tourism and Environmental Affairs (KwaZulu-Natal)
Dilution	The reduction in concentration of a substance due to mixing with water
DWS	Department of Water and Sanitation (formerly Department of Water Affairs (DWA) and Department of Water Affairs & Forestry (DWAF))
EFZ	Estuarine Functional Zone. Low lying land adjacent to the river or estuary periodically flooded and where river borne materials are deposited, including areas adjacent to the estuary banks and below the 5 m amsl for the intermittently open estuaries along the KZN coastline, as described on BGIS
EIA	Environmental Impact Assessment in terms of the 2014 Regulations under the National Environmental Management Act No. 107 of 1998
Environmental Flows	The quantity and quality of water required to sustainably keep aquatic systems healthy and in the classified ecological management category
Environmental impact	A discrete (definable) interaction between a project activity and one or more components of the environment (biophysical and social)
Eutrophic	Rich in mineral and organic nutrients that facilitate prolific plant growth
GIS	Geographic Information System. GIS is a combination of computer software and hardware tools used for creating maps and analysing spatial data. GIS links the map and database information so that questions can be asked and answers given in map or visual form
Guidelines	Guidelines for the Development and Implementation of Estuarine Management Plans in terms of the National Estuarine Management Protocol, published by the Department of Environmental Affairs in March 2015

Habitat	The natural home of an organism or community of organisms (this also includes the surrounding area). This includes biotic and abiotic features. Habitat loss or fragmentation is one of the primary causes of the loss of biodiversity and resilience
Hypertrophic	Conditions characterised by elevated mineral and organic nutrients in aquatic environments resulting in boom-and-bust cycles of plant growth often leading to cycles of oxygen super-saturation and oxygen depletion in the water column
IAP	Invasive Alien Plant. A plant species that does not naturally occur in a specific area and whose introduction does or is likely to cause economic or environmental harm or harm to human health
ICM Act	National Environmental Management: Integrated Coastal Management Act No.24 of 2008
Invasive alien species	A species that does not naturally occur in a specific area and whose introduction does or is likely to cause economic or environmental harm or harm to human health
IOE	Intermittently Open Estuary, also known as Temporarily Open/Closed Estuary. This is an estuarine classification that groups all estuaries that are periodically closed off from the sea by a sand bar. These systems can close for varying lengths of time, and during closure, the areas upstream from the mouth are back-flooded. The highest water level reached by KwaZulu-Natal estuaries during natural mouth closure events is approximately 5 m above mean sea level
KZN	KwaZulu-Natal
MAR	Mean Annual Runoff
MER	Marine & Estuarine Research cc
NEMA	National Environmental Management Act No. 107 of 1998
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act No. 36 of 1998
Oligotrophic	Conditions characterised by low mineral and organic nutrients resulting in limitations to plant growth / primary production
PES	Present Ecological Status. This is a measure of the health of a water resource. The status is based on a comparison between the original / reference condition and the present state according to the reserve determination method of the Department of Water and Sanitation (DWA 2008. Water Resource Protection and Assessment Policy Implementation Process. Resource Directed Measures for protection of water resources: Methodology for the Determination of the Ecological Water Requirements for Estuaries. Version 2). This is generally denoted by a classification that can range from an “A” being unmodified to an “F” being critically modified
Protocol	National Estuarine Management Protocol in terms of section 33 of the National Environmental Management: Integrated Coastal Management Act No. 24 of 2008; Government Notice No. 341, published in Government Gazette No. 36432 on 10th May 2013
Runoff	Runoff is the water yield from an individual catchment – the sub-catchment plus the runoff from all upstream sub-catchments. Runoff includes any seepage, environmental flow releases and overflows from the reservoirs in a catchment, if they are present
SANBI	South African National Biodiversity Institute
Special Limit Values	Department of Water Affairs and Sanitation’s more stringent water quality limits / requirements that are applied when wastewater / effluent quality should be higher than General Limit Values for release to a water resource without a water use licence in accordance with GN 169 of 2013
Stormwater run-off	Stormwater run-off from paved areas, including parking lots, streets, residential subdivisions, buildings, roofs, highways, etc
TOCE	Temporarily Open/Closed Estuary. Also known as an Intermittently Open Estuary

TWQR	Target Water Quality Range established by the Department of Water Affairs and Forestry in a set of guidelines published in 1996
Wastewater	Water containing solid, suspended or dissolved material (including sediment) in such volumes, composition or manner that, if spilled or deposited in the natural environment, will cause, or is reasonably likely to cause, a negative impact
WWTW	Wastewater treatment works. Facility for the treatment of domestic or industrial wastewater designed to remove biological or chemical waste products from water to ensure that water discharged downstream/to the environment is of an acceptable quality
WULA	Water Use Licence Application under the National Water Act No. 36 of 1998

1 Introduction

iSimangaliso has three major estuary systems, viz. Lake St Lucia, Mgobozeleni and Kosi Bay, all of which are categorised as estuarine coastal lakes (Figure 1). Estuarine coastal lakes are estuaries that have a large water surface area. These are usually drowned river valleys filled in by reworked sediments and separated from the sea by vegetated sand dune systems. These types of estuaries can be permanently open or closed for periods when the link with the sea is lost and can have large salinity fluctuations driven by fluctuations in freshwater input, evaporation, and sea condition. The tidal prism is small and marine and river input have little influence on water temperatures, which are directly related to solar heating and radiation. Estuarine, marine and freshwater organisms all occur depending on the salinity condition of the system. These are three of nine estuarine coastal lakes on the South African coast and are now the only three intact systems within the sub-tropical bioregion.

The Lake St Lucia estuarine system, the largest estuary in the country, is situated on the Mozambique coastal plain in the north of the province of KwaZulu-Natal. The estuary is a dominant feature of the iSimangaliso Wetland Park and from a biodiversity point of view is one of the country's most significant estuaries. It also plays an important socio-economic role in the region (Clark *et. al.*, 2015) and, in terms of ecosystem services, has high tourism value. The estuary incorporates a large lake-like water body running parallel with the coastline in the north, with compartments known as North Lake, South Lake and False Bay. South of the lakes is a 20 km channel, referred to as the Narrows, which provides a physical and biological link between the lakes and the sea, allowing both water exchange and animal migration. The southern end of the Narrows links with the largest catchment to feed St Lucia, viz. the uMfolozi River, which complements the Lakes and Narrows as a source of freshwater and a driving force in terms of mouth dynamics.

This document details the Estuary Management Plan (EstMP) for the Lake St Lucia system (Figure 1) and draws on the Situation Assessment background report (iSimangaliso, 2015c) and other supporting documents. This plan provides a summary of the situation assessment, which describes the estuary's features, health status, the activities and issues affecting estuary health, and the management objectives and programme of actions for estuary management.

1.1 Framework for Estuary Management Plans

The development of three Estuary Management Plans for iSimangaliso is governed by section 34 of the National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008) (ICM Act) read with the National Estuarine Management Protocol 2013 (the Protocol). However, implementation is also governed by the World Heritage Convention Act (Act No. 49 of 1999) (WHC Act) read together with the ICM Act. This is because iSimangaliso is required to conduct its affairs in accordance with an Integrated Management Plan (Section 21 (2) WHC Act). The Department of Environmental Affairs (DEA) has also published *Guidelines for the Development and Implementation of Estuarine Management Plans* (DEA, 2015).

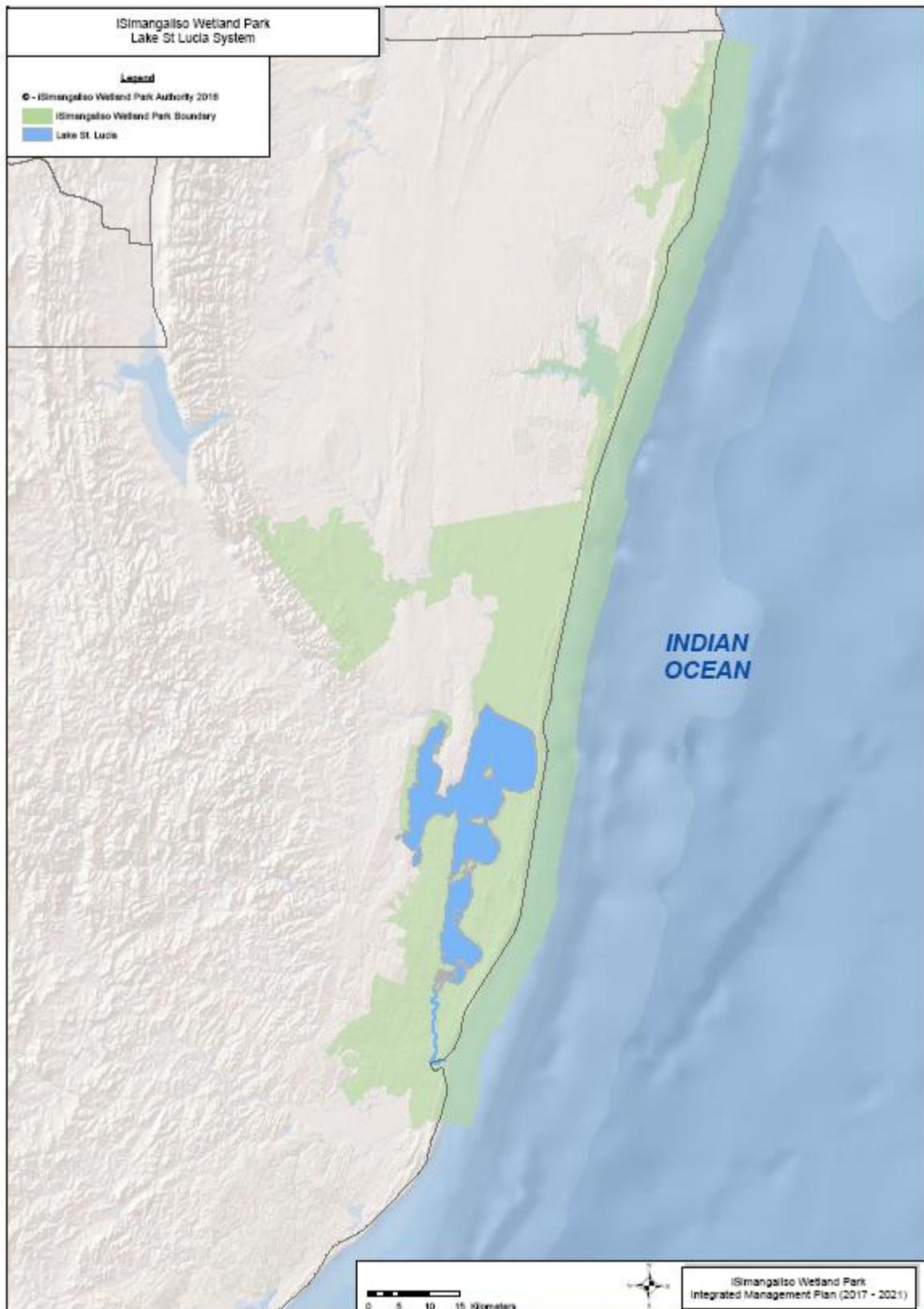


Figure 1 Location of the Lake St Lucia system within the iSimangaliso Wetland Park

The Protocol states that as the responsible authority, iSimangaliso must develop the EstMPs. Also, section 34 (1) (b) (i & ii) state that the EstMP must be consistent with the Protocol and the National Coastal Management Programme (NCMP). The Protocol is silent about the adoption of one or more EstMPs in the iSimangaliso circumstances. Neither a provincial management programme nor a municipal coastal programme is applicable to iSimangaliso. However, the national coastal management programme is applicable to iSimangaliso. Section 52 of the ICM Act requires consistency between coastal management programmes and other statutory plans. A statutory plan means a plan, policy or programme adopted by an organ of state. The IMP for iSimangaliso is such a statutory plan. The Minister approves the IMP and, consequently, to give effect to the purpose of the ICM Act, the EstMP can, therefore, only form part of the IMP.

This EstMP has taken into consideration all the requirements of the ICM Act and the Protocol. In terms of section 34(1) (d) of the ICM Act, iSimangaliso is required to submit an annual report to the Minister on the implementation of the EstMPs. iSimangaliso already reports to the Minister through the Department annually and will include this EstMP reporting requirement in that annual report.

The development of these EstMPs followed a three-step process that involved a scoping phase (Situation Assessment Report), objecting setting phase and the development of the implementation phase.

Prior to the ICM Act and the Protocol, all the estuaries in iSimangaliso were managed in terms of the provisions of the IMP and various statutes, including:

- ❖ World Heritage Convention Act, 1999 (Act 49 of 1999).
- ❖ National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA).
- ❖ National Environmental Management: Protected Areas Act, 2003 (Act 57 of 2003).
- ❖ National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- ❖ National Heritage Resources Act, 1999 (Act 25 of 1999).
- ❖ KwaZulu-Natal Heritage Act, 1997 (Act 10 of 1997).
- ❖ National Forests Act, 1998 (Act 84 of 1998).
- ❖ National Water Act, 1998 (Act 36 of 1998).
- ❖ Marine Living Resources Act, 1998 (Act 18 of 1998).
- ❖ Seashore Act, 1935 (Act 21 of 1935).
- ❖ Maritime Zone Act, 1994 (Act 15 of 1994).

Before the proclamation of iSimangaliso, all the estuaries in iSimangaliso were in protected areas and were managed as part of a greater conservation area by the duly appointed conservation manager for the particular area.

Most of the estuary (Figure 2) lies within the iSimangaliso Wetland Park. The iSimangaliso Wetland Park Authority is accordingly the responsible authority for the development and implementation of an Estuary Management Plan for St Lucia Estuary (including the five rivers that are part of this estuarine system) and any other activity that influences the system¹.

Given the legislative and institutional complexity of coastal management in South Africa, the purpose of an EstMP is to provide for the integrated and coordinated management of activities affecting estuarine resources. The top five such activities prioritised in the National Biodiversity Assessment (SANBI, 2012) were:

- ❖ Flow modification e.g. water abstraction (either directly from the system or indirectly by alien plants, timber plantations), urban stormwater runoff, etc.
- ❖ Pollution e.g. wastewater treatment works, industrial effluent, agrochemicals, etc.
- ❖ Exploitation of living resources e.g. fish, invertebrates, plants and plant-parts.
- ❖ Habitat destruction (e.g. low-lying development, bridges, mining, etc).
- ❖ Climate change (reflected in modified rainfall patterns, temperature changes, increased storminess and sea level rise).

The EstMP Guidelines have, therefore, determined the core sectors to be addressed by the management objectives within each EstMP. These are:

- ❖ Resource use.
- ❖ Conservation.
- ❖ Water quantity and quality.
- ❖ Socio-cultural values.
- ❖ Capacity building.
- ❖ Land use regulation.
- ❖ Compliance monitoring and enforcement.
- ❖ Climate change.

The EstMP for Lake St Lucia has been developed using existing and available information to:

- ❖ Develop a Situation Assessment.
- ❖ Set a vision and management objectives, which are aligned with iSimangaliso's IMP.
- ❖ Provide a description and guidance for the key management actions and programme.

¹ National Estuarine Management Protocol in terms of section 33 of the National Environmental Management: Integrated Coastal Management Act No. 24 of 2008; Government Notice No. 341, published in Government Gazette No. 36432 on 10th May 2013.

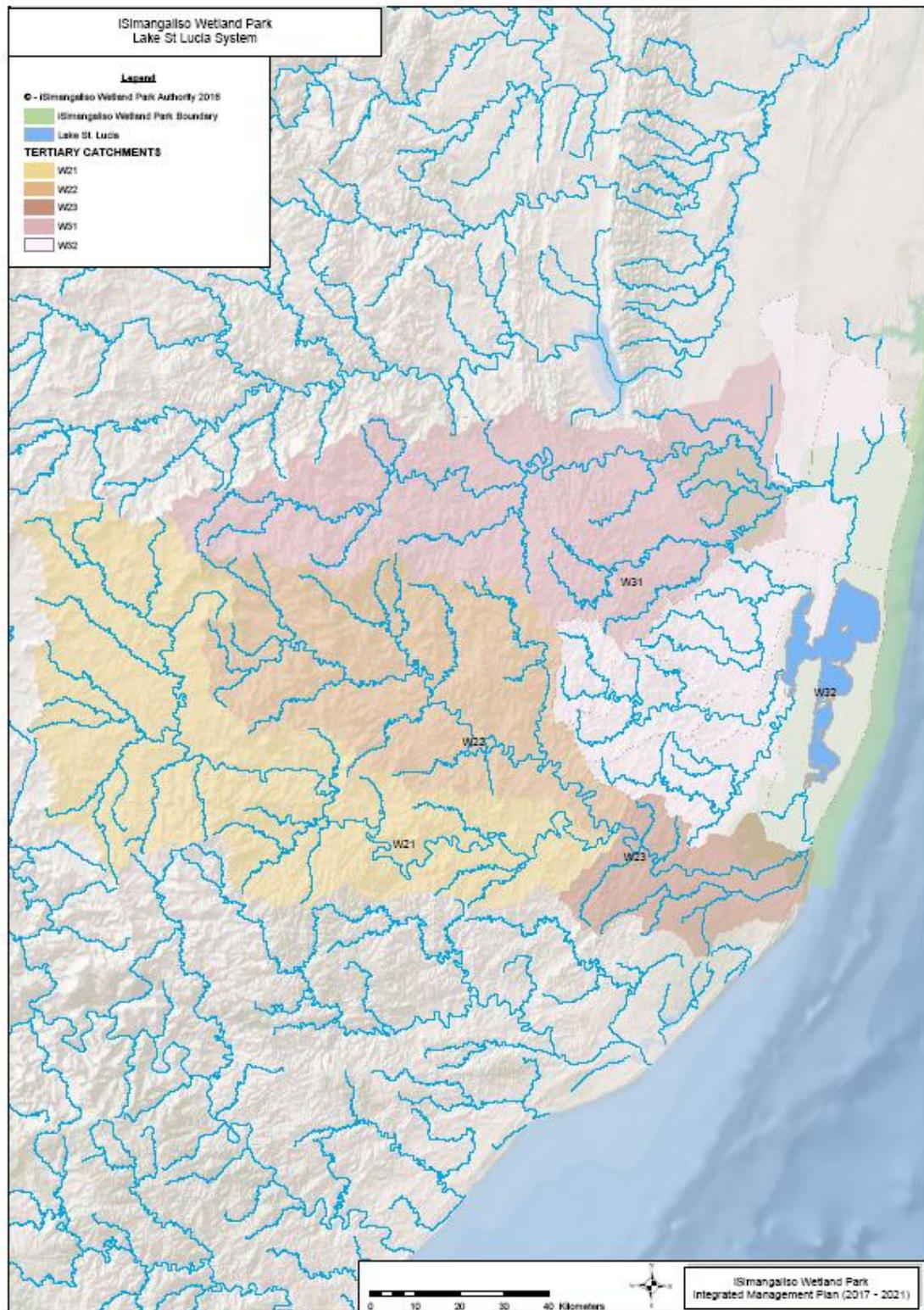


Figure 2 Lake St Lucia estuary (blue outline) with the tertiary catchments indicated (shaded and labelled)

EstMPs regulate and manage human activities impacting on estuaries and in, this particular case, on the Lake St Lucia Estuarine system. This means that this EstMP will describe the current status of the estuary and associated activities and will not table future developments. Importantly, as the first EstMP published in terms of the requirements of the ICM Act and the Protocol, it provides opportunities to identify and address many of the factors identified in the Situation Assessment as impacting on the health of the system. In addition, there are opportunities to explore positive interventions to improve estuarine functioning, including rehabilitation of habitat where possible.

2 The Lake St Lucia Estuary

2.1 Background

This section provides an overview of the key features, concerns and issues of the Lake St Lucia system to provide context for the management objectives and actions (Section 3).

The Lake St Lucia system is situated in the southern region of the iSimangaliso Wetland Park and is the southernmost estuarine coastal lake within the subtropical region (this would have been Lake Nhlabane estuary north of Richards Bay previously but major changes to this system have resulted in the lake no longer having a connection with the sea). This estuary type is one of the rarer types of estuary, being classified in the category of 'coastal lake' on the basis of its size and the relative extent of tidal influence (Whitfield & Baliwe, 2013).

Unlike the other two large iSimangaliso estuaries, Kosi Bay and Mgobezeleni, the Lake St Lucia system is primarily a surface water driven estuary with smaller groundwater inputs. It is served by five large tributary rivers, four of which enter the lakes, viz. the uMkhuze and uMzinene Rivers in the north, and the Hluhluwe and Nyalazi Rivers entering False Bay from the south. The fifth major river, the uMfolozi River, links with the system in the south at the lower end of the Narrows and provides a dual function as a major source of freshwater and the driver of the estuary's mouth dynamics. The artificial separation of the uMfolozi River from the system has compromised estuarine integrity and had a significant effect on water balance and salinity. Two smaller rivers also provide surface water to the system; the relatively small Mpate River enters the Narrows about 15 km from the sea on the Western Shores and input into the lakes from the Nkazana Stream on the Eastern Shores. Some local input (6-7%) also comes to the system in the form of groundwater derived from rainfall from the immediate areas surrounding the estuary and, in particular, the steep coastal dunes on the eastern margin. From a water resources planning perspective, the estuary is fed by five large tertiary catchments, W21, W22, W23 (uMfolozi), W31 (uMkhuze) with the remaining three rivers (Hluhluwe, Nyalazi and Mzinene) in W32 (Figure 2). The long-term significance of changes to all these systems in terms of declines in freshwater inputs into the lake as a result of catchment modification, damming, abstraction and expanding commercial forestry cannot be overemphasised.

The estuary has a diversity of important habitats including swamp forest, mangrove, reeds and sedge swamp. Despite its present fragile state it remains a nationally critically important coastal estuarine lake by virtue of its unique size, animal and plant diversity and its role in coastal biological processes, especially as nursery ground for both fish and invertebrates, particularly crustaceans.

The Lake St Lucia estuary complex has been the subject of more research, scientific publications and controversy than any other estuary in the country. It is clear from the large body of information that the high variability of the physical and chemical parameters of the system is natural, and that this is an important driver of spatial and temporal biotic diversity. However, the removal of the uMfolozi River from the system has resulted in the variability being pushed to extremes as low water levels and extremely high salinities were experienced during the drought.

The estuary was described in the National Biodiversity Assessment (SANBI, 2012) as being in poor condition generally but largely as a result of the historical separation of the uMfolozi River combined with prolonged drought conditions. At that time, the estimates of estuary health suggested a Present Ecological Status of E, being “*highly modified*”² (SANBI, 2012). Since the NBA a more detailed re-evaluation of estuary health concluded that as a result of the relinkage of the uMfolozi River the ecological health score should be raised to a low ‘C’ category “*Modified*”.

2.2 Geographical Boundaries of the Estuary

It is important to define the boundaries of the estuary and by virtue of this, the extent of the plan.

This step defines and maps the geographic boundaries of the estuary as follows:

- ❖ **Downstream boundary.** The estuary mouth, which may include the surfzone, seaward extent of the flood tide delta and/or transitional waters. This extension can be determined on salinity observations, and variations observed in historical aerial photographs or satellite imagery.
- ❖ **Upstream boundary.** The extent of tidal influence, i.e. the point up to where tidal variation in water levels can still be detected or the extent of saline intrusion or the extent of back-flooding during the closed mouth state, whichever is furthest upstream.
- ❖ **Lateral boundaries.** The lateral boundaries include all areas below the high tide mark, all estuarine vegetation (including mangroves, swamp forest, reeds/sedges and supratidal saltmarsh), and any floodplain areas below the upstream boundary as determined by the 1:100 flood line. Where these boundaries have not been defined by scientific methods, they can be defined at a desktop level using the 5 m topographical contour as indicative of 5 m above Mean Sea Level (MSL) along each bank. It should be noted that the littoral active zones adjacent to an estuary can stretch beyond the 5 m contour and should be incorporated in the estuarine functional zone in specific cases where scientific work determines these are an integral part of the estuary function.

² In accordance with the PES classification system developed by the Department of Water and Sanitation (DWA 2008).

2.3 The Geographical Boundary of the St Lucia Estuary

The geographic boundary of the estuary is defined by the 5 m amsl topographical contour. The coastal management line may also be a useful guide when defining the terrestrial extent of the estuary area. The 1,000 m development buffer provides an indication of the area in which listed activities are regulated relative to the high water mark in accordance with the EIA Regulations, and the extent of the coastal protection zone for rural areas as defined by the ICMA. These zones are designed to more formally regulate certain activities that may cause degradation of the estuary. The 1:100-year floodline is also an important guideline for land-use and town planning, in that it indicates areas of high risk where development should not be allowed. The location of the 1:100 year floodline needs to be determined so that future planning can take this into account. It will also provide an indication of existing and future activities that are at risk.

This estuary boundary is depicted graphically using the 5 m amsl topographical contour in Figure 3.

2.4 Summary of Key Features and Health Status of the St Lucia Lake Estuary

2.4.1 Estuary Type

In South Africa, estuaries are generally classified on the basis of physiographic (tidal prism and size), hydrographic (mouth state and mixing process) and salinity characteristics (Whitfield, 1992). Of the five generally recognised estuary types, the St Lucia Lake complex is classified as an estuarine lake system (Whitfield & Baliwe, 2013). Estuarine coastal lakes are estuaries that have a large surface area. The estuaries have been formed over time with changes in sea level creating drowned river valleys which are then filled in by reworked sediments and separated from the sea by vegetated sand dune systems. These types of estuaries can be permanently open or closed for periods when the link with the sea is lost and can have large salinity fluctuations, driven by fluctuations in freshwater input, evaporation and sea condition. The tidal prism is small and marine and river input have little influence on water temperatures, which are directly related to solar heating and radiation. Estuarine, marine and freshwater organisms all occur depending on the salinity condition of the system. These are three of nine coastal lake estuaries on the South African coast and are now the only three intact systems within the sub-tropical bioregion.

2.4.2 Estuary Health Status

The health status of an estuary is determined using the Estuary Health Index (EHI). The EHI is a standardised metric for use in estuary management and the determination of ecological water requirements. To determine overall health, the estuary is evaluated by estimating the estuary conditions, both physical and biological characteristics, for the Reference Condition and then scoring the present conditions relative to this estimated Reference Condition. The score derived from this assessment is the Present Ecological State (PES) score and falls into one of six categories (A-F) detailed in the table overleaf.



Figure 3 St Lucia Lake estuarine functional zone

Estuary Health Index Score	Present Ecological State	Description
100 - 91	A	Unmodified, natural
76 – 90	B	Largely natural with few modifications
61 – 75	C	Moderately modified
41 – 60	D	Largely modified
21 – 40	E	Highly degraded
0 – 20	F	Extremely degraded

The Lake St Lucia estuary was described in the National Biodiversity Assessment (SANBI, 2011) as being in poor condition generally but largely as a result of the historical separation of the uMfolozi River combined with prolonged drought conditions. At that time, the estimates of estuary health suggested a Present Ecological State of 'E', being "*highly degraded*" (SANBI, 2011). Since the NBA, a more detailed re-evaluation of estuary health concluded that as a result of the relinkage of the uMfolozi River, the ecological health score is now a low 'C' category "*Modified*" (Clark *et. al.*, 2014). A preliminary Recommended Ecological Category has been generated for all estuaries and for the Lake St Lucia system, this has been determined to be 'A or Best Attainable State' given that the estuary is:

- ❖ Located within a proclaimed protected area and World Heritage Site.
- ❖ Within the St Lucia Ramsar Site (Figure 4).
- ❖ Listed as a national priority for estuary conservation (SANBI, 2012).
- ❖ In relatively good condition considering the current state of the collective estuarine resource in KwaZulu-Natal and South Africa (SANBI, 2012; Whitfield & Baliwe, 2013).
- ❖ By far the largest estuary in the country, comprising approximately 60% of the national estuarine area, 80% of the sub-tropical estuarine area and 90% of the protected estuarine area.
- ❖ Recognised as one of the three most important nursery habitats for estuary-dependant marine fauna in the country.
- ❖ Known to support a number of rare and threatened species, being situated within a transition zone between the tropical and subtropical bioregions (iSimangaliso Wetland Park Authority, 2011).

2.4.3 Key Features

St Lucia is the world's oldest protected estuary (1895) and Africa's largest estuarine system. It is also the centre piece of South Africa's first UNESCO World Heritage Site, the iSimangaliso Wetland Park, and has been a Ramsar Wetland of International Importance since 1986. Its importance as a functioning ecosystem is also confirmed by its selection as a priority estuary to satisfy the biodiversity targets of the country. This is an obvious choice as the estuary supports high levels of biodiversity and viable populations of threatened species, which are of international and national importance, including feeding and breeding areas for endangered and endemic species. The interaction of these environments with major floods and coastal storms in the Park's transitional location has resulted in continuing speciation and exceptional species diversity. Its vivid natural spectacles include nesting turtles and large aggregations of flamingos and other waterfowl.

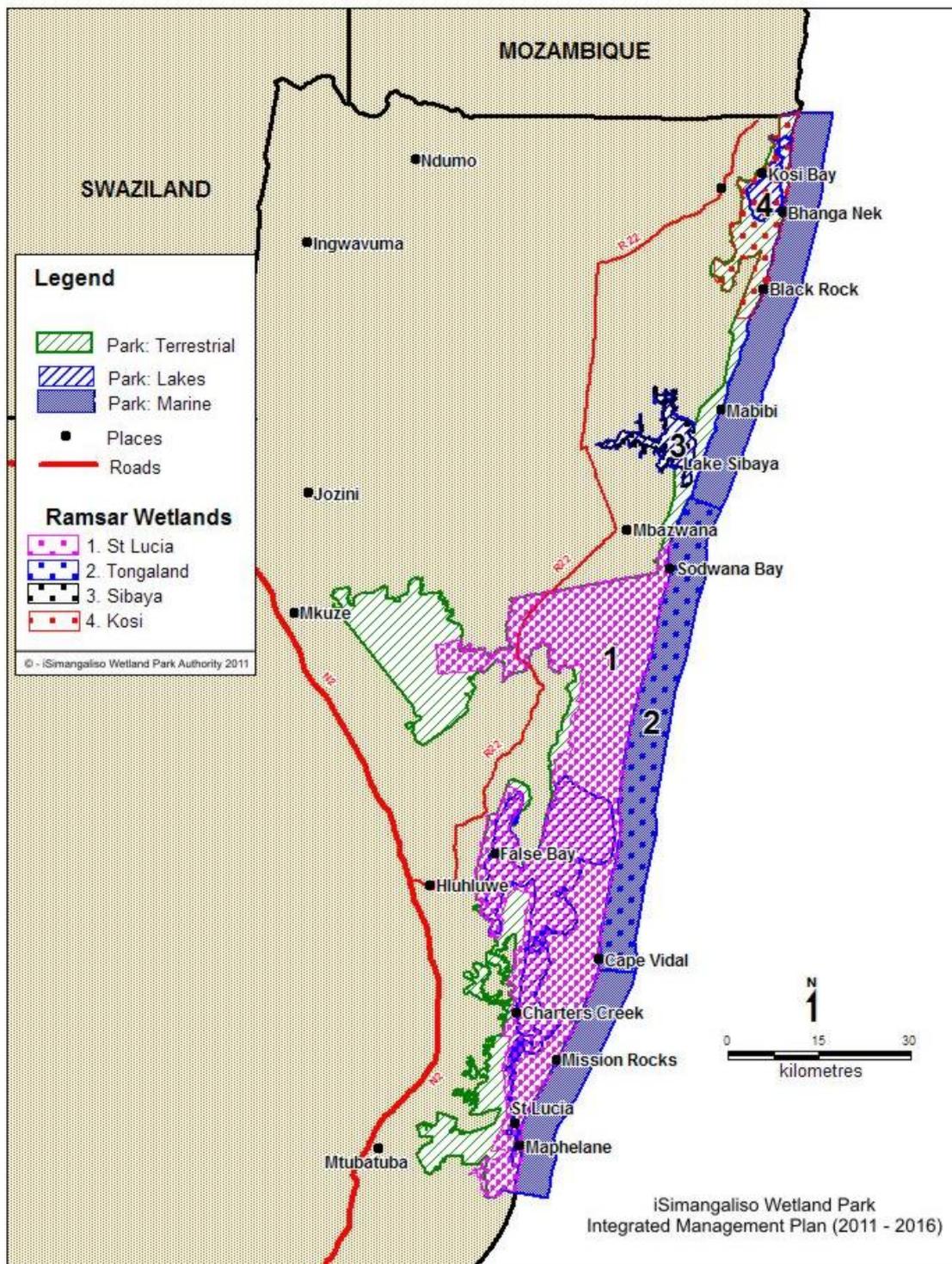


Figure 4 iSimangaliso Wetland Park Ramsar Sites (Source: iSimangaliso Wetland Park Authority, 2011)

Estuaries play a unique role in coastal functioning. They are critical habitats for many species of fish, shellfish, birds and marine mammals. They are nursery areas for many species of fish that return to and are harvested in the open sea. As many as 75% of all commercially important marine fish depend upon estuaries at some stage in their life cycle. Estuaries, therefore, play a critical role in the generation of protein-rich fish and shellfish. In many parts of the world, communities living near estuaries depend upon them for their food and livelihoods. Lake St Lucia is no different and is an important system for neighbouring communities, recreational and commercial fisheries, and local and international tourists.

Despite their importance as nursery areas for a large number of important recreational and commercial fish species, estuaries have not been well protected from impacting activities. This elevates the importance of Lake St Lucia for the prawns and fish of the sub-region making it one of the most important nursery grounds for juvenile marine fish and prawns along the sub-tropical east coast. It is also the most important estuary in terms of the numbers and diversity of waterbirds, which it supports. The estuary is a very important staging area³ with more than 50% of all waterbirds in KwaZulu-Natal feeding, roosting and nesting in this estuary. Importantly, it is the breeding area for several birds, which are rare or have limited distributions in South Africa. This has contributed to it being proclaimed a protected area, a Ramsar Wetland of International Importance and then finally a World Heritage Site.

Crocodiles are internationally recognized as important keystone predators in aquatic and terrestrial food webs, tourist attractions, good indicators of ecosystem health and flagship conservation species. The Lake St Lucia estuarine system is the most important protected area for the conservation of the Nile crocodile in South Africa. In terms of large aquatic mammals the hippopotamus is an iconic animal for Lake St Lucia and contributes significantly to the 'brand recognition' of many of the businesses associated with the St Lucia Village. It is listed as 'Vulnerable' on the IUCN Red List and Lake St Lucia is recognized as having the largest viable population in South Africa. This provides significant conservation value to this already important system.

2.5 Strategic Analysis of Threats and Issues

Estuaries and the adjacent marine environments are affected by direct and indirect anthropogenic impacts from their catchments and they are used by people for consumptive and non-consumptive purposes. Given the role that estuaries play in the broader coastal environment, and their sensitivity to human impacts (DEAT, 2000); a focused and coordinated approach to sustainable use of these ecosystems is essential to the continued delivery of ecosystem values, goods and services.

The main issues and threats that affect the ecological health and integrity of the St Lucia Lake estuary are considered to be:

³ A vast number of migratory wading birds stop in St Lucia to feed and rest during migration. Staging areas are where migratory birds stop and are vital stepping stones in migratory routes.

- ❖ The limited water inflows from the uMfolozi River due to its partial separation from the estuary as a result of human manipulation to mitigate damage from upstream agricultural practices.
- ❖ Direct abstraction from tributary rivers and indirect abstraction of the groundwater feeds affecting the freshwater volumes reaching the estuary (activities such as *Eucalyptus* spp. plantations affecting ground water recharge). Changes in water volume have resulted in a loss of connectivity between the different parts of the Lakes and Narrows while the historical separation of the uMfolozi River has had a major impact on mouth status⁴. Ensuring that the environmental (ecological) flow requirement is determined and adequate flow is maintained to preserve water quantity/volume or flow is a major priority. The flow requirement for the estuary has not yet been determined but is the subject of a Department of Water and Sanitation study due to be completed during 2016/2017.
- ❖ Water quality in tributary rivers.
- ❖ Alien species. Several alien plant species occur around the system. The tree *Casuarina equisetifolia* alters dune dynamics with the potential to influence estuary mouth behaviours. Casuarinas were removed from the vicinity of the mouth but seed bank re-establishment needs to be controlled. Aquatic alien invasive animal species also occur such as the snail, *Tarebia granifera*.
- ❖ Climate change – rainfall, sea level rise and temperature changes.

Key impacting activities that affect the ability of the St Lucia Lake estuary to continue to deliver ecosystem goods and services are described in more detail below.

2.5.1 Artificial Breaching and Mouth Manipulation

Breaching is the term for the opening of an estuary mouth and is a natural response to rainfall and sea conditions. An estuary may be temporarily cut off from the sea by the development of a sand barrier across the inlet or mouth. When rainfall increases and freshwater outflow is strong enough to remove the sand, the estuary will break through or breach the sand barrier. Sand is constantly deposited in the open mouth of an estuary by the sea during high tide and if river flow is not strong enough will ultimately close. It is an important natural and highly seasonal process in the life-cycle of an estuary as it establishes the connection of an estuary with the sea. This allows for the immigration and emigration of fish and invertebrates, tidal exchanges, flushing and the re-establishment of salinity gradients along the estuary which is one of the drivers of estuarine diversity and productivity.

Artificial breaching is the active removal of the sandbar from an estuary by human manipulation. This is usually done in response to rising water levels that rise behind the sand barrier once the estuary is cut off from the sea. A variety of fish species and invertebrates have life histories geared to the natural cycles of opening and closing, and along with many plants and birds are dependent on these natural cycles. Once estuaries close, habitat, nutrients and food availability increases dramatically thereby providing ideal conditions for growth and survival.

Artificial breaching in KwaZulu-Natal is most often carried out during winter or when rainfall is low. Unseasonal flushing of these systems as a result of artificial breaching reduces the nursery function for many fish and invertebrates by the removal of food resources and premature flushing of juvenile fish and prawns out into a hostile marine environment while they are still too young to cope.

Thus, artificial breaching disrupts the natural cycle and, therefore, has a negative effect on the plants and animals within estuaries (which in one study showed a twentyfold decrease in biomass). Artificial breaching is a convenient, but ecologically disruptive, means of altering the natural processes of an estuary. This is often done for the benefit of a few individuals but at the expense of the ecological health and services that these important systems provide and in this way having a ripple effect through many other lives. It is recognised and has been shown in the literature to be a highly damaging activity for estuaries.

Historically, the uMfolozi River flowed into the Lake St Lucia system. The mouth of the system opened to the sea at any point on the approximately 3 km of sandy beach between the Maphelane dunes to the south and the higher ground to the north at St Lucia village. Patterns of mouth closure, breaching and migration were driven by the interactions of river flow, wave driven sand movement, wave direction, and mouth bank scour and erosion during tidal ebb and flow. Under natural conditions the system would have behaved like any other intermittently open system on the KwaZulu-Natal coast whereby mouth closure would have resulted in backflooding onto both the uMfolozi floodplain and the low lying margins of the Lakes. However, in 1952 the uMfolozi River was partially separated from the system by artificially breaching the river in the south and conducting extensive dredging. Breaching was always carried out as far south as possible in order to maximise the separation of the systems.

The iSimangaliso Authority's strategy announced in 2011/2012 saw the uMfolozi River returning along its natural pathway into the system, thus, beginning the process of restoring estuarine function. This policy of minimum interference in the estuarine system to facilitate as much natural functioning as possible, limiting artificial breaching and then only for ecological reasons, will continue to be implemented.

2.5.2 Water Quality

Although turbidity of the water is a significant feature of the St Lucia estuary, influencing light penetration and the distribution of visual versus tactile predatory fish, the over-riding feature of the water quality in the St Lucia Lake estuary is salinity which can vary between fresh throughout, as existed in the mid 1970s, and up to 300 as has been recorded during 2015. A combination of freshwater and low temperatures can be lethal to migrant estuarine fish and fish kills under such conditions have been recorded (Blaber & Whitfield, 1976). Seawater has a salinity of 35 and once the salinity exceeds ca. 70,

differential solubility of different ions results in proportional changes and the solution is no longer simply concentrated seawater. The typical estuarine invertebrate fauna broadly cannot tolerate salinities greater than 55-60 (Forbes, A.T. pers. comm.) although many estuarine fish can tolerate 80-90 (Whitfield, Blaber & Cyrus, 1981).

At this time there is no evidence of bacterial or nutrient contamination in the Lakes and Narrows although some nutrient enrichment has been recorded in the uMsunduzi River (Nondoda, Adams, Bate & Taylor, 2011).

2.5.3 *Casuarina equisetifolia*

Casuarina equisetifolia was historically planted on the south bank of the lower reaches of the Narrows to stabilize sand movement (Begg, 1978). This stabilization acts against the normal sediment movement patterns of the highly dynamic estuary and beaches, and once stands of the tree have established they tend to accelerate dune and beach erosion (Digiamberardino, 1986). In addition to influencing dune morphology, *C. equisetifolia* alters dune and beach vegetation structure and species composition (Avis, 1995; Kraus *et al.*, 2003), decreasing biological diversity and compromising beach integrity (Awale & Phillott, 2014). This tree has since been identified as an invasive alien (Conservation of Agricultural Resources Act No. 43 of 1983; National Environmental Management: Biodiversity Act No. 10 of 2004; Invasive Species South Africa, 2014) particularly in the province of KwaZulu-Natal.

2.5.4 Tourism and Recreation

The St Lucia Village is a highly popular tourism node within the iSimangaliso Wetland Park, with high numbers of visitors accessing and using the beaches. Tourists are catered for by a variety of accommodation types, restaurants and craft shops. Various activities are offered by concession holders, which enable tourists to take boat trips on the Narrows, go on a game drive on the Eastern and Western Shores, whale watching, deep-sea fishing or swim and snorkel at Cape Vidal. Guided night drives are available on the Eastern and Western Shores that provide opportunities to observe nocturnal animals. The area is rich in birdlife and bird watching, which is catered for by knowledgeable local guides, and is a popular activity.

2.5.5 Invasive Alien Species

The Lake St Lucia system is known to have populations of the invasive alien freshwater snail *Tarebia granifera* (Appleton *et al.*, 2009; Miranda *et al.*, 2011). This parthenogenetic snail has proved to be a very successful invader of estuaries and lake systems on the KwaZulu-Natal coast, although the significance of possible ecological impacts on these habitats remains unknown (Miranda *et al.*, 2011).

2.5.6 Development Pressures

The St Lucia Village tourism node is located immediately north of the mouth of the St Lucia Estuary with a secondary development node further north at Cape Vidal). The village has a remarkably high concentration of tourist accommodation and supporting infrastructure such as restaurants, supermarkets, craft shops and booking centres for tourism activities. Delineation of the estuary, a setback line to ensure a buffer and zonation of the estuary to protect sensitive habitats and species will serve to mitigate the impact of development pressures.

3 Management Plan

3.1 Vision and Guiding Principles for Management of Activities Affecting the Management of Estuaries in the iSimangaliso Wetland Park

The vision, mission and management goals for the iSimangaliso Wetland Park are set out in the World Heritage Convention Act. These apply to the estuaries that fall within the Park. Although these are outlined in Chapter 4 of the IMP they are repeated here for ease of reference.

iSimangaliso's vision is to create Africa's greatest conservation-based tourism destination driven by community empowerment. Its mission is to protect, conserve and present the Wetland Park and its World Heritage Values for current and future generations in line with the standards laid down by UNESCO and the World Heritage Act, and to deliver benefits to communities living in and adjacent to the Park by facilitating optimal tourism and related development.

This aligns closely with the national estuaries protocol, which provides the national (strategic) vision for estuary management in South Africa, which states that:

The estuaries of South Africa are managed in a sustainable way that benefits the current and future generations.

3.2 Management Objectives and Key Actions

The specific key management objectives for the St Lucia Estuary complex are described and paired with the management goals of the IMP.

There are four overarching and interdependent management goals for iSimangaliso, which are derived from the World Heritage Convention Act. These are:

1. **Management goal 1:** To protect, conserve, enhance and present the Park's:
 - a. World Heritage values (ecological processes; superlative natural phenomena and scenic beauty; and biodiversity and threatened species); and its
 - b. Cultural heritage.
2. **Management goal 2:** To promote, manage, oversee, market and facilitate optimal tourism and related development in the Park.
3. **Management goal 3:** To promote the empowerment and development of historically disadvantaged communities in and adjacent to the Park.

4. **Management goal 4:** To ensure that iSimangaliso’s operations are properly funded and cost-effectively managed while maintaining an appropriate system of internal control and reporting of accounting, management, and statutory information.

The IMP’s five-year implementation plan is defined by identifying strategic drivers, key objectives and actions to support the achievement of the management goals, and setting timeframes over a five-year period. The same approach is followed here as estuaries are not managed separately from the rest of the Park. The table below shows the relationship between the National Estuarine Management Strategic Objectives and iSimangaliso’s Management Goals.

National Estuarine Management Strategic Objectives (Defined by the National Estuarine Management Protocol 2013)	Management Goals for the iSimangaliso Wetland Park (Defined by the World Heritage Convention Act (IMP Chapter 4))	Strategic Driver (Defined in IMP in Chapter 4)					
		1	2	3	4	5	6
		Park Operations and Conservation Management	Commercial Development (Tourism)	Empowerment & Transformation	Effective Corporate Governance	Interpretation, Presentation & Education	Research
To conserve, manage and enhance sustainable economic and social use without compromising the ecological integrity and functioning of estuarine ecosystems	To promote, manage, oversee, market and facilitate optimal tourism and related development in the Park		▲	▲			
	To promote the empowerment and development of historically disadvantaged communities in and adjacent to the Park		▲	▲			
To maintain and/or restore the ecological integrity of South African estuaries by ensuring that the ecological interactions between adjacent estuaries; between estuaries and their catchments; and between estuaries and other ecosystems, are maintained	To protect, conserve, enhance and present the Park's World Heritage values (ecological processes; superlative natural phenomena and scenic beauty; and biodiversity and threatened species)	▲					▲
To manage estuaries co-operatively through all spheres of government; and to engage the private sector/ entities and civil society in estuarine management	To ensure that iSimangaliso's operations are properly funded and cost-effectively managed while maintaining an appropriate system of internal control and reporting of accounting, management, and statutory information				▲		

National Estuarine Management Strategic Objectives (Defined by the National Estuarine Management Protocol 2013)	Management Goals for the iSimangaliso Wetland Park (Defined by the World Heritage Convention Act (IMP Chapter 4))	Strategic Driver (Defined in IMP in Chapter 4)					
		1	2	3	4	5	6
		Conservation Management	Park Operations and (Tourism) Commercial Development	Empowerment & Transformation	Effective Corporate Governance	Education Interpretation, Presentation &	Research
To protect a representative sample of estuaries (such protection could range from partial protection to full protection) in order to achieve overall estuarine biodiversity targets as determined by the 2011 National Biodiversity Assessment and the subsequent updates	To protect, conserve, enhance and present the Park's World Heritage values (ecological processes; superlative natural phenomena and scenic beauty; and biodiversity and threatened species)	▲					▲
To promote awareness, education and training that relate to the importance, value and management of South African estuaries	To protect, conserve, enhance and present the Park's World Heritage values (ecological processes; superlative natural phenomena and scenic beauty; and biodiversity and threatened species)					▲	
To minimize the potential detrimental impacts of predicted climate change through a precautionary approach to development in and around estuaries and with regard to the utilization of estuarine habitat and resources	To protect, conserve, enhance and present the Park's World Heritage values (ecological processes; superlative natural phenomena and scenic beauty; and biodiversity and threatened species)	▲					

The EstMP is a subsidiary plan to the IMP. Like the IMP, the EstMP is high level plan implemented via the annual plan of operation and incorporated in the strategic plan/corporate strategy. The annual plan of operation refines the EstMP with reference to prevailing circumstances. Furthermore, the implementation of the EstMP is subject to the availability of resources, including funding and human capacity.

The activities to be implemented under this EstMP fall mainly into the Park Operations & Conservation Management (1), and Research (6) strategic drivers, and are detailed below. Additional activities that relate to socio-economic development of the estuary and surrounds have not been singled out as they form part of the broader strategic plan of the iSimangaliso Wetland Park Authority. These are included in Chapter 4 of the IMP under the Commercial Development (2), Empowerment and Transformation (3), and Interpretation, Presentation & Education (5) strategic drivers.

3.3 Strategic Driver 1: Park Operations and Conservation Management

Key Objectives	1. Key Actions	Timeframes	Lead Agency
1. To conserve, protect and maintain the Lake St Lucia estuarine system's biodiversity, eco-system health, sense of place and ecological processes, and minimise internal and external negative impacts on the system	1.1. Oversee the implementation of the Conservation Operational Plan and revise annually	2017-2021	Ezemvelo KZN Wildlife & iSimangaliso
	1.2. Manage and monitor consumptive and non-consumptive recreational and community based natural resource use of the estuarine resources	2017-2021	Ezemvelo KZN Wildlife & iSimangaliso
	1.3. Review and refine the zonation of the Lake St Lucia estuarine system in order to better protect sensitive habitats and species, particularly estuarine dependent biota	2017-2021	iSimangaliso
	1.4. Implement an effective compliance system, which includes both <u>awareness</u> and <u>law enforcement</u>	2017-2021	Ezemvelo KZN Wildlife
	1.5. Implement the policy of minimum interference in the estuarine system to facilitate as much natural function as possible, limiting artificial breaching and then only for ecological reasons	2017-2021	iSimangaliso
	1.6. Implement restoration measures, including the removal of artificially placed dredge spoil and levies	2017-2021	iSimangaliso
	1.7. Support DWS in the completion of the reserve determination study of St Lucia estuary	2017-2021	DWS
	1.8. Support DAFF in the implementation of the small scale fisheries policy, including the issuing of small scale fishing permits, in the estuary and adjacent marine area	2017-2021	DAFF & iSimangaliso
	1.9. Support DWS' initiatives to manage catchment water use.	2017-2021	DWS
	1.10. Implement the Zone of Influence (Buffer Zone) Policy, which stipulates compliance with legal requirements and due process for the authorisation and operation of developments in the Zone of Influence	2017-2021	iSimangaliso
	1.11. Participate in planning in the Zone of Influence, including through the Municipal IDPs	2017-2021	iSimangaliso

3.4 Strategic Driver 6: Research

Key Objectives	Key Actions	Timeframes	Lead Agency
2. Improve the scientific understanding of the Lake St Lucia system in order to monitor its ecosystem health and inform management decisions	2.1 Authorise and process research from external research institutions to conduct research in the Lake St Lucia estuarine system in accordance with the research policy	2017-2021	iSimangaliso
	2.2 Review the current monitoring programme, identify areas needing strengthening, including selected physico-chemical variables, indicators that reveal presence of contaminants, status of estuarine plants and animals	2017-2021	iSimangaliso

4 Zonation of Estuary Activities

The zonation of the St Lucia Estuary follows the same system as the zonation for the Park as defined by the IMP (Chapter 5). The iSimangaliso estuaries are multiple use areas. Zonation helps to manage and protect both the sensitive areas and species within these systems as well as separate potentially conflicting activities. Increasing development and utilization result in the resource deteriorating, which usually lead to conflicts between stakeholders (users) of that particular estuary.

Within the general provisions of the Wilderness (Marine), Restricted (Marine) and Controlled (Marine) Zonation which apply to the St Lucia Estuary, the following zones also apply:

- ❖ No boating zones.
- ❖ No-take zones (particularly at the mouth).

Zonation of the St Lucia Estuary is illustrated in Figure 5 and the zones are described in the following tables.

The Wilderness areas within Lake St Lucia have been zoned to include the water surface and shoreline of most of north lake, including the eastern barrier dune complex. The Restricted areas of the estuary includes the northern and western sections of False Bay, including the delta inlet areas where the Mzinene and the Hluhluwe /Nyalazi interface with the lake, the upper two thirds of the Narrows from a demarcated point at the junction of the old Link Canal northwards to the northern side of Mitchell Island, and the mouth. The balance of the estuary is zoned Controlled (the southern end of the Narrows from the Link Canal entrance in the North to the Skiboat Club, and South Lake from Mitchell Island to Fanies Island including the navigable channel area leading to Hells Gates and the eastern portion of False Bay).

Furthermore, no fishing for subsistence, commercial and recreational angling from the shore or boat using baited/lured rod, reel and line as well as any foul line hooking is permitted within the mouth area of the Lake St Lucia estuarine system. This area includes the water surface of the Narrows east of the skiboat club, the shorelines of the lower uMfolozi River where it interfaces with St Lucia, and the St Lucia shoreline beach.

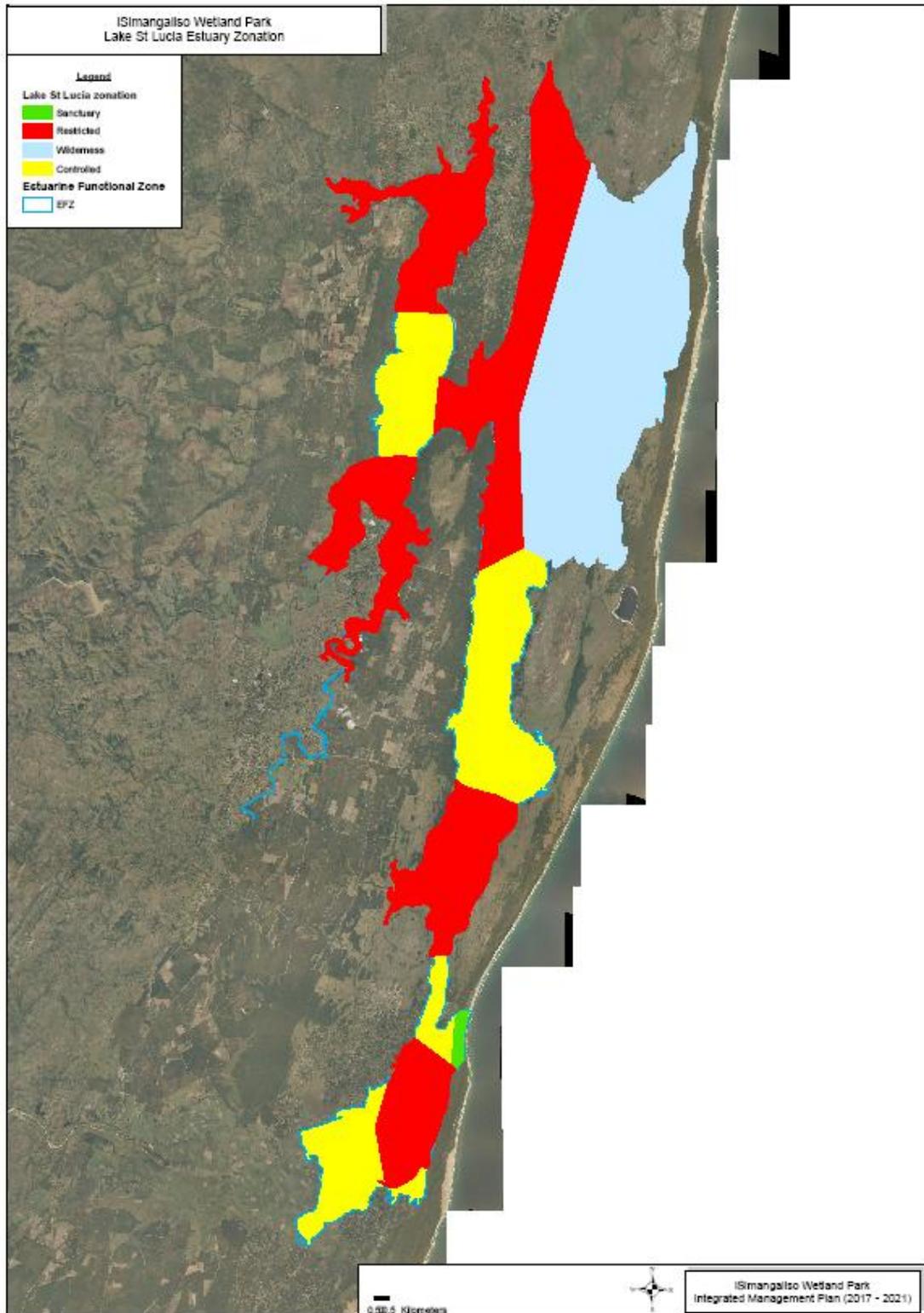


Figure 5 Zonation of the Lake St Lucia system

Wilderness (Marine)

UNMODIFIED NATURAL ENVIRONMENT. Largely equivalent to IUCN Category 1b Protected Area^{NOTE 1}, but may include areas that are not designated as such, but, nevertheless, have all the attributes and characteristics of true wilderness. Similar in principle to a Terrestrial Wilderness Zone.

Inherent Attributes/ Characteristics	<p>A marine area having no existing human settlement, infrastructure within it (e.g. buoys, piers, outflow pipes), nor consumptive use of marine resources (e.g. invertebrate harvesting, fishing, etc.), nor activities that cause disturbance to wildlife (e.g. dolphins, birds, crabs) occurring within it, having no adjacent land/sea which has human settlement or infrastructure development, and no access roads/ramps, no parking, no view sites and no picnic areas in the dune cordon alongside it. The adjacent land and seascape bear negligible visual evidence (even to the 'educated eye') of human influence (settlement/infrastructure) in the recent past. Thus, to even the 'educated eye', the area has an inherent pristine appearance and character, or at least the potential of being restored accordingly in the short to medium term with an absolute minimum of intervention. It must also be sufficiently unspoilt and of a large enough size to:</p> <ul style="list-style-type: none"> i Maintain ecological processes with an absolute minimum of management intervention. ii Provide a high quality wilderness experience by being physically, visually and audibly buffered from adjacent areas of human settlement (heightened 'sense of place' and of World Heritage values).
Focal Purpose of Zone ^{NOTE 2}	<ul style="list-style-type: none"> i Maintain an undisturbed pristine benchmark area of biodiversity and ecosystem processes. ii Provide visitors with wilderness/spiritual experiences in a marine environment (heightened 'sense of place' and of World Heritage values).
Permissible Uses & Activities ^{NOTE 3}	<p><i>Inshore:</i></p> <ul style="list-style-type: none"> i Walking on beaches and rocks. ii Swimming and snorkelling. iii Guided wilderness, special interest/educational trails and activities (non-motorised, including on foot, horseback and cycling) within the parameters of other permissible and non-permissible uses and activities. iv Highly regulated scientific research and monitoring that cannot be carried out elsewhere in the Park. v Essential management activities and intervention, including law enforcement operations (scheduled patrols and reaction) applying the 'minimum tool' principle and in line with national and international principles of wilderness management. vi Special access, assessed on a case by case basis, and requiring permits. <p><i>Offshore:</i></p> <ul style="list-style-type: none"> i Guided wilderness, special interest/educational activities (non-motorised vessels only) within the parameters of other permissible and non-permissible uses and activities. ii Highly-regulated scientific research, monitoring and World Heritage presentation that cannot be carried out elsewhere in the Park. iii Essential management activities, including law-enforcement operations (scheduled patrol and reaction) applying the 'minimum tool' principle. iv Special access, assessed on a case by case basis, and requiring permits. <p><i>Estuarine Lakes:</i></p> <ul style="list-style-type: none"> i Walking on estuary margins. ii Guided wilderness, special interest/educational trails and activities (non-motorised, including on foot, horseback and canoe) within the parameters of other permissible and non-permissible uses and activities. iii Highly regulated scientific research and monitoring that cannot be carried out elsewhere in the Park. iv Essential management activities and intervention, including law enforcement operations (scheduled patrols and reaction) applying the 'minimum tool' principle and in line with national and international principles of wilderness management.

	v Special access, assessed on a case by case basis, and requiring permits.
Non-Permissible Uses & Activities	<p><i>Inshore:</i></p> <ul style="list-style-type: none"> i. All forms of extractive use, including rock and surf angling, harvesting of intertidal or shallow subtidal organisms, and collection of biota and marine products (e.g. shells, driftwood, rocks, sand). ii. Fossicking^{NOTE 4}. iii. Beach driving, including management vehicles (except in emergencies). iv. Launching of motorised vessels except for management purposes. <p><i>Offshore:</i></p> <ul style="list-style-type: none"> i. Scuba diving except for highly regulated research, monitoring and World Heritage presentation. ii. Kite and wind-surfing. iii. Parasailing from boats or use of jet skis. iv. All forms of extractive use, including all types of fishing, and collection of biota and marine products (e.g. shells, rocks, sand etc.). v. Use of motorised vessels except for essential management and research/monitoring and vessels at sea within the 3 nautical mile limit offshore which have the right of passage, but may not be in possession of any marine life or parts thereof, and may not stop for any reason, other than a declared^{NOTE 5} emergency (e.g. sinking). <p><i>Estuarine Lakes</i></p> <ul style="list-style-type: none"> i. All forms of extractive use, including angling, harvesting of intertidal or shallow subtidal organisms, and collection of biota and marine products (e.g. shells, driftwood, rocks and sand). ii. Fossicking^{NOTE 4}. iii. Driving, including management vehicles (except in emergencies). iv. Launching of motorised vessels except for essential management and research/monitoring
Use Intensity/ Frequency^{NOTE 6}	<p>Law enforcement, management activities and visitor use strictly limited to:</p> <ul style="list-style-type: none"> i. The principles of 'minimum tool' and 'leave no trace' apply. ii. Very low intensity. iii. Very low frequency, the emphasis being on transient use only. iv. Very small group sizes. v. Very strict regulation and control over entry.
Development Nodes	No development or infrastructural facilities (e.g. buoys, beacons) permitted.
Development Restrictions	All types and forms of development prohibited, regardless of circumstances and needs.

NOTES: Wilderness (Marine)

NOTE 1: IUCN Category Ib protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.

NOTE 2: A combination of these purposes will reinforce the branding of the Park as a protected area of integrity and quality.

NOTE 3: The impacts of these permissible uses and activities must be managed to a level below the natural dynamics of the system, while maintaining the inherent wilderness experience of the area. All permissible activities are subject to the parameters set by legislation and Permissible Activities Framework in the IMP.

NOTE 4: Fossicking is the activity undertaken by persons, who while walking, actively explore the marine life of the intertidal zone (shore and rock pools) without removing biota in the process.

NOTE 5: A declared emergency means that the appropriate radio communication is had.

NOTE 6: Actual density levels, activities and group sizes are specified in the Development Node and Activities Frameworks in the IMP.

Sanctuary (Marine)

UNMODIFIED NATURAL ENVIRONMENT. Designated Sanctuary to enable the protection of specific attributes of value.

<p>Inherent Attributes/ Characteristics</p>	<p>The primary purpose of a Sanctuary Zone is the protection of a particular species, community, habitat type or ecosystem, also to be used for benchmarking purposes. Inherent attributes/characteristics are also similar to those of a Wilderness area but the area under consideration does not qualify for true wilderness status due to:</p> <ul style="list-style-type: none"> i Some visual evidence (limited in extent yet discernible to even the general public) of human activities in the recent past, for example, ship wrecks). ii It being too small in size to maintain ecological processes without some ongoing management intervention. iii It not being large enough to be physically, visually and/or audibly buffered from adjacent areas to provide an authentic wilderness experience.
<p>Focal Purpose of Zone^{NOTE 1}</p>	<ul style="list-style-type: none"> i Maintain a scientific benchmark area of biodiversity and ecosystem processes. ii Provide visitors with nature/spiritual/education experiences in a marine environment (heightened 'sense of place' and of World Heritage values).
<p>Permissible Uses & Activities^{NOTE 2}</p>	<p><i>Inshore:</i></p> <ul style="list-style-type: none"> i Walking on beaches and rocks. ii Swimming and snorkelling. iii Guided special interest/educational activities (non-motorised, including on foot, horseback and cycling) within the parameters of other permissible and non-permissible uses and activities. iv Highly-regulated scientific research and monitoring that cannot be carried out elsewhere in the Park. v Essential management activities and intervention, including law enforcement operations (scheduled patrols and reaction) applying the 'minimum tool' principle. vi Special access, assessed on a case by case basis, and requiring permits. <p><i>Offshore:</i></p> <ul style="list-style-type: none"> i Guided special interest/educational activities (non-motorised vessels only) within the parameters of other permissible and non-permissible uses and activities. ii Highly regulated scientific research and monitoring that cannot be performed elsewhere in the Park. iii Essential management activities, including law enforcement operations (scheduled patrol and reaction) applying the 'minimum tool' principle. iv Special access, assessed on a case by case basis, and requiring permits. <p><i>Estuarine Lakes</i></p> <ul style="list-style-type: none"> i Walking on estuary margins. ii Guided wilderness, special interest/educational trails and activities (non-motorised, including on foot, horseback and canoe) within the parameters of other permissible and non-permissible uses and activities. iii Highly regulated scientific research and monitoring that cannot be carried out elsewhere in the Park. iv Essential management activities and intervention, including law enforcement operations (scheduled patrols and reaction) applying the 'minimum tool' principle. v Special access, assessed on a case by case basis, and requiring permits.
<p>Non-Permissible Uses & Activities</p>	<p><i>Inshore:</i></p> <ul style="list-style-type: none"> i All forms of extractive use, including rock and surf angling ^{NOTE 3}, harvesting of intertidal or shallow subtidal organisms, and collection of biota and marine products (e.g. shells, driftwood, rocks, sand). ii Fossicking. iii Beach driving except for essential management activities and scientific research and monitoring under special permit.

	<p>iv Launching of motorised boats except management and scientific research and monitoring vessels.</p> <p><i>Offshore.</i></p> <p>i Scuba diving except for highly regulated research, monitoring and World Heritage presentation.</p> <p>ii Kite and wind-surfing.</p> <p>iii Parasailing from boats or use of jet skis.</p> <p>iv All forms of extractive use, including all types of fishing, and collection of biota and marine products (e.g. shells, rocks, sand etc.).</p> <p>v Use of motorised vessels except for essential management and research/monitoring and vessels at sea within the 3 nautical mile limit offshore which have the right of passage, but may not be in possession of any marine life or parts thereof, and may not stop for any reason, other than a declared^{NOTE 4} emergency (e.g. sinking).</p> <p><i>Estuarine Lakes</i></p> <p>i All forms of extractive use, including rock and surf angling ^{NOTE 3}, harvesting of intertidal or shallow subtidal organisms, and collection of biota and marine products (e.g. shells, driftwood, rocks and sand).</p> <p>ii Fossicking.</p> <p>iii Driving except for essential management activities and scientific research and monitoring under special permit.</p> <p>iv Launching of motorised boats except management and scientific research and monitoring vessels.</p>
Use Intensity/ Frequency ^{NOTE 5}	<p>Law enforcement, management, research, monitoring and visitor use strictly limited to:</p> <p>i Very low intensity.</p> <p>ii Very low frequency, the emphasis being on transient use only.</p> <p>iii Small group sizes.</p> <p>iv Special events.</p> <p>v Very strict regulation and control over entry.</p>
Development Nodes	No Development Nodes permitted.
Development Restrictions	All types and forms of development prohibited, regardless of circumstances and needs.

NOTES: Sanctuary (Marine)

NOTE 1: A combination of these purposes will reinforce the branding of the Park as a protected area of integrity and quality.

NOTE 2: All permissible activities are subject to the parameters set by legislation and Permissible Activities Framework in the IMP.

NOTE 3: This includes no-take unless for approved research purposes.

NOTE 4: A declared emergency means that the appropriate radio communication is had.

NOTE 5: Actual density levels, activities and group sizes are specified in the Development Node and Activities Frameworks in the IMP.

Restricted (Marine)

PARTLY MODIFIED NATURAL ENVIRONMENT. Although only partly modified, normally less pristine and less sensitive than Wilderness or Sanctuary areas. Similar in principle to a Terrestrial Restricted Zone.

Inherent Attributes/ Characteristics	A marine area that may have some (but limited in extent and impact) adjacent current human settlement, developed infrastructure (e.g. buoys, piers) and/or consumptive activities, (e.g. fishing), management interventions and some visual evidence (limited in extent and impact but relatively more than that acceptable for Sanctuary zones) of their occurrence in the recent past. Nevertheless, regardless of whether current or residual, the human-induced modifications to the environment must either pose no significant threats (to ecological processes, biodiversity and landscape quality) or it is feasible to dispose of or remove them and/or mitigate their negative impacts over time. Accordingly, the area must have the potential for restoration to a state that the general public regards, for the most part, as largely unmodified and/or near-pristine. This may require proactive and responsive management interventions indefinitely for the maintenance of the above.
Focal Purpose of Zone	<ul style="list-style-type: none"> i Conservation of biodiversity and ecological processes. ii Where applicable, the restoration and maintenance of natural landscapes and ecological processes. iii Provide visitors with a high quality nature-based outdoor experience in a marine environment.

<p>Permissible Uses & Activities ^{NOTE 1}</p>	<p><i>Inshore:</i></p> <ul style="list-style-type: none"> i Walking on beaches and rocks and fossicking (non-extractive). ii Horse riding. iii Cycling. iv Swimming, snorkelling, surfing, surf-skiing, kite and wind surfing and kayaking. v Recreational ^{NOTE 2} and subsistence rock and surf angling. vi Concession, research, and monitoring and management beach driving only. vii Boat launching at recognised boat-launching sites (concession, research and monitoring and management only). viii Special interest/educational activities within parameters of other permissible and non-permissible uses and activities. ix Restricted subsistence invertebrate harvesting in designated areas. x Scientific research and monitoring with a scientific permit. xi Law enforcement patrols and reaction. xii Management intervention to restore/maintain ecological processes and the unspoilt appearance of the landscape. <p><i>Offshore</i></p> <ul style="list-style-type: none"> i Scuba diving. ii Snorkelling. iii Kayaking, surf-skiing, and kite and wind-surfing. iv Use of motorised vessels. v Recreational fishing (pelagic only). ^{NOTE 2} vi Spearfishing (pelagic game fish only). vii Special interest/educational activities within the parameters of other permissible and non-permissible uses and activities. viii Artificial substrates including artificial reefs. ix Research and monitoring with a scientific permit. x Law enforcement patrols and reaction. xi Management intervention to restore/maintain ecological processes and the unspoilt appearance of the landscape. <p><i>Estuarine Lakes:</i></p> <ul style="list-style-type: none"> i Walking on estuary margins. ii Boats operating under concessions or licenses, iii Access (including on foot, horseback and canoe) within the parameters of other permissible and non-permissible uses and activities. iv Highly regulated scientific research and monitoring that cannot be carried out elsewhere in the Park. v Essential management activities and interventions, including law enforcement operations (scheduled patrols and reaction) applying the 'minimum tool' principle. vi Special access, assessed on a case by case basis, and requiring permits. vii Launching of boats when the mouth is open.
<p>Non-Permissible Uses & Activities</p>	<p><i>Inshore:</i></p> <ul style="list-style-type: none"> i Beach driving except under recreational and educational use permits for concession operators, and authorised management and research, and monitoring vehicles. ii Harvesting of intertidal organisms other than subsistence invertebrate harvesting or under special permit. iii Collection of marine aquarium fish, invertebrates and plants except for educational or scientific purposes, and under special permit. iv Collection of organic (e.g. driftwood, shells) and inorganic (e.g. rocks, sand) materials except for educational or scientific purposes and under special permit. v Commercial fishing. vi Launching from non-recognised sites except under special permit.

	<p><i>Offshore.</i></p> <ul style="list-style-type: none"> i. Fishing for, or being in possession of, bottom fish. ii. Chumming or feeding of fish (including sharks). iii. Jet skis except for fishing and under special permit. iv. Parasailing from boats. v. Collection of marine aquarium fish, invertebrates and plants except for educational or scientific purposes and under special permit. vi. Use of fish aggregating devices (FADs), anchored or drifting. vii. Commercial fishing. <p><i>Estuarine Lakes:</i></p> <ul style="list-style-type: none"> i. All forms of extractive use, including rock and surf angling ^{NOTE 3}, harvesting of intertidal or shallow subtidal organisms, and collection of biota and marine products (e.g. shells, driftwood, rocks and sand). ii. Fossicking. iii. Driving except for essential management activities and scientific research and monitoring under special permit.
Use Intensity/ Frequency ^{NOTE 3}	Regulated and controlled use of low and moderate intensity with entry/access restricted to and controlled at entrance gates or other demarcated points of entry.
Development Nodes	Only Low and Medium (temporary) Intensity Tourism Day Visitor Nodes and Park Management Nodes permitted.
Development Restrictions	Only very low key, unobtrusive and low impact development permitted from base of dunes to the low water mark. No development of any type or form permitted from low water mark to outer limit of Marine Reserve, regardless of circumstances or needs. Development from base-of-dune to dune-crest and inland must conform to restrictions laid down for the adjacent Development Node or Terrestrial Zone which, in most instances, will be a Terrestrial Restricted or Controlled Zone.

NOTES: Restricted (Marine)

NOTE 1: All permissible activities are subject to parameters set by legislation and the Permissible Activities Framework in the IMP.

NOTE 2: No-take areas will be introduced within restricted zones into the future.

NOTE 3: Actual density levels, activities and group sizes are specified in the Development Node and Activities Frameworks in the IMP.

Controlled (Marine)

MODIFIED NATURAL ENVIRONMENT. Noticeably less pristine than a Controlled Pelagic Zone and, thus, normally less sensitive to the development of visitor facilities. Similar in principle to a Terrestrial Controlled Zone.

Inherent Attributes/ Characteristics	<p>A marine area where the seascape, ecosystems and habitats, and ecological processes may have been noticeably transformed by past or present developments (piers, buoys) or human activities (fishing, estuary mouth manipulation) within the area or in the terrestrial area immediately adjacent to it, but with significant interventions over time it could be restored to:</p> <ul style="list-style-type: none"> i A natural setting that appears to the general public as largely unmodified. ii A system in which the ecological processes function naturally. iii A situation in which, as a combination of achieving the above, the area could be regarded as partly modified and, hence, could be upgraded to a Controlled Pelagic Zone. Proactive and responsive management interventions may be required indefinitely for the maintenance of the above.
Focal Purpose of Zone	<ul style="list-style-type: none"> i Where applicable, the restoration and maintenance of natural landscapes and ecological processes. ii Provide an affordable, comfortable, informative, safe, enjoyable and sustainable outdoor recreational experience in a relatively-unspoilt marine environment.

<p>Permissible Uses & Activities <small>NOTE 1</small></p>	<p><i>Inshore:</i></p> <ul style="list-style-type: none"> i Walking on beaches and rocks and fossicking. ii Swimming, snorkelling, surfing, surf-skiing, kite and wind surfing and kayaking. iii Horse riding. iv Cycling. v Concession, research and monitoring, and management beach driving only. vi Recreational and subsistence rock and surf angling. vii Boat launching (self and concession) at recognised boat-launching sites. viii Special interest/educational activities within parameters of other permissible and non-permissible uses and activities. ix Controlled subsistence invertebrate harvesting in designated areas. x Research and monitoring with a scientific permit. xi Law enforcement patrols and reaction. xii Management intervention to restore/maintain ecological processes and the unspoilt appearance of the landscape. <p><i>Offshore.</i></p> <ul style="list-style-type: none"> i Scuba diving. ii Snorkelling. iii Kayaking, surf-skiing, kite and wind-surfing, and parasailing from boat. iv Use of motorised vessels. v Recreational pelagic fishing (except at 2-mile reef = only in waters > 30 m). vi Spear fishing (except at 2-mile reef = only in waters > 18 m, only pelagic game fish). vii Special interest/educational activities within the parameters of other permissible and non-permissible uses and activities. viii Establishment of artificial substrates including artificial reefs. ix Research and monitoring with a scientific permit. x Law enforcement patrols and reaction. xi Management intervention to restore/maintain ecological processes and the unspoilt appearance of the landscape. <p><i>Estuarine Lakes:</i></p> <ul style="list-style-type: none"> i Walking on estuary margins and fossicking. i Concession, research and monitoring, and management beach driving only. ii Recreational and subsistence rock and surf angling. iii Boat launching (self and concession) at recognised boat-launching sites. iv Special interest/educational activities within parameters of other permissible and non-permissible uses and activities. v Controlled subsistence invertebrate harvesting in designated areas. vi Research and monitoring with a scientific permit. vii Law enforcement patrols and reaction. viii Management intervention to restore/maintain ecological processes and the unspoilt appearance of the landscape.
<p>Non-Permissible Uses & Activities</p>	<p><i>Inshore.</i></p> <ul style="list-style-type: none"> i Vehicles on the beach except for boat launching purposes at recognised launch sites, and concession beach driving and authorised management and research and monitoring vehicles <small>NOTE 2</small>. ii Launching from non-recognised sites except under special permit. iii Jet skis except under special permit. iv Harvesting of intertidal organisms other than subsistence invertebrate harvesting or under special permit. v Collection of marine aquarium fish, invertebrates and plants except for educational or scientific purposes and under special permit. vi Collection of organic (drift wood, shells) and inorganic (e.g. rocks, sand) materials except for educational or scientific purposes and under special permit. vii Commercial fishing.

	<p><i>Offshore.</i></p> <ul style="list-style-type: none"> i Fishing for, or being in possession of, bottom fish⁵. ii Chumming or feeding of fish (including sharks). iii Jet skis except under special permit. iv Collection of marine aquarium fish except for educational or scientific purposes and under special permit. v Use of fish aggregating devices (FADs), anchored or drifting. vi Commercial fishing. <p><i>Estuarine Lakes:</i></p> <ul style="list-style-type: none"> i Vehicles on the beach barrier except for boat launching purposes at recognised launch sites, concession beach driving and authorised management and research and monitoring vehicles NOTE 2. ii Launching from non-recognised sites except under special permit. iii Jet skis except under special permit. iv Harvesting of intertidal organisms other than subsistence invertebrate harvesting or under special permit. v Collection of marine aquarium fish, invertebrates and plants except for educational or scientific purposes and under special permit. vi Collection of organic (drift wood, shells, etc) and inorganic (e.g. rocks and sand) materials except for educational or scientific purposes and under special permit. vii Commercial fishing.
Use Intensity/ Frequency <small>NOTE 2</small>	Regulated and controlled use of moderate intensity and relatively high frequency, with entry/access restricted to and controlled at entrance gates or other demarcated points of entry.
Development Nodes	Only Tourism Day Visitor Nodes and Park Management Nodes permitted.
Development Restrictions	Only very low key, unobtrusive and low impact development permitted from base of dunes to the low water mark. No development of any type or form permitted from the low water mark to the outer limit of the Park boundary (3 nautical miles) regardless of circumstances or needs. Development from base-of-dune to dune-crest and inland must conform to restrictions laid down for the adjacent Development Node or Terrestrial Zone which, in most instances, will be a Terrestrial Controlled Zone.

NOTES: Controlled (Marine)

NOTE 1: All permissible activities are subject to parameters set by legislation and the Permissible Activities Framework in the IMP.

NOTE 2: In the event of changes to the regulations governing the use of vehicles in the coastal zone, for example, a lessening of current restrictions, iSimangaliso will review its restrictions related to permissible and non-permissible activities in the Marine Controlled Zone, to give equivalent force to the above restrictions that rely significantly on the prohibition of vehicles in the coastal zone..

⁵ There are a number of reasons why the Authority has taken the decision to prohibit all bottom fishing in the Park. Firstly, the then Minister of Environmental Affairs and Tourism declared South Africa's line fishery in a state of emergency in 2000 because of the crisis in this fishery (Government Gazette, 29 December 2000 No. 21949, Notice 4727 of 2000). In the Southern African marine line fish status reports, a number of species of commercial and recreational marine fish, including bottom fish species, were considered over exploited and/or collapsed and stock rebuilding is required. Firstly, there is also an extensive body of scientific literature that motivates for protection of reef fish in the iSimangaliso Wetland Park and the Natal Bioregion. Secondly, bottom fish are often highly resident, a key feature that makes these species vulnerable to overexploitation. Thirdly, the area south of Cape Vidal falls in the Natal Bioregion, which up to now has not received adequate protection consistent with the other bioregions in South Africa.

4.1 Appropriate Buffers to the Estuary Boundary or EFZ

The Park's Zone of Influence is the buffer to the estuary beyond the Park's boundaries.

5 Integrated Monitoring Plan

Good data need to be available to assess long-term changes in the hydrological, hydrodynamic and ecological health and functioning of the St Lucia estuarine system. A review of the monitoring plan for the Lake St Lucia estuarine system will be undertaken as part of this EstMP (see key action in the plan in Section 3.4 (Research)). The monitoring plan that is finally put in place should be made as practical as possible and with essential indicators selected, taking into account availability of human and financial resources. It should aim at collecting appropriate and reliable quantitative data, which are essential for the implementation of management actions and review of the responses of the system.

The table below defines a comprehensive monitoring plan for the Lake St Lucia system, and is a good starting point for the review. Given that the current resource constraints are likely to persist during the lifetime of this EstMP, it is unlikely that all indicators will be included. However, the indicators should cover the following:

- ❖ Biological. Diversity and Abundance and Areal Coverage.
- ❖ Exploitation of Living Resources: Invertebrates and Fish.
- ❖ Water Quantity and Quality.

Focus Areas and Indicators	Monitoring Objective	Frequency	Location	Collection/Analytical Method
<p>Water Quality</p> <p>Essential physical parameters (salinity, temperature, dissolved oxygen, conductivity, depth, pH and turbidity/suspended solids)</p> <p>Inorganic nutrients (phosphates, nitrates, ammonium etc)</p> <p>Toxic substances (heavy metals, hydrocarbons, pesticides, herbicides, etc)</p> <p>Coliform bacteria (<i>Escherichia coli</i> and total coliforms)</p>	<p>To determine changes in water quality in response to management actions</p>	<p>Monthly</p>	<p>A minimum of ten fixed sample sites</p>	<p>According to laboratory specifications and/or as stipulated in the Methods for the Determination of the Ecological Water Reserve for Estuaries (DWA, 2010)</p>
<p>Water Quantity</p> <p>Water flow into the estuary</p> <p>Depth of the estuary</p>	<p>To detect decreases in volume of water reaching the estuary to inform management actions</p> <p>To assess the sediment entering the system</p>	<p>Monthly</p>	<p>Water quantity from all inflowing rivers</p>	<p>Installation of suitable flow gauging stations</p> <p>Review of new WULA and mining permit applications</p>
<p>Mouth Condition</p> <p>Bathymetry</p>	<p>To assess mouth behaviour and long term changes in mouth dynamics</p> <p>To detect changes in depth and sedimentation rates</p>	<p>Daily</p> <p>Every 5 years</p>	<p>Mouth and sand barrier</p> <p>Whole system</p>	<p>Mouth condition by trained observers with GPS and photography</p> <p>Bathymetric surveys</p>

Focus Areas and Indicators	Monitoring Objective	Frequency	Location	Collection/Analytical Method
Biological. Diversity and Abundance and Areal coverage Phytoplankton/Microphytobenthos Macrophytes (reedswamp, other peripheral vegetation types, alien invasives) Macrocrustaceans (prawns and crabs) Fish Birds Reptiles Mammals	To determine baseline and then on-going changes in biota in response to management actions	Quarterly for the 1st year for fauna Then twice a year once during summer and winter rainfall months Twice a year for macrophytes	A minimum of ten fixed sample sites	As stipulated in the Methods for the Determination of the Ecological Water Reserve for Estuaries (DWA, 2010) Fixed photo monitoring/aerial photography of macrophyte coverage
Exploitation of living resources : Macrocrustaceans, Fish, iNcema Reed and Thatch Grass Permits issued Levels of non-compliance	To assess the level of exploitation of living resources to inform management actions	Weekly	Through-out system for fish Reed swamp for iNcema Reed and Thatch Grass harvesting	Patrol survey of the number of permits issued and non-compliance

6 Bibliography and Useful References

- Appleton C.C., Forbes A.T. & Demetriades N.T. 2009. The occurrence, bionomics and potential impacts of the invasive freshwater snail *Tarebia granifera* (Lamarck, 1822) (Gastropoda: Thiaridae) in South Africa. *Zool. Med. Leiden* 83 (4): 525-536
- Avis A.M. 1995 An evaluation of the vegetation developed after artificially stabilizing South African coastal dunes with indigenous species. *Journal of Coastal Conservation* 1: 41-50.
- Begg G. 1978. The Estuaries of Natal. Natal Town and Regional Planning Report Volume 41.
- Blaber S.J.M. & Whitfield A.K. 1976 Large scale mortality of fish at Lake St Lucia. *South African Journal of Science* 72:218
- Clark B., Turpie, J., Görgens, A., Basson, G., Stretch, D. & Geldenhuys, M. 2014. Synthesis and recommendations. Vol V. In: Clark, B.M & Turpie, J.K. (eds) Analysis of alternatives for the rehabilitation of the Lake St Lucia estuarine system. Anchor Environmental Consultants Report no. AEC/1487/6 submitted to iSimangaliso Wetland Park Authority.
- Cooper J., Jayiya T., Van Niekerk L., De Wit M., Leaner J. & Moshe D. 2003. An assessment of the economic values of different uses of estuaries in South Africa. CSIR Report No. ENV-S-C 2003-139. CSIR, Stellenbosch, South Africa.
- Costanza R., D'Arge R., De Groot R., Farber S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R.V., Paruelo J., Raskin R.G., Sutton P. & van den Belt M. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387:253 – 260.
- Department of Environmental Affairs (DEA). 2015. Guidelines for the Development and Implementation of Estuarine Management Plans in terms of the National Estuarine Management Protocol. Cape Town.
- Department of Water Affairs and Forestry (DWAF) 2008. Water Resource Protection and Assessment Policy Implementation Process. Resource Directed Measures for protection of water resources: Methodology for the Determination of the Ecological Water Requirements for Estuaries. Version 2. Pretoria.
- Forbes A.T. & Demetriades N.T. 2010 Estuaries of Durban, KwaZulu-Natal, South Africa. Report for the Environmental Management Department, eThekweni Municipality. Second edition.
- Hart R.C. 1995. South African coastal lakes. In: Cowan, G.I. (ed.), Wetlands of South Africa. Department of Environmental Affairs and Tourism, Pretoria.
- iSimangaliso Wetland Park Authority 2008. iSimangaliso Wetland Park Integrated Management Plan, December 2011.
- Kraus, T.E.C., Dahlgren R.A., & R.J. Zasoski. 2003. Tannins in nutrient dynamics of forest ecosystems-A review. *Plant and Soil* 256: 41-66.

- Lamberth SJ & Turpie JK. 2003. The role of estuaries in South African fisheries: economic importance and management implications. *Afr. J. mar. Sci.* 25: 131-157.
- Lotze, H.K., Lenihan H.S., Bourque B.J., Bradbury R.H., Cooke R.G., Kay M.C., Kidwell S.M., Kirby M.X., Peterson C.H. and Jackson J.B.C. 2006 Depletion, degradation, and recovery potential of estuaries and coastal seas. *Science* 312:1806–1809.
- Macnae W. 1963. Mangrove swamps in South Africa. *Journal of Ecology* 51: 1-25. In: Begg G. 1978. The Estuaries of Natal. Natal Town and Regional Planning Report Volume 41. 657pp.
- Mander M. 2001. The value of estuaries. In Breen, C & McKenzie, M (eds.) *Managing estuaries in South Africa: An introduction*, pp 2-9. Scottsville: Institute of Natural Resources.
- Miranda N.A.F., Perissinotto R., & Appleton C.C. 2011. Population Structure of an Invasive parthenogenetic gastropod in coastal lakes and estuaries of northern KwaZulu-Natal, South Africa. *PLoS ONE* 6(8): e24337. doi:10.1371/journal.pone.0024337.
- Nondoda S., Adams J.B. Bate G.C. & Taylor R.H. (2011) Microalgae and Macrophytes: A Preliminary Assessment of the micro algae and macrophytes of the Msunduzi Estuary. In: *Bate G.C., Whitfield A.K. & Forbes A.T. (Eds) A Review of studies on the Mfolozi Estuary and associated floodplain, with emphasis on information required by management for future reconnection of the river to the St Lucia System.* WRC Report No. KV 255/10
- Orme, A.R. 1973. Barrier and lagoon systems along the Zululand coast, South Africa. In: Coates, D.R., (ed). *Coastal geomorphology*. Binghamton, State University of New York. Technical report. Office of naval research. In: Hart RC 1995. *South African coastal lakes*. In: Cowan, G.I. (ed.), *Wetlands of South Africa*. Department of Environmental Affairs and Tourism, Pretoria.
- Pooley A.C. 1976. Observations on the Lake St. Lucia crocodile population. The St. Lucia scientific advisory council workshop meeting. Charters Creek, 15-17 Feb 1976: 1-9. In: Begg G 1978. *The Estuaries of Natal*. Natal Town and Regional Planning Report Volume 41.
- SANBI 2011 *South African National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component*. CSIR Report Number CSIR/NRE/ECOS/ER/2011/0045/B. Council for Scientific and Industrial Research, Stellenbosch.
- Savage C., Thrush S.F., Lohrer A.M. & Hewitt J.E. 2012 Ecosystem Services Transcend Boundaries: Estuaries Provide Resource Subsidies and Influence Functional Diversity in Coastal Benthic Communities. *PLoS ONE* 7(8): e42708. Doi:10.1371/journal.pone.0042708.
- Statistics South Africa. 2012. *Census 2011 Municipal Report – KwaZulu-Natal*. Statistics South Africa Report No. 03-01-53. Report available on the Stats SA website: www.statssa.gov.za.

Turpie, J.K., Taljaard, S., van Niekerk, L., Adams, J., Wooldridge, T., Cyrus, D., Clark, B. & Forbes, N. 2012. The Estuary Health Index: a standardised metric for use in estuary management and the determination of ecological water requirements. WRC Report No. 1930/1/12 Turpie JK, Adams JB, Joubert A, Harrison TD, Collopy BM, Maree RC, Whitfield AK, Woolridge TH, Lamberth SJ, Taljaard S & van Niekerk L 2002. Assessment of the conservation priority status of South African estuaries for use in management and water allocation. *Water SA* 28 (2): 191-206.

Turpie JK, Clark B, Knox D, Martin P, Pemberton C & Savy C 2004. Improving the biodiversity rating of South African estuaries. Vol 1. Contributions to information requirements for the implementation of resource directed Measures for estuaries. WRC Report no. 1247/1/04.

Ward CJ & Steinke TD 1982. A note on the distribution and approximate areas of mangroves in South Africa. *South African Journal of Botany* 1: 51-53.

Whitfield A.K. 2000 Available scientific information on individual South African estuarine systems. WRC report No. 577/3/00. (Updates available online via Consortium for Estuarine Research and Management website).

Whitfield, A.K. & Baliwe, N.G. 2013. A century of science in South African estuaries: Bibliography and review of research trends. SANCOR Occasional Report No. 7.

Whitfield A.K., Blaber S.J.M. & Cyrus D.P. 1981 Salinity ranges of some southern African fish species occurring in estuaries. *South African Journal of Zoology* 16:151-155.