water and sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

# Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments

## ESTUARY SURVEY REPORT

October 2022

FC/02838.cdr
Last updated: 2022/10/27

Department of Water Affairs and Sanitation
**Chief Directorate: Water Ecosystems Management**

PROJECT NUMBER**:** WP 11387

# Estuary Survey Report

# CLASSIFICATION OF SIGNIFICANT WATER RESOURCES AND DETERMINATION OF RESOURCE QUALITY OBJECTIVES FOR WATER RESOURCES IN THE USUTU TO MHLATHUZE CATCHMENTS

## OCTOBER 2022



**REFERENCE**
***This report is to be referred to in bibliographies as:***
Department of Water and Sanitation, South Africa, October 2022. Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: Estuary Survey Report. DWS Report. Prepared by: WRP Consulting Engineers (Pty) Ltd. DWS Report: WEM/WMA3/4/00/CON/CLA/1022.

# REPORT SCHEDULE

| Index Number | DWS Report Number | Report Title |
|---|---|---|
| 1 | WEM/WMA3/4/00/CON/CLA/0122 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Inception Report including Gap Analysis chapter** |
| 2 | WEM/WMA3/4/00/CON/CLA/0222 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Status Quo and Delineation of Integrated Units of Analysis and Resource Unit Report** |
| 3 | WEM/WMA3/4/00/CON/CLA/0322 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Units Delineation and Prioritisation Report** |
| 4 | WEM/WMA3/4/00/CON/CLA/0422 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Hydrology Systems Analysis Report** |
| 5 | WEM/WMA3/4/00/CON/CLA/0522 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River EWR estimates for Desktop Biophysical Nodes Report** |
| 6 | WEM/WMA3/4/00/CON/CLA/0622 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River Survey Report** |
| 7 | WEM/WMA3/4/00/CON/CLA/0722 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Basic Human Needs Report** |
| 8 | WEM/WMA3/4/00/CON/CLA/0822 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Groundwater Report** |
| 9 | WEM/WMA3/4/00/CON/CLA/0922 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River specialist meeting Report** |
| 10 | WEM/WMA3/4/00/CON/CLA/1022 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Estuary Survey Report** |
| 11 | WEM/WMA3/4/00/CON/CLA/1122 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Wetland Report** |
| 12 | WEM/WMA3/4/00/CON/CLA/1222 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Water Requirements Report** |
| 13 | WEM/WMA3/4/00/CON/CLA/1322 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Scenario Description Report** |
| 14 | WEM/WMA3/4/00/CON/CLA/0123, | Classification of Significant Water Resources and |

| Index Number | DWS Report Number | Report Title |
|---|---|---|
| | volume 1 | Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Consequences Report, Volume 1: Rivers** |
| | WEM/WMA3/4/00/CON/CLA/0123, volume 2 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Consequences Report, Volume 2: Estuaries** |
| 15 | WEM/WMA3/4/00/CON/CLA/0323 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecosystem Services Consequences Report** |
| 16 | WEM/WMA3/4/00/CON/CLA/0423 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Economic & User water quality Consequences Report** |
| 17 | WEM/WMA3/4/00/CON/CLA/0523 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Water Resource Classes Report** |
| 18 | WEM/WMA3/4/00/CON/CLA/0623, volume 1 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 1: Rivers** |
| | WEM/WMA3/4/00/CON/CLA/0623, volume 2 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 2: Estuaries** |
| | WEM/WMA3/4/00/CON/CLA/0623, volume 3 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 3: Wetlands and Groundwater** |
| 19 | WEM/WMA3/4/00/CON/CLA/0723 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Monitoring and Implementation Report** |
| 20 | WEM/WMA3/4/00/CON/CLA/0124 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Main Report** |
| 21 | WEM/WMA3/4/00/CON/CLA/0224 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Issues and Responses Report** |
| 22 | WEM/WMA3/4/00/CON/CLA/0324 | Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Close out Report** |

**Shaded Grey** indicates this report.

# APPROVAL

| | |
|---|---|
| *Project Name:* | *Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments* |
| *Report Title:* | ***Estuary Survey Report*** |
| *Author(s):* | *Van Niekerk, L; Adams, JB, Lamberth, SJ, MacKay CF, Allen, D, Weerts, SP, Lemely, DA, Raw, J* |
| *Editor:* | *S Koekemoer* |
| *Client Report No.:* | *WEM/WMA3/4/00/CON/CLA/1022* |
| *Contract Number:* | *WP11387* |
| *Lead Consultant:* | *WRP Consulting Engineers, supported by Scherman Environmental* |
| *Status of Report:* | *Draft* |
| *First Issue:* | *October 2022* |
| *Final Issue:* | |

***Approved for the PSP by:***

.....  10/11/2022

***CJ Seago***
*Study Leader*

*Date*

***Approved for the Department of Water and Sanitation by:***

..... 11/11/2022

***Ms Mohlapa Sekoele***
*Project Manager*

..... 16/11/2022

***Ms Lebogang Matlala***
*Director: Water Resource Classification of*
*CD: Water Ecosystems Management*

# ACKNOWLEDGEMENTS

The following persons are acknowledged for their contribution to this report.

**Project Management Team**

Sekoele, M DWS: Water Resource Classification

# SITE VISIT TEAM

The following persons participated in the site visit:

| Author | Company | Role during site visit |
|---|---|---|
| Prof L van Niekerk | CSIR | Estuaries component leader<br>Estuarine hydrodynamics and physical processes specialist |
| Prof J Adams | NMU | Estuarine macrophytes & microalgae specialist |
| Dr Stephen J Lamberth | DFFE | Estuarine fish & fisheries specialist |
| Fiona MacKay | ORI | Estuarine Invertebrates specialist |
| Steven Weerts | CSIR | Estuarine fish & invertebrates specialist |
| Dave Allen | Private | Bird specialist |
| Dr Daniel Lemley | NMU | Estuarine microalgae & water quality specialist |
| Dr Jackie Raw | NMU | Blue Carbon specialist |
| **Technical/student field support** | | |
| Anesu Machite | NMU | Estuarine macrophytes & mapping |
| Riaan Weitz | NMU | Estuarine macrophytes & blue Carbon technical support |
| Bianca McKelvey | ORI | Estuarine invertebrates technical support: |
| Stacey Jordaan | ORI | Estuarine invertebrates technical support: |
| Prof. Sven Kerwath | DFFE | Estuarine fish & fisheries specialist |
| Corne Erasmus | DFFE | Estuarine fish & fisheries technical support |
| Sivuyisiwe Mbede | DFFE | Intern fish & fisheries intern |
| Zwelakhe Mhlongo | DFFE | Estuarine fish & fisheries technical support |
| Prof. S Taljaard (not in field) | CSIR | Estuarine water quality specialist & pre-field site selection |
| Dr Taryn Riddin (not in field) | NMU | Estuarine macrophytes specialist & preparation of maps for fieldwork |
| **Capacity building participants** | | |
| Mohlapa Sekoele | DWS | |
| Lwandle Sibango | DWS | |
| Molefi Mazibuko | DWS | |
| Michael Singh | DWS | |
| Obed Nhlanhla Mngomezulu | DWS | |

# TABLE OF CONTENTS

# LIST OF TABLES



# LIST OF FIGURES

# TERMINOLOGY AND ACRONYMS

| | |
|---|---|
| CD: WEM | Water Ecosystems Management |
| CSIR | Council for Scientific and Industrial Research |
| CWAC | Coordinated Waterbird Counts |
| DFFE | Department of Forestry, Fisheries and Environment |
| DWA | Department of Water Affairs |
| DWAF | Department of Water Affairs and Forestry |
| DWS | Department of Water and Sanitation |
| NMU | Nelson Mandela University |
| NTU | Nephelometric Turbidity unit |
| NWA | National Water Act |
| ORI | Oceanographic Research Institute |
| ORP | Oxidation-Redox Potential |
| POM | Particulate organic matter |
| RQO | Resource Quality Objective |
| TOC | Total Organic Carbon |
| WRCS | Water Resource Classification System |

# SELECTED SPELLING FOR THIS STUDY

There are multiple references to the spelling of various Rivers, Lakes, Dams and Estuaries, depending on the source of information. For the purposes of this report, the following Table presents the selected spelling of indicated water resources and places. The estuary names were taken from the NBA 2018 and the National Ecosystems Classification.

| **Selected Spelling for this Study** | **Alternate spellings** |
|---|---|
| Usutu | Usuthu |
| Mhlathuze River | Mhlatuze, uMhlatuze River |
| Umfolozi River | Mfolozi River |
| aMatigulu/iNyoni Estuary | Matigulu/Nyoni Estuary Amatigulu Estuary, Amatikulu Estuary, Matigulu Estuary |
| iSiyaya Estuary | Siyaya Estuary |
| uMlalazi Estuary | Mlalazi Estuary |
| uMhlathuze/Richards Bay Estuary | Mhlathuze Estuary, Richards Bay Habour/Port |
| iNhlabane Estuary | Nhlabane Estuary |
| uMfolozi/uMsunduze Estuary | Mfolozi Estuary, Msunduze Estuary |
| St Lucia Estuary | St Lucia Estuarine Lake |
| uMgobezeleni Estuary | Mgobezeleni Estuary |
| Kosi Estuary | Kosi Bay |
| iSimangaliso Wetland Park | |

# GLOSSARY

| | |
|---|---|
| *Basic Human Needs* | Water needs to be set aside for basic human needs such as drinking, food preparation, and health and hygiene purposes. This is referred to as the Basic Human Needs Reserve (BHNR). |
| *Ecological Water Requirements (EWR)* | The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components. |
| *Ecosystem services* | The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. |
| *EcoClassification* | The term used for the Ecological Classification process - refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative the natural or close to the natural reference condition. The purpose of the EcoClassification process is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river. |
| *Integrated Unit of Analysis (IUAs)* | An IUA is a homogeneous area that can be managed as an entity. It is the basic unit of assessment for the Classification of water resources, and is defined by areas that can be managed together in terms of water resource operations, quality, socio-economics and ecosystem services. |
| *Resource Quality Objectives (RQOs)* | RQOs are numeric or descriptive goals or objectives that can be monitored for compliance to the Water Resource Classification, for each part of each water resource. “The purpose of setting RQOs is to establish clear goals relating to the quality of the relevant water resources” (NWA, 1998). |
| *Sub-quaternary reaches (SQR)* | A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments), to a sub-quaternary reach or quinary level. |
| *Target Ecological Category (TEC)* | This is the ecological category toward which a water resource will be managed once the Classification process has been completed and the Reserve has been finalised. The draft TECs are therefore related to the draft Classes and selected scenario. |
| *Water Resource Class* | The Water Resource Class (hereafter referred to as Class) defines three management classes, Class I, II, and III, based on extent of use and alteration of ecological condition from the predevelopment condition. |

# 1 INTRODUCTION

## 1.1 BACKGROUND

Chapter 3 of the National Water Act, 1998 (NWA) (Act 36 of 1998), deals with the protection of water resources. Section 12 of the NWA requires the Minister to develop a system to classify water resources. In response to this, the Water Resource Classification System (WRCS) was gazetted on 17 September 2010 and published in Government Gazette 33541 as Regulation 810. The WRCS is a stepwise process whereby water resources are categorised according to specific classes that represent a management vision of a particular catchment. This vision takes into account the current state of the water resource, the ecological, social and economic aspects that are dependent on the resource. Once significant water resources have been classified following the WRCS, Resource Quality Objectives (RQOs) must be determined to give effect to the class. The implementation of the WRCS therefore assesses the costs and benefits associated with utilisation versus protection of a water resource. Section 13 of the NWA requires that Water Resource Classes and RQOs be determined for all significant water resources.

Thus, the Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS) initiated a study for determining the Water Resource Classes and RQOs for all significant water resources in the Usutu to Mhlathuze Catchment. The Usutu to Mhlathuze Catchments are amongst many water-stressed catchments in South Africa. These catchment areas are important for conservation and contain a number of protected areas, natural heritage sites, cultural and historic sites as well as other conservation areas that need protection. There are five RAMSAR[1] sites within the catchment, which includes the world heritage site and St Lucia. The others are Sibaya, Kosi Bay, Ndumo Game Reserve and Turtle Beaches.

## 1.2 STUDY AREA

The study area is the Usutu to Mhlathuze Catchment that has been divided into six drainage areas and secondary catchment areas as follows (refer to the locality map provided as **Figure 1.1**):

- W1 catchment (main river: Mhlathuze).
- W2 catchment (main river: Umfolozi).
- W3 catchment (main river: Mkuze).
- W4 catchment (main river: Pongola) - part of this catchment area falls within Eswatini.
- W5 catchment (main river: Usutu) - much of this catchment falls within Eswatini.
- W7 catchment (Kosi Bay estuary and Lake Sibaya).

Note that all assessments within Eswatini are excluded apart from the hydrological modelling required to assess any downstream rivers in South Africa that either run through Eswatini or originate (source) in Eswatini.

[1] A Ramsar site is a wetland site designated to be of international importance under the Ramsar Convention, also known as "The Convention on Wetlands", an intergovernmental environmental treaty established in 1971 by UNESCO in the Iranian city of Ramsar, which came into force in 1975.

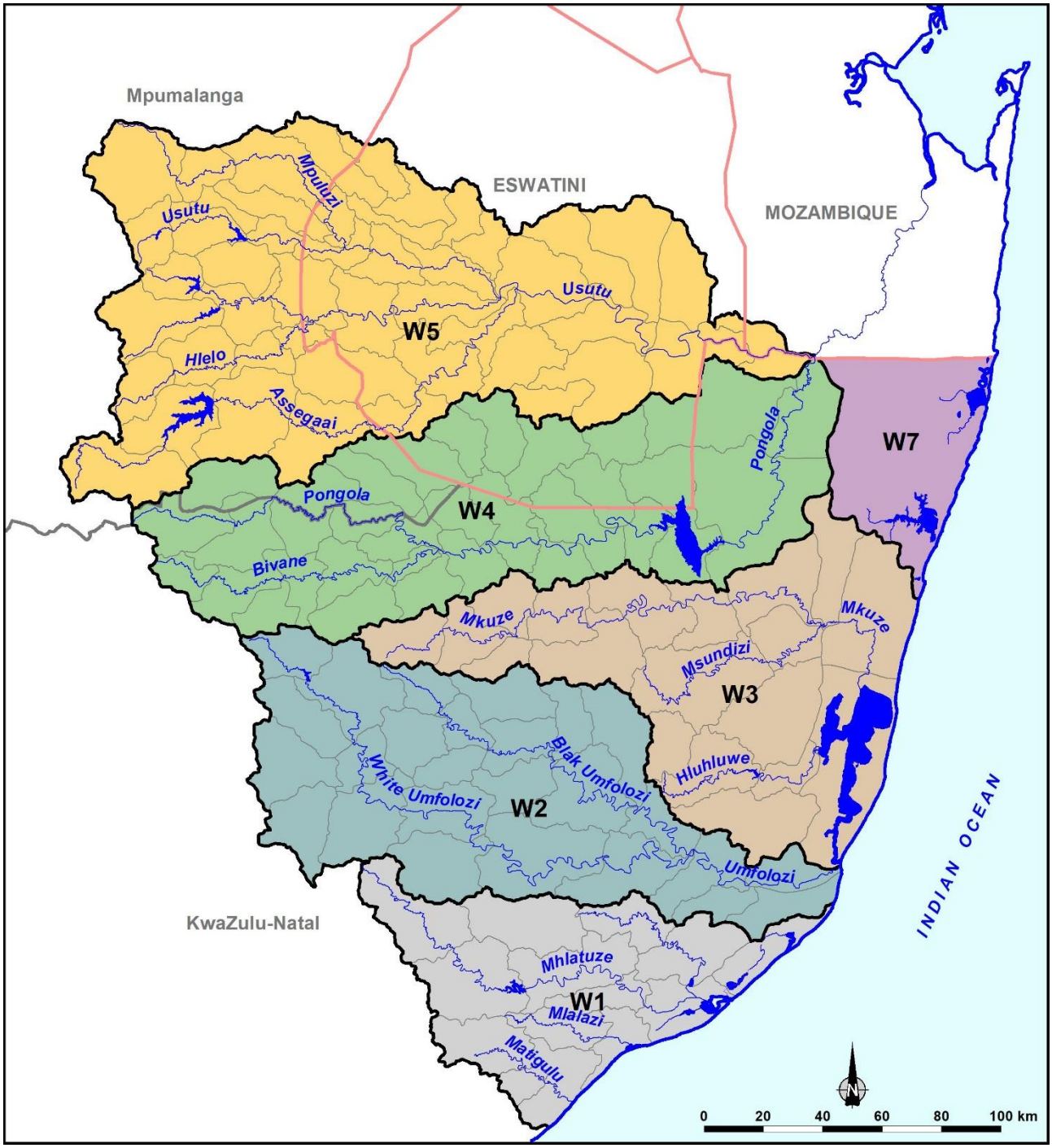


**Figure 1.1 Locality Map of the Study Area**

## 1.3 PURPOSE OF THIS REPORT

As part of the study a once-off field visit was planned to the Kosi Bay, uMgobezeleni, iNhlabane, iSiyaya, uMlalazi, and aMatigulu/iNyoni estuaries (in spring/summer) in accordance with the data requirements specified in the EWR methods for estuaries - Resource Directed Measures for Protection of Water Resources: Methodologies for the determination of ecological water requirements for estuaries (Version 2) (DWAF 2008). Kosi Bay was not part of the formally planned field trip, but in response to concerns raised about its declining conditions efforts were made at own cost to include this system.

The purpose of this report is purely to document the activities and provisional findings of the Estuary EWR site visit. **Figure 1.3** provides the project plan for this study and illustrates where

Task 3 fits within the project plan. The analysis of information collated data and the EWR assessment will be documented in Report 12: Ecological Water Requirements Report following a specialist meeting during September 2022.

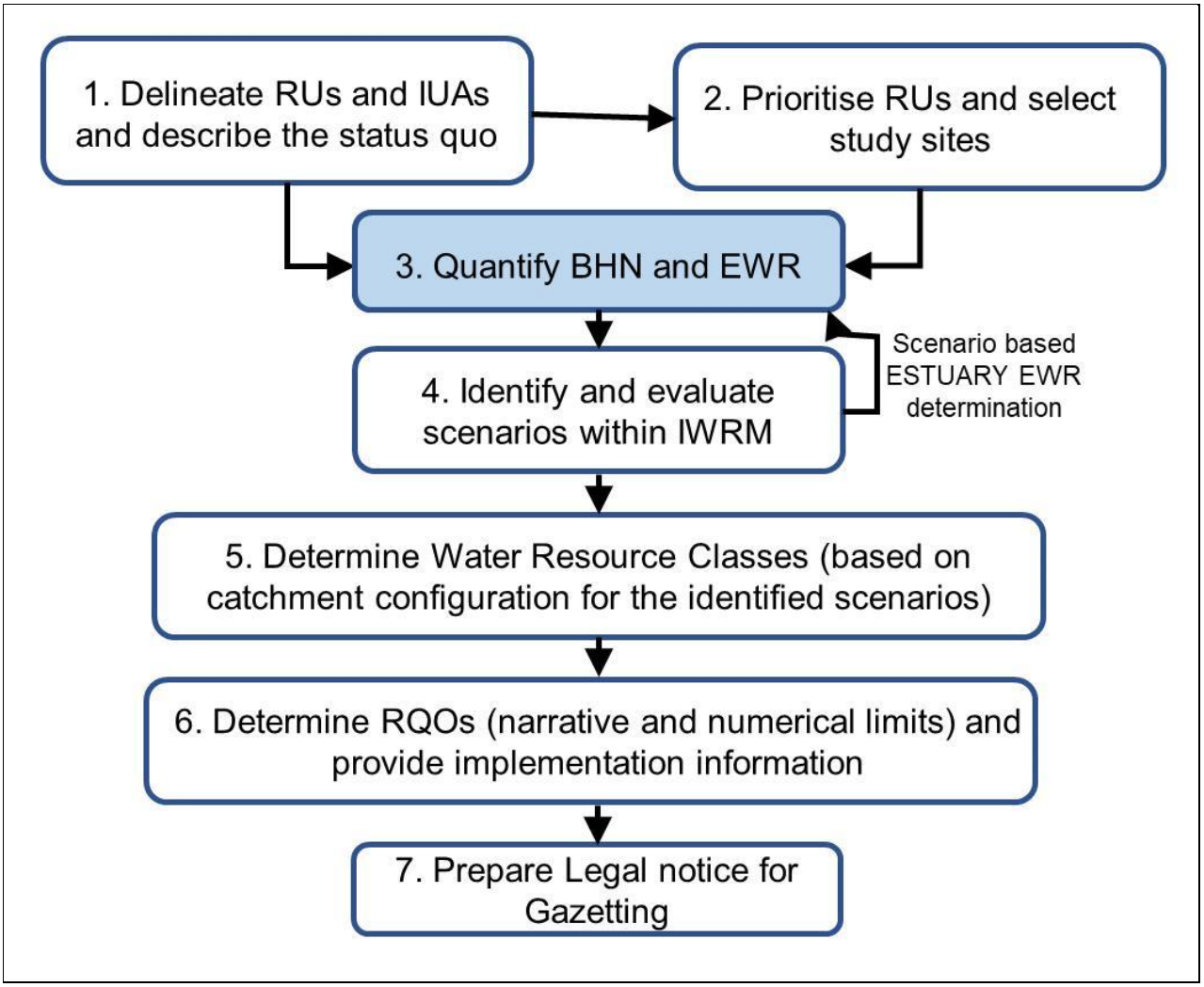


**Figure 1.2 Project Plan for the Usutu-Mhlathuze Classification study**

# 2 FIELD TEAM

The Estuary field team consisted of team members from the Council for Scientific and Industrial Research (CSIR), Nelson Mandela University (NMU), Oceanographic Research Institute (ORI) and Department of Forestry, Fisheries and Environment (DFFE). Given the complexity of the study, the field team was enlarged to bring in more expertise and to increase data collection efforts (Figure 2.1).

The CSIR (Prof. Lara van Niekerk) led the fieldwork and focused on collecting data on water quality and physical processes.

Nelson Mandela University was represented by Prof. Janine Adams (water quality, macrophytes, microalgae), Dr Daniel Lemley (microalgae and water quality) and Dr Jackie Raw (Blue carbon) (**Figure 2.1**) Mapping and field support were provided by MSc student Mr Anesu Machite and Mr Riaan Weitz respectively. While Dr Taryn Riddin assisted with preparing macrophytes maps for field validation.

ORI under the leadership of Ms Fiona MacKay conducted the sampling of the estuarine invertebrates, with support from Ms Bianca McKelvey and Ms Stacey Jordaan. Mr Steven Weerts provides support to both the invertebrate and fish teams.

The Department of Forestry, Fisheries and the Environment (DFFE) led the sampling of the fish (Dr Stephen Lamberth), supported by Prof. Sven Kerwath and three research assistants/interns (Mr Corne Erasmus, Ms Sivuyisiwe Mbede, Mr Zwelakhe Mhlongo) all with a background in estuarine ecology.

Mr Dave Allen surveyed the estuarine and aquatic birds, with Ms Debbie Allen acting as scribe.

**Figure 2.1 Members of the estuary field team (Photo: Riaan Weitz)**

# 3 ESTUARIES FIELD SURVEY

A detailed field visit was undertaken to six estuaries between 28 September and 8 October 2022 following the data requirements in the EWR methods (**Table 3.1**).

During the field surveys, water and sediment samples were collected, ground-truthing for habitat maps was done, grab samples of invertebrates were taken and fish netted, along with bird counts. Each section will be discussed separately below.

Transnet industrial action and civil unrest prevented access to uMhlathuze Sanctuary planned for 6 and 7 October 2022. This system was replaced with the sampling of the uMlalazi and aMatigulu/iNyoni estuaries at short notice when it became clear that the above is not possible.

**Table 3.1 Sampling dates for the estuaries and sites visited for the EWR assessment**

| DATE | ESTUARY | SITES SAMPLED |
|---|---|---|
| 29 September | Kosi Bay | Lake 3 west bank and Lake 4 macrophytes mapped.<br>Three invertebrate sites for grab sampling in lake 3 (Nhlange). Three sites for invertebrate sediment grain size and Total Organic Carbon (TOC) assessment and water physico-chemical measurements.<br>1 fish site (caught in gill nets). |
| 30 September | Kosi Bay | Lakes 1, 2 and Lake 3 east bank macrophytes mapped.<br>Three sites for carbon cores in reeds and sedges, mixed mangroves community, *Lumnitzera*.<br>Seven invertebrate sites for grab sampling (1 in Lake Nhlange, 1 in the channel between Nhlange and lake 2 (Mpungwini, 3 in Mpungwini and 3 in Lake 1 (Makhuwulani). Seven sites for invertebrate sediment grain size and TOC assessment and eight sites for water physico-chemical measurements.<br>Six fish sites. |
| 1 October | Kosi Bay | Kosi Mouth and Lake Zilonde macrophytes mapped.<br>Three sites for carbon cores, sedges, black mangroves and adjacent salt marsh.<br>Four invertebrate sites for grab sampling (3 in the estuary, including mouth and 1 in Lake Zilonde). Four sites for invertebrate sediment grain size and TOC assessment and water physico-chemical measurements.<br>Four fish sites. |
| 3 October | uMgobezeleni | Mouth area and lake macrophytes mapped.<br>Two sites for carbon cores swamp forest adjacent to road and above bridge in reeds and sedges, adjacent to dead mangroves.<br>Six invertebrate sites for grab sampling (4 in uMgobezeleni Estuary and 2 in Lake uMgobezeleni). Six sites for invertebrate sediment grain size and TOC assessment and seven sites for water physico-chemical measurements.<br>Four fish sites. |
| 4 October | iNhlabane | Mouth area and upper reaches at barrage macrophytes mapped.<br>One site for carbon core in reeds and sedges.<br>One invertebrate site for grab sampling (lower reaches). One site for invertebrate sediment grain size and TOC assessment and two sites for water physico-chemical measurements.<br>Two fish sites. |
| 5 October | iSiyaya | Estuary accessed at mouth and 1.7 km upstream.<br>Macrophytes mapped.<br>One site for carbon cores, reeds and sedges.<br>Three invertebrate sites for grab sampling. Three sites for invertebrate sediment grain size and TOC assessment and five sites for water physico-chemical measurements. |

| DATE | ESTUARY | SITES SAMPLED |
|---|---|---|
| | | Three fish sites. |
| 6 October | uMlalazi | Macrophytes mapped.<br>One site for carbon cores mangroves (x3), reeds and sedges and salt marsh.<br>Seven invertebrate sites for grab sampling. Seven sites for invertebrate sediment grain size and TOC assessment and nine sites for water physico-chemical measurements.<br>Seven fish sites. |
| 7 October | aMatigulu/iNyoni | Macrophytes mapped.<br>One site for carbon core in reeds and sedges.<br>Five invertebrate sites for grab sampling. Five sites for invertebrate sediment grain size and TOC assessment and water physico-chemical measurements.<br>Five fish sites. |

# 4 STUDY METHODS

## 4.1 WATER QUALITY AND MICROALGAE

Sampling stations were selected to represent the spatial variability along the length of each study estuary, i.e., mouth to upper reaches. Field surveys were conducted in the Kosi (22 sites), uMgobezeleni (4 sites), iNhlabane (3 sites), iSiyaya (4 sites), uMlalazi (3 sites), and aMatigulu/iNyoni (3 sites) estuaries. The selected stations are presented in **Figures 4.1** to **4.6** below.

At each sampling station, physico-chemical measurements were recorded using a YSI ProDSS multiparameter meter. These included salinity, water temperature (°C), dissolved oxygen (mg $l^{-1}$), pH, and turbidity (Nephelometric Turbidity unit - NTU). Measurements were recorded at specified depth intervals from the surface to the bottom-waters to capture any vertical gradients. In addition extra data was also collected at the invertebrate stations (See **Appendix B**). For inorganic nutrient analyses (orthophosphate, ammonium, and total oxidised nitrogen), sub-surface and bottom-water samples were collected at each site. Samples were filtered in the field through glass-fibre Munktell MGF filters (0.7 µm pore size) and placed into acid-washed polyethylene bottles before being frozen. Orthophosphate ($PO_4^{3-}$), ammonium ($NH_4^+$), and total oxidised nitrogen ($NO_x$ = $NO_3^-$ and $NO_2^-$) concentrations will be determined using standard spectrophotometric methods (Bate and Heelas, 1975; Parsons *et al*., 1984).

Water samples for phytoplankton analyses were collected concomitantly with those for inorganic nutrient analyses. Water samples for phytoplankton biomass, measured as chlorophyll-*a* concentration (expressed as mg Chl-*a* $l^{-1}$), were collected by filtering replicate samples of a known volume (i.e., 250 ml) through 0.7 µm pore-sized glass-fibre filters (Munktell© MGF). The filters were then placed in aluminium foil and frozen prior to analysis. Once in the laboratory, chlorophyll-*a* will be determined as per the method described by Nusch (1980). For the purposes of phytoplankton identification and enumeration, surface and bottom-water samples were fixed with 25% glutaraldehyde solution (Sigma-Aldrich R Chemicals G5882) to a final concentration of 1% (by volume). Once in the laboratory, 25 ml of each fixed sample will be placed into 26.5 mm diameter Utermöhl chambers and allowed to settle for 24 h before identification and enumeration (cells $ml^{-1}$; as per Snow et al., 2000) of phytoplankton classes/species using an inverted Leica DMIL phase contrast microscope at a magnification of 630X.


**Figure 4.1 Water quality and microalgal sampling stations in the Kosi Estuary**


**Figure 4.2 Water quality and microalgal sampling stations in the uMgobezeleni Estuary**


**Figure 4.3 Water quality and microalgal sampling stations in the iNhlabane Estuary**


**Figure 4.4 Water quality and microalgal sampling stations in the iSiyaya Estuary**


**Figure 4.5 Water quality and microalgal sampling stations in the uMlalazi Estuary**


**Figure 4.6 Water quality and microalgal sampling stations in the aMatigulu/iNyoni estuaries**

## 4.2 MACROPHYTES

The macrophytes (vegetation) and microalgae were sampled to assess the present state condition from 29 September to 7 October 2022 (**Table 3.1**). Research funding was used to complete the microalgal sampling as well as carbon core measurements to fill a data gap in our national datasets. Vegetation maps were ground-truthed in the field to assess the boundaries of different habitat types i.e. reeds, sedges, swamp forest. Point photographs were taken to identify different plant species and community types. In the Kosi Estuary mangrove population structure was assessed in three 5 x 5 m quadrats at the same site as the mangrove carbon core samples. The height and circumference of adult trees are measured and the height of saplings and seedlings.

The number of harvested stumps was also recorded as well as tree phenology (i.e. fruiting, flowering). At Mgobezeleni Estuary all mangroves found were measured as only 50 adult trees were present.

## 4.3 SEDIMENT CARBON STOCKS

Sediment cores were collected from representative estuarine vegetation types at each estuary. The sampling was carried out primarily to address national data gaps for blue carbon ecosystems (mangroves and salt marshes) in the subtropical and tropical biogeographic regions. Reeds and sedges as well as swamp forest were sampled if they were representative of the habitat for a particular estuary, or when they occurred in close proximity (in a mosaic or across an ecotone) to mangroves. This will be the first instance of sampling and reporting on sediment carbon for reeds and sedges and swamp forest for comparison with the traditional blue carbon ecosystems. GPS co-ordinates of the sampling sites, as well as a description of the dominant vegetation species were recorded at the time of sampling.

Within each estuary, the number of sampling sites was determined by the distribution and diversity of the vegetation types, as well as the ease of accessibility to sample in different locations. Each site was defined by the presence of different vegetation types. Therefore, some sites had more vegetation types represented than others. Within each vegetation type, four cores (50 cm depth) were collected using a Russian Peat Corer. Two of the cores were sectioned at 2 cm intervals for the first 20 cm, and then 2 cm every 10 cm to allow for sediment accumulation rates to be determined through Pb210 radio-isotope analyses. The other two cores were sectioned at intervals of 5 - 10 cm, 10 - 20 cm, 20 - 30 cm, and 30 - 50 cm for estimating sediment organic matter, moisture content, bulk density, organic carbon content, and particle size. Sediment pH, temperature, and ORP (oxidation-redox potential) were measured at the surface, middle, and bottom (50 cm) of two of the cores sampled in each vegetation type at each site using a handheld HANNA combo-tester. Any autocompaction or collapse of the core was noted and measured. All sectioned cores were placed in sealed Ziplock bags and kept cool until transported to the laboratory for further processing.

## 4.4 INVERTEBRATES

Sites were selected within each estuary at varying intervals from the lower reaches (vicinity of the mouth) to upper reaches (head - area of maximum discernible saline penetration) depending on the axial length of the system and the salinity gradient. This profile was adopted in order that the full range of physico-chemical and habitat types within each system could be represented, given accessibility and time limits. The lakes were sampled based on accessibility.

At each site the physico-chemistry of the water column was measured using an EXO 3 multiparameter sonde for determining changes and stratification in temperature ($^{o}$C), salinity, oxygen saturation (% saturation, mg/L, pH and turbidity (NTU) along a depth profile to include bottom, surface and mid water layers.

Six Zabalocki-type Eckman grab samples (area 0.0236 $m^2$) were used to sample sediment invertebrates. One sample at each site was used for sediment analysis (grain size distribution and total organic carbon) with the remaining five randomly placed samples collected per site being used for invertebrate fauna sampling. The majority of invertebrate infauna reside in the top 10 cm of the sediment, the grab ‘bite’ depth was measured, if < 5 cm, the sample was discarded and the procedure repeated until five comparable replicate samples were collected. Where the majority of

sediments at a station were of a fine grain size (i.e. pass through a 0.5 mm mesh) the entire sample was agitated to bring animals into suspension and washed through a collection net. Animals and other biological material retained were bottled and fixed in 4% formaldehyde. Where sediment grain size was too large for this procedure of entire decanting, a small amount of formaldehyde (~5 ml) was added to the collected sample and agitated to encourage benthic organisms to leave burrows and tubes and swim in the suspension. Whilst being continuously stirred, the supernatant was poured through a 0.5 mm collection mesh. This process of elutriation was repeated five times. The remaining sediment and coarse vegetable matter was sieved through a 1mm mesh and examined visually. Larger animals such as molluscs and crabs that were too heavy to be lifted into suspension through elutriation were picked out before the remaining sediment was discarded. All sediment samples were transported back to the laboratory where they will be picked, sorted, analysed and identified by means of microscopy.

## 4.5 FISH

Fish were sampled at sites which could be accessed along the lengths of each system, using seine net and dip net. Species were identified in the field, measured (tail length) and returned live to the water.

## 4.6 BIRDS

All waterbird counts were done by two observers using binoculars and a telescope on a tripod. Data were recorded directly onto a smart-phone using the BirdLasser application. Details recorded for each waterbird record included species, number of individuals, time, latitude and longitude, and altitude. Waterbirds at iSiyaya Estuary were counted on 5 October 2022 by walking upstream from the mouth on the seaward (eastern) side of the estuary to the wooden bridge and then walking upstream on the landward (western) side of the estuary to the uppermost reaches of the estuary. Visibility was highly constrained however by forested vegetation but the estuary's waterlevel was too low to allow access by boat. This count can be considered incomplete due to visibility constraints and will require repeat using a canoe. Waterbirds at Umlalazi Estuary were counted on 6 October 2022 using an inflatable Arc boat with a 4 hp outboard motor. The count covered from the mouth to just short of the N2 bridge. Waterbirds at Amatigulu/Inyoni were counted on 7 October 2022 also using the Arc inflatable and covered the area from just upstream of the confluence of the two rivers to just short of the mouth (time constraints precluded covering the actual mouth region). The latter two counts can be considered fairly comprehensive.

# 5 KOSI ESTUARY

## 5.1 WATER QUALITY AND MICROALGAE

The Kosi system consists of a series of four interconnected lakes about 10 km in length that run parallel to the Indian Ocean. A salinity gradient was apparent in September 2022 from Lake 4 to the estuary with salinity of 0.63 reported for Lake 4, 5.55 - Lake 3, 11.2 - Lake 2 and 15.6 for Lake 1 surface waters and 27 for bottom waters. The salinity in the estuary ranged from 22 to 27. The edges of Lake 3 were supersaturated with oxygen values of 120 – 130% (**Table 5.1**).

**Table 5.1 *In situ* water quality observations at Kosi Estuarine Lake (29 Sep – 1 Oct 2022) (Mouth state – open)**

| Zone | Station | Coordinates | Time | Depth | Salinity | Conduc-tivity (mS/cm) | Temp. (°C) | pH | NTU[1] | DO (mg/l) | DO (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Estuary | 1 | 26°53'42.92"S 32°52'43.24"E | 13h20 | 0 | 27.84 | 43.32 | 27.50 | 8.38 | 0.85 | 7.40 | 109.50 |
| | | | | 1 | 27.88 | 43.39 | 27.50 | 8.40 | 0.85 | 7.47 | 110.00 |
| | 2 | 26°53'52.53"S 32°52'20.38"E | 12h15 | 0 | 28.35 | 44.04 | 26.90 | 8.29 | 0.94 | 6.77 | 99.50 |
| | | | | 0.5 | 28.42 | 44.15 | 26.90 | 8.30 | 0.90 | 6.80 | 100.00 |
| | 3 | 26°53'44.65"S 32°51'59.72"E | 11h30 | 0 | 22.53 | 35.61 | 26.70 | 7.90 | 0.83 | 7.01 | 99.30 |
| | | | | 0.75 | 23.74 | 37.76 | 26.80 | 8.00 | 0.99 | 6.99 | 100.20 |
| | 4 | 26°54'6.16"S; 32°51'23.81"E | 10h30 | 0 | 15.93 | 26.10 | 25.90 | 7.78 | 0.67 | 6.20 | 83.70 |
| | | | | 0.8 | 17.77 | 28.85 | 26.50 | 7.78 | 0.67 | 0.92 | 13.30 |
| Lake Zilonde | LZ1 | 26°53'43.63"S 32°51'57.13"E | 11h00 | 0 | 0.13 | 0.27 | 22.70 | 7.18 | 0.13 | 1.85 | 21.50 |
| | LZ2 | | 16h30 | 0 | 0.12 | 0.26 | 26.12 | 7.49 | 2.98 | 5.97 | 73.80 |
| Channel 1 | 5 | 26°55'33.96"S 32°51'13.15"E | 11h00 | 0 | 15.63 | 25.66 | 25.70 | 8.05 | 1.24 | 7.06 | 94.30 |
| | | | | 0.5 | 15.67 | 25.70 | 25.60 | 8.12 | 1.21 | 7.03 | 94.00 |
| | | | | 1 | 16.26 | 26.66 | 25.60 | 8.14 | 1.19 | 7.01 | 94.20 |
| | | | | 2 | 19.41 | 31.51 | 25.50 | 8.08 | 1.04 | 6.08 | 83.00 |
| | | | | 2.5 | 20.42 | 32.74 | 25.20 | 8.09 | 0.64 | 5.97 | 81.60 |
| Lake 1 | 6 | 26°55'38.20"S 32°51'37.17"E | 11h30 | 0 | 15.80 | 25.91 | 25.60 | 8.30 | 1.25 | 7.17 | 96.10 |
| | | | | 0.5 | 15.81 | 25.94 | 25.60 | 8.28 | 1.23 | 7.06 | 94.50 |
| | | | | 1 | 17.21 | 28.11 | 25.60 | 8.24 | 1.10 | 6.71 | 91.10 |
| | | | | 2 | 19.13 | 31.07 | 25.80 | 8.20 | 1.13 | 6.33 | 87.60 |
| | | | | 3 | 22.01 | 34.95 | 26.20 | 8.20 | 1.03 | 6.26 | 87.60 |
| | | | | 4 | 25.50 | 39.97 | 26.10 | 8.17 | 0.97 | 6.07 | 86.00 |
| | | | | 5 | 25.59 | 40.21 | 25.80 | 8.16 | 0.96 | 5.94 | 82.40 |
| | | | | 6 | 27.24 | 42.50 | 25.90 | 8.15 | 0.63 | 4.36 | 62.40 |
| | | | | 7 | 27.28 | 42.60 | 26.00 | 8.14 | 0.71 | 4.39 | 63.40 |
| | 7 | 26°55'59.33"S 32°51'33.27"E | 11h50 | 0 | 14.73 | 24.28 | 25.50 | 8.40 | 1.24 | 7.09 | 94.60 |
| | | | | 0.5 | 14.75 | 24.31 | 25.70 | 8.38 | 1.26 | 6.98 | 92.90 |
| | | | | 1 | 14.83 | 24.38 | 25.70 | 8.38 | 1.26 | 6.93 | 92.00 |
| | | | | 2 | 20.16 | 32.12 | 25.70 | 8.23 | 1.00 | 5.87 | 82.30 |
| | | | | 2.25 | 20.20 | 32.71 | 26.60 | 8.22 | 1.12 | 5.86 | 81.60 |
| Channel 2 | 8 | 26°56'1.23"S; 32°51'7.10"E | 12h10 | 0 | 11.56 | 19.49 | 25.50 | 8.52 | 1.18 | 7.96 | 104.20 |
| | | | | 0.5 | 11.60 | 19.54 | 25.70 | 8.49 | 1.14 | 7.87 | 103.10 |
| | | | | 1 | 11.62 | 19.55 | 25.70 | 8.47 | 1.13 | 7.81 | 102.20 |
| | | | | 1.5 | 12.00 | 20.15 | 25.70 | 8.47 | 1.12 | 7.94 | 104.20 |
| Lake 2 | 9 | 26°56'11.51"S 32°51'25.67"E | 12h45 | 0 | 11.29 | 19.02 | 24.90 | 8.58 | 1.18 | 7.79 | 100.50 |
| | | | | 0.5 | 11.29 | 19.02 | 24.90 | 8.54 | 1.18 | 7.66 | 98.50 |
| | | | | 1 | 11.34 | 19.10 | 24.70 | 8.51 | 1.19 | 7.77 | 99.80 |
| | | | | 2 | 11.35 | 19.15 | 24.70 | 8.51 | 1.17 | 7.75 | 98.80 |
| | | | | 3 | 11.65 | 19.56 | 24.30 | 8.50 | 1.12 | 8.45 | 108.10 |
| | | | | 4 | 11.76 | 19.73 | 24.10 | 8.50 | 1.07 | 8.16 | 103.60 |
| | | | | 5 | 11.94 | 20.03 | 24.10 | 8.46 | 0.90 | 7.79 | 99.20 |
| | 10 | 26°56'32.49"S 32°51'14.85"E | 13h10 | 0 | 11.24 | 18.94 | 25.30 | 8.47 | 1.20 | 7.80 | 101.20 |
| | | | | 0.5 | 11.24 | 18.95 | 25.30 | 8.47 | 1.21 | 7.79 | 101.10 |

| Zone | Station | Coordinates | Time | Depth | Salinity | Conduc-tivity (mS/cm) | Temp. (°C) | pH | NTU[1] | DO (mg/l) | DO (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 11.30 | 18.95 | 25.30 | 8.47 | 1.20 | 7.76 | 100.60 |
| | | | | 2 | 11.32 | 19.50 | 25.30 | 8.46 | 1.22 | 7.73 | 99.80 |
| | | | | 4 | 11.35 | 19.61 | 24.70 | 8.45 | 1.20 | 7.70 | 99.70 |
| | | | | 6 | 11.77 | 19.99 | 24.70 | 8.45 | 1.16 | 7.70 | 99.60 |
| | | | | 8 | 12.24 | 20.35 | 24.50 | 8.43 | 1.10 | 7.68 | 97.30 |
| | | | | 10 | 12.38 | 20.61 | 24.20 | 8.41 | 1.07 | 7.63 | 95.70 |
| | | | | 11 | 13.07 | 21.12 | 23.20 | 8.40 | 1.11 | 7.60 | 94.90 |
| | 10A | 26°56'48.88"S 32°50'52.85"E | 13h20 | 0 | 11.18 | 18.88 | 25.90 | 8.39 | 1.21 | 7.30 | 96.00 |
| | | | | 0.5 | 11.18 | 18.88 | 25.90 | 8.38 | 1.28 | 7.31 | 96.20 |
| | | | | 1 | 11.18 | 18.88 | 26.10 | 8.37 | 1.25 | 7.35 | 96.60 |
| | | | | 1.5 | 11.18 | 18.88 | 26.40 | 8.37 | 1.22 | 7.53 | 97.90 |
| **Channel 3** | 11 | 26°57'1.44"S; 32°50'39.11"E | 13h35 | 0 | 10.20 | 17.37 | 26.50 | 8.00 | 1.08 | 5.92 | 78.60 |
| | | | | 0.5 | 10.20 | 17.37 | 26.50 | 7.99 | 1.06 | 5.73 | 75.70 |
| | | | | 1 | 10.20 | 17.37 | 26.50 | 7.93 | 1.10 | 5.66 | 74.60 |
| | | | | 1.25 | 10.20 | 17.38 | 26.50 | 7.85 | 1.12 | 5.66 | 73.90 |
| **Lake 3** | 12 | 26°57'26.95"S 32°50'37.04"E | 14h00 | 0 | 5.79 | 10.27 | 25.30 | 8.69 | 1.25 | 8.72 | 109.60 |
| | | | | 0.5 | 5.79 | 10.27 | 25.20 | 8.72 | 1.25 | 8.73 | 109.60 |
| | | | | 1 | 5.82 | 10.30 | 24.60 | 8.69 | 0.90 | 8.26 | 103.00 |
| | | | | 2 | 6.10 | 10.43 | 24.20 | 8.68 | 2.40 | 8.22 | 102.30 |
| | 13 | 26°58'58.91"S 32°50'20.19"E | 14h30 | 0 | 5.81 | 10.30 | 24.60 | 8.72 | 1.18 | 8.50 | 105.50 |
| | | | | 1 | 5.81 | 10.30 | 24.60 | 8.68 | 1.17 | 8.54 | 105.90 |
| | | | | 3 | 5.81 | 10.30 | 24.20 | 8.65 | 1.21 | 8.52 | 105.20 |
| | | | | 6 | 5.82 | 10.31 | 24.30 | 8.63 | 1.20 | 8.44 | 105.10 |
| | | | | 9 | 5.85 | 10.31 | 22.70 | 8.57 | 1.17 | 8.34 | 102.80 |
| | | | | 12 | 5.85 | 10.35 | 22.50 | 8.52 | 1.20 | 7.83 | 95.80 |
| | | | | 15 | 5.87 | 10.38 | 22.50 | 8.50 | 5.40 | 7.48 | 89.00 |
| | 14 | 26°58'4.67"S; 32°49'19.16"E | 15h30 | 0 | 5.79 | 10.28 | 25.40 | 8.78 | 1.29 | 9.60 | 120.80 |
| | | | | 0.5 | 5.79 | 10.28 | 25.40 | 8.81 | 1.23 | 9.55 | 120.40 |
| | | | | 1 | 5.80 | 10.28 | 25.40 | 8.82 | 1.22 | 9.55 | 120.20 |
| | | | | 2 | 5.79 | 10.28 | 25.40 | 8.83 | 1.18 | 9.58 | 120.80 |
| | 15 | 26°59'34.44"S 32°51'38.53"E | 15h00 | 0 | 5.84 | 10.33 | 23.10 | 8.61 | 1.22 | 8.77 | 106.20 |
| | | | | 0.5 | 5.84 | 10.33 | 23.20 | 8.60 | 1.18 | 8.62 | 104.40 |
| | | | | 1 | 5.84 | 10.33 | 23.20 | 8.58 | 1.21 | 8.55 | 103.80 |
| | | | | 2 | 5.84 | 10.33 | 23.20 | 8.56 | 1.19 | 8.51 | 103.10 |
| | 16 | 27°0'22.98"S 32°49'42.26"E | 14h00 | 0 | 5.55 | 9.89 | 26.40 | 8.64 | 0.26 | 10.16 | 129.00 |
| | | | | 0.5 | 5.56 | 9.89 | 26.40 | 8.70 | 0.64 | 10.29 | 131.90 |
| | | | | 1 | 5.56 | 9.89 | 26.40 | 8.80 | 7.16 | 10.32 | 132.20 |
| **Channel 4** | 17 | 27°1'10.23"S 32°49'5.93"E | 13h40 | 0 | 1.31 | 2.61 | 26.50 | 7.83 | 0.01 | 6.48 | 81.80 |
| | | | | 0.5 | 1.36 | 2.62 | 26.50 | 7.78 | 0.01 | 6.23 | 78.30 |
| | | | | 1 | 4.96 | 9.07 | 26.10 | 7.60 | 0.04 | 6.60 | 82.60 |
| | | | | 1.5 | 5.21 | 9.40 | 25.30 | 7.82 | 6.80 | 6.96 | 86.00 |
| **Lake 4** | 18 | 27°1'34.49"S 32°49'26.94"E | 13h10 | 0 | 0.81 | 1.61 | 26.00 | 7.48 | 0.64 | 7.36 | 91.70 |
| | | | | 0.5 | 0.81 | 1.61 | 26.00 | 7.54 | 0.61 | 7.12 | 88.30 |
| | | | | 1 | 0.81 | 1.61 | 25.90 | 7.55 | 0.56 | 7.04 | 86.80 |
| | | | | 2 | 0.81 | 1.61 | 25.90 | 7.56 | 0.96 | 6.85 | 84.50 |
| | 19 | 27°1'56.34"S 32°49'20.95"E | 12h50 | 0 | 0.63 | 1.28 | 25.50 | 7.10 | 1.40 | 6.13 | 76.30 |
| | | | | 0.5 | 0.63 | 1.28 | 25.50 | 7.14 | 1.41 | 5.63 | 68.90 |
| | | | | 1 | 0.63 | 1.28 | 25.40 | 7.17 | 4.74 | 5.53 | 67.80 |
| | | | | 2 | 0.63 | 1.29 | 25.20 | 7.19 | 4.80 | 4.71 | 65.50 |
| **River** | 20 | 27°2'10.36"S 32°49'3.69"E | 12h30 | 0 | 0.19 | 0.39 | 25.00 | 7.78 | 3.36 | 2.30 | 30.30 |
| | | | | 0.5 | 0.19 | 0.39 | 24.60 | 7.59 | 3.64 | 1.50 | 17.40 |
| | | | | 1 | 0.19 | 0.39 | 24.60 | 7.29 | 3.45 | 1.45 | 16.50 |
| | | | | 2 | 0.19 | 0.39 | 22.20 | 7.22 | 4.12 | 0.84 | 9.80 |
| | | | | 2.5 | 0.19 | 0.39 | 22.20 | 7.05 | 30.20 | 0.65 | 7.50 |

See **Appendix B** for more detail on physico-chemical data collected as part of invertebrates sampling collected using a YSI multi probe.

## 5.2 MACROPHYTES

The estuarine lake system is of considerable botanical importance because the salinity gradient that characterises the transition from the lakes to the sea supports nationally important areas of submerged macrophytes, swamp forest and mangrove habitat. Kosi is a unique estuary with characteristics of a tropical system as indicated by the seagrass *Halodule universis* that only occurs here as well as the mangrove species *Lumnitzera racemosa, Ceriops tagal* and *Xylocarpus granatum.*

The same transects sampled in 2016 were revisited to check the distribution of submerged and emergent macrophytes along a water depth and elevation gradient. Only sites 19 and 22 were not checked in detail in 2022 due to hippos blocking access. On 29 September the west bank of Lake 3 and Lake 4 and Sihadhla River / Channel were visited to check macrophyte distribution. Since the field work in 2016 the vegetation (reeds and sedges) had grown further downstream in the channel towards Lake 4. On 30 September Lakes 1, 2 and east bank of Lake 3 was visited. Thick pondweed and filamentous green macroalgae filled the water column up to a depth of 2 m parallel to the steep east banks characterizing Lake 3. The estuary / mouth area was visited on 1 October 2022. The mangrove area was very disturbed due to harvesting activities but was fringed by healthy *Juncus kraussi* marshes. We walked along the water's edge to the estuary mouth. Two seagrass species were present *Halodule universis* and *Zostera capensis*. There has been an increase in macroalgal cover in all lakes and the estuary; possible indication of nutrient enrichment. Although extensively harvested the stands of mangroves were regenerating as indicated by a range of size classes. We walked through the water channel and past the fish traps to the mangroves adjacent to the steep east banks. Here there were some signs of harvesting; overall the mangroves are extensive and healthy (**Figure 5.1 - 5.7**).

**Figure 5.1 The Kosi estuarine lake is nationally important as a tropical system that supports high biodiversity. Photo of estuary habitats (Photo: J Adams, 1 October 2022)**

**Figure 5.2 Diversity of algae and submerged macrophytes from Lake 3, Kosi Bay (left to right filamentous green algae, *Najas* sp., *Potamogeton sweinfurthii* and *Stuckenia pectinata*). (Photo: J Adams)**

**Figure 5.3 Sihadhla River flows into Lake 4 of Kosi estuarine lake; there was little water movement at the time of sampling. Grasses, reeds, sedges encroached into the water column that was filled with dense submerged vegetation (Photo: J Adams, 29 September 2022)**

**Figure 5.4 Burning of vegetation on Mtando Channel that links Lakes 3 and 2, Kosi Estuary. This activity threatens bank stability. (Photo: J Adams, 29 September 2022)**

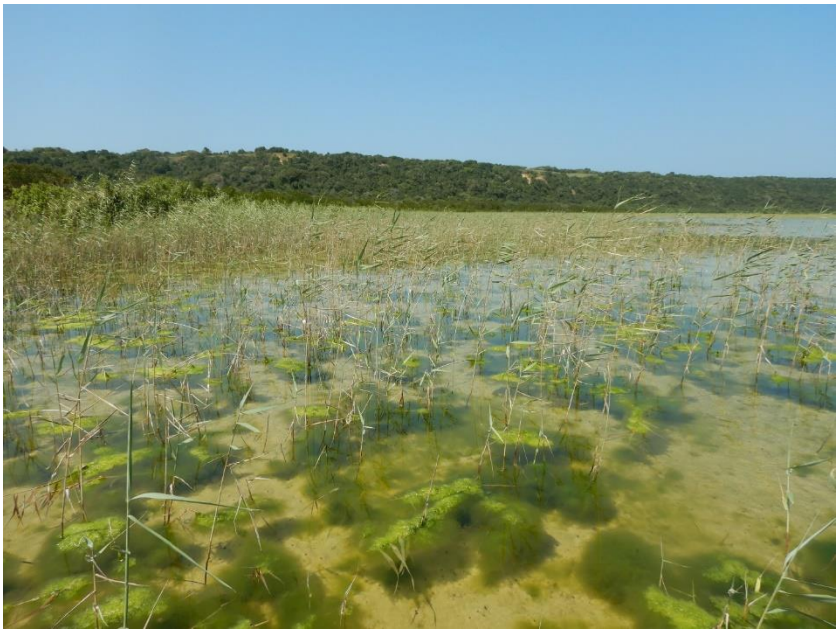

**Figure 5.5 Filamentous green algae occurred amongst the reeds in Lakes 1 and 2 at Kosi Estuary (Photo: J Adams, 30 September 2022)**

**Figure 5.6 Mangrove and palm harvesting near Kosi Estuary mouth for materials to build and maintain adjacent fish traps (Photo: J Adams, 1 October 2022)**

**Figure 5.7 Black mangrove harvested for use in fish traps. Location: Kosi Estuary opposite mouth adjacent to steep eastern dunes. (Photo: J Adams, 1 October 2022)**

## 5.1 SEDIMENT SAMPLING

Sediment samples were collected from three sites at the Kosi Estuary (See **Appendix A**). Site 1 was located within the tidal estuary (26.89879°S; 32.86250°E), Site 2 was located on the southern bank of Lake Makhawulani (26.93263°S; 32.85558°E), and Site 3 was located within the Mthando Channel (26.94530°S; 32.84606°E) between Lake kuMpungwini and Lake kuNhlange. Sites 2 and 3 were sampled on Saturday, 30 September 2022, and Site 1 was sampled on Sunday, 1 October 2022. At Site 1, four cores each were sampled from mixed mangrove (*Rhizophora mucronata*, *Bruguiera gymnorrhiza*, and *Avicennia marina*), reeds and sedges (*Phragmites australis*), and salt marsh (*Juncus kraussii*). There was evidence of cattle trampling in the salt marsh. The sediment ranged from being muddy in mangroves, to sandy mud and sand in the reeds and sedges and salt

marsh respectively. At Site 2, four cores each were sampled from mixed mangrove (*Lumnitzera racemosa*, and *Ceriops tagal*), as well as from reeds and sedges (mosaic of *Phragmites australis* and *Cyperus crassipes*). There was a very narrow band of salt marsh (*Sporobolus virginicus*) parallel to the water's edge that was not sampled as it was traversed by a footpath. This site had evidence of disturbance from mangrove harvesting, as well as trampling. The sediment appeared predominantly sandy mud to sand, with an organic layer at ~ 20 cm depth. At Site 3, four cores were sampled each from mangrove (*Lumnitzera racemosa*) and reeds and sedges (*Phragmites australis*). There was evidence of disturbance at the site, with lots of wood debris (dead wood). The cores were predominantly muddy sand, to mud, with up to 10 cm of compaction. Some sections of the cores were lost during extraction due to high volume of water down to 20 cm depth.

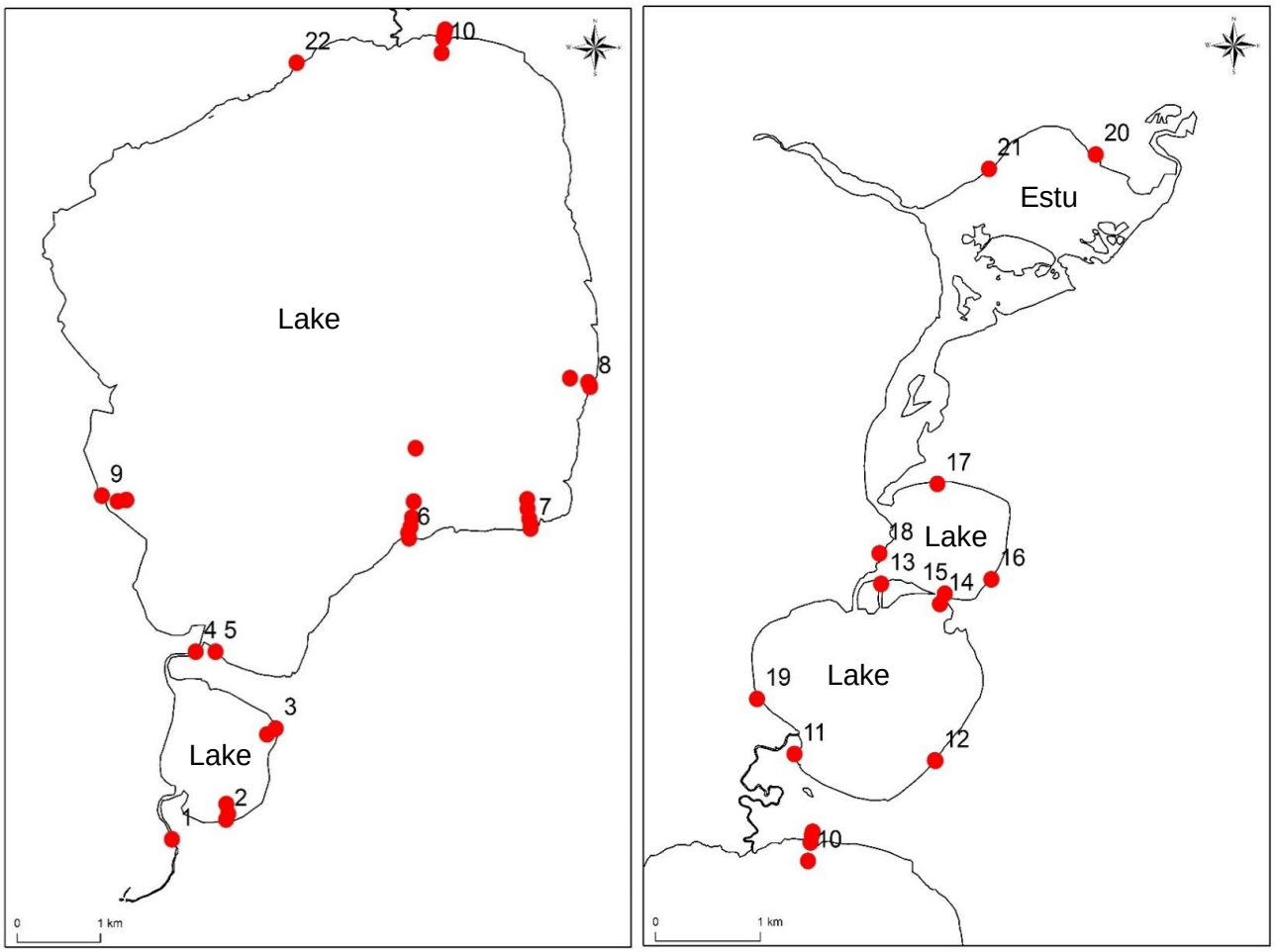


**Figure 5.8 Macrophyte sites sampled in 2016 and 2022 to measure the distribution of submerged and emergent macrophytes along a depth and elevation gradient**

## 5.2 INVERTEBRATES

All samples are yet to be analysed but the impression was of a system that has an increasing salinity profile in the upper reaches. This was also evidenced by for e.g., the sand prawn (*Kraussillichirus kraussi)* which was historically prolific in Lakes Mpungwini and Makhawulani, but this survey found evidence of increased distribution into Lake Nhlange (Lake 3, sites NHL1, NHL3 and NHL4; **Figure 5.9**). Also notable was the spread of the invasive gastropod *Tarebia granifera* further into Lake Nhlange where it seems to have spread from the boat launch area initially. The giant mangrove whelk, *Terebralia palustris* (**Figure 5.10**) was fairly common at waypoint 221 and the shells of which were used by an as yet unknown species of hermit crab. The whelk has all but

disappeared from every other mangrove system to the south. Invertebrate bycatch from fish seines were retained for identification.


**Figure 5.9 Invertebrate fauna, sediment and physico-chemical stations 29/09-1/10/2022 at Kosi and Lake Zilonde**

**Figure 5.10 The giant mangrove whelk *Terebralia palustris* found across the Indo-west pacific, but now limited to Kosi Estuary**

## 5.3 FISH

In all, 25 species of fish were caught and at least another 10 seen whilst sampling and using mask and snorkel. Harrison recorded a total of 18 species in this estuary. Local fisherman indicated that the high abundance of macroalgal growth in the fish traps has not happened before in living history. See **Appendix C** for a summary of fish species caught during the trip. A high number of Illegal gillnets were found in 4th Lake, never observed before (new pressure).

## 5.4 SUMMARY

- Mouth open.
- Lake water levels higher than in 2016.
- System shows signs of drought recovery.
- Despite being a very Important Estuarine Lake in a formally protected area there are significant signs of further decline in condition – system now likely to be B Category.
- Significant increase in clearing of natural vegetation (land use change), increase harvesting pressure on mangroves, more fish traps (first time fish traps observed in 3de Lake), and gill nets observed for the first time in 4$^{th}$ Lake.
- Significant submerged macrophyte and macroalgal growth observed in 3$^{rd}$ lake.
- Local fisherman indicated that this has not happened before in living history, e.g., macroalgal growth in fish traps. Indicating nutrient enrichment but will need to confirm source.
- In all, 25 species of fish were caught and at least another 10 seen whilst sampling or using a mask and snorkel.

# 6 UMGOBEZELENI ESTUARY

## 6.1 WATER QUALITY AND MICROALGAE

On Monday 3 October 2022 the mouth of the estuary was open to the sea. The estuary was perched and freshwater flowed to the sea. The lower (Site 1) and middle (Site 2) reaches of the estuary were characterised by fresh (salinity < 1) surface waters, with brackish (>5) and hypoxic (< 2 mg $l^{-1}$) bottom-waters. The upper reaches (Site 3) were fresh and hypoxic. The mouth area is a boat launching site for Sodwana Bay fishing and diving and is severely disturbed by the high intensity of vehicle activity (**Table 6.1**).

**Table 6.1 *In situ* water quality observations uMgobezeleni Estuarine Lake (03 10 2022) (Mouth state – open)**

| Station | Coordinates | Time Sampled | Depth (m) | Salinity | Conduc-tivity (mS/cm) | Temp. (°C) | pH | NTU | DO (mg/l) | DO (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27°32'26.22"S 32°40'43.43"E | 10h00 | 0.0 | 0.57 | 1.15 | 24.60 | 7.92 | 0.07 | 6.29 | 75.90 |
| | | | 1.0 | 5.36 | 9.56 | 24.40 | 7.25 | 0.93 | 3.02 | 37.70 |
| 1A | 27°32'27.17"S 32°40'39.49"E | 10h45 | 0.0 | 0.52 | 1.06 | 24.80 | 8.07 | 2.83 | 5.33 | 64.50 |
| | | | 1.2 | 1.19 | 2.37 | 24.60 | 7.70 | 3.20 | 4.20 | 52.30 |
| 2 | 27°32'28.94"S 32°40'37.30"E | 09h15 | 0.0 | 0.24 | 0.50 | 24.30 | 8.27 | 0.00 | 3.16 | 37.40 |
| | | | 0.5 | 0.70 | 1.40 | 24.20 | 8.23 | 0.00 | 2.44 | 28.70 |
| | | | 1.0 | 13.70 | 22.71 | 24.90 | 7.01 | 2.22 | 1.67 | 21.50 |
| 3 | 27°32'31.55"S 32°40'34.55"E | 11h40 | 0.0 | 0.20 | 0.42 | 24.20 | 7.60 | 6.50 | 2.56 | 30.40 |
| | | | 0.8 | 0.22 | 0.46 | 23.90 | 7.64 | 4.70 | 0.96 | 11.40 |
| Lake 1 | 27°31'44.66"S 32°39'24.11"E | 14h30 | 0.0 | 0.18 | 0.37 | 27.90 | 7.89 | 4.12 | 7.16 | 91.40 |

See **Appendix B** for more detail on physico-chemical data collected as part of invertebrates sampling collected using a YSI multi probe.

## 6.2 MACROPHYTES

Grassy banks characterized the lower reaches with fringing swamp forest. Surviving mangroves occurred adjacent to the road on the west bank. There were seedlings, saplings and adults of the black mangrove *Bruguiera gymnnorhiza*. Across from this site were dead trunks of black mangrove growing amongst the mangrove fern and adjacent to reeds and sedges closer to the water column and swamp forest (*Hibiscus tiliaceus*) closer to land. Mangroves died in the estuary in the 1970s when he road bridge was built across the estuary. There was another dieback in 2007 when there was mouth closure and high water level (Taylor, 2016). Mangrove fern *Acrostichum* occurred in the area of dead trees with dense surrounding reeds. Reeds and sedges were abundant colonizing most of the lower estuary reaches. The surviving mangroves require protection; there were signs of bark harvesting and disturbance from road and recent fence construction.

**Figure 6.1 Submerged macrophyte *Urticularia* sp. from Lake uMgobezeleni. These species are carnivorous and capture small organisms by means of bladder-like traps (Photo: J Adams, 3 October 2022)**

**Figure 6.2 Bark harvesting of the black mangrove *Bruguiera gymnorrhiza* above the road bridge at uMgobezeleni Estuary (Photo: J Adams, 3 October 2022)**

**Figure 6.3 Dead black mangrove trees (*Bruguiera gymnorrhiza*) occur among reeds and mangrove fern adjacent to swamp forest (*Hibiscus tiliaceus*) at uMgobezeleni Estuary (Photo: J Adams, 3 October 2022)**

## 6.3 SEDIMENT SAMPLING

Sediment samples were collected from two sites at the uMgobezeleni Estuary (See **Appendix A**). Site 1 was located just beyond the bridge, on the northern bank of the estuary channel (27.54182°S; 32.67612°E) and Site 2 was located slightly further upstream on the southern bank (27.54250°S; 32.67623°E). Site 2 was accessed from the road as the swamp forest vegetation prevented access from the estuary channel.

At Site 1, four cores were sampled each from swamp forest (*Hibiscus tiliaceus*) and reeds and sedges (*Phragmites australis*). The site was a mosaic of reeds and sedges and swamp forest. The vegetation was dense. The site was located among tall dead mangrove (*B. gymnorrhiza*). The cores were predominantly sandy mud with compaction ranging from 0 - 6 cm. At Site 2, four cores were sampled from swamp forest only (*Hibiscus tiliaceus*). Reeds and sedges at this site were not accessible for sampling, as they only occurred in areas where the sediment was submerged. Under these conditions the sediment is lost from the corer when it is extracted. There were individual live mangrove trees (*B. gymnorrhiza*) in amongst the swamp forest vegetation.

## 6.4 INVERTEBRATES

All samples are yet to be analysed (**Figure 6.4** for site locations). Samples appeared more depauperate than from similar sediment habitats in Kosi and sediments had much particulate organic decaying matter (POM) which with the low oxygen levels measured would not support an abundant benthic invertebrate community. Invertebrate bycatch from fish seines were retained for identification.


**Figure 6.4 Invertebrate fauna, sediment and physico-chemical stations 3/10/2022 at uMgobezeleni Estuary and Lake (Photo: F MacKay)**

## 6.5 FISH

A total of 18 fish species were sampled which compares well with 14 recorded across all previous studies. Of interest, is the existence of spotted bass *Micropterus punctulatus*, probably descendants of bass introduced in the 1950s to 1970's. The system represents a fully functional estuarine lake system. More important than previously indicated. New recruits of obligate estuarine-dependent fish species were recorded in uMgobezeleni Lake (< 2 weeks old freshwater mullet that was recruited from the sea). See **Appendix C** for a summary of fish species caught during the trip. Illegal gillnets found in the uMgobezeleni Lake.

## 6.6 SUMMARY

- Mouth open.
- Limited salinity penetration in lower reaches.
- System in good condition.
- Fully functional estuarine lake system.
- More important than previously indicated.
- New recruits of fish were recorded in uMgobezeleni Lake (< 2 weeks old freshwater mullet that recruited from the sea).
- New individuals of black mangrove were observed.
- However, urgent action is needed to protect mangroves (e.g., road through mangroves) and fish (high number of illegal gillnets in the lakes).

- A total of 18 fish species were sampled which compares well with 14 recorded across all previous studies.
- Of interest, is the existence of spotted bass *Micropterus punctulatus*, an alien invasive not previously recorded in the system.

# 7 iNHLABANE ESTUARY

## 7.1 WATER QUALITY and MICROALGAE

On Tuesday 4 October 2022 the estuary was accessed at the mouth and then in the upper reaches at the barrage that separates the lake from the estuarine lake. The lower estuary was highly impacted from plastic pollution and water quality deterioration as indicated by the presence of leeches and bilharzia snails. The estuary was closed to the sea (**Figure 7.1**). Freshwater conditions (< 0.6) were present throughout the estuary, with biologically stressful (< 5 mg $l^{-1}$) and hypoxic (< 2 mg $l^{-1}$) conditions characterising the surface and bottom waters, respectively (**Table 7.1**). Standing stagnant water near the mouth was surrounded by dense emergent vegetation of bulrush, reeds, sedges and bulrush. Water lilies covered the water surface area and the herb *Centella asiatica* and sedge *Eleocharis* sp. was abundant on the sandy edges (**Figure 7.1 - 7.4**).

**Table 7.1 *In situ* water quality observations iNhlabane Estuary (04 10 2022) (Mouth state – closed for years)**

| Station | Coordinates | Time | Depth (m) | Salinity | Conduc-tivity (mS/cm) | Temp. (°C) | pH | NTU | DO (mg/l) | DO (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28°39'35.13"S32° 15'28.00"E | 16h35 | 0 | 0.57 | 1.14 | 23.10 | 8.02 | 0.41 | 5.11 | 59.80 |
| | | | 0.8 | 0.57 | 1.14 | 23.10 | 7.95 | 0.78 | 4.68 | 54.80 |
| 2 | 28°39'27.40"S32° 15'33.84"E | 17h00 | 0 | 0.57 | 1.14 | 22.90 | 7.88 | 0.00 | 1.98 | 23.10 |
| | | | 0.5 | 0.57 | 1.14 | 23.10 | 7.82 | 0.66 | 1.88 | 22.00 |
| 3 | 28°38'29.25"S32° 16'9.24"E | 17h45 | 0 | 0.56 | 1.12 | 23.13 | 7.51 | 1.09 | 4.21 | 49.50 |
| | | | 1 | 0.56 | 1.12 | 23.13 | 7.53 | 1.20 | 3.80 | 44.30 |
| | | | 2 | 0.56 | 1.12 | 23.03 | 7.45 | 8.06 | 2.71 | 32.20 |

See **Appendix B** for more detail on physico-chemical data collected as part of invertebrates sampling collected using a YSI multi probe.

**Figure 7.1 High dunes at the mouth of the iNhlabane Estuary (Photo: J Adams, 4 October 2022)**

**Figure 7.2 Stagnant lower reaches of iNhlabane Estuary (Photo: Riaan Weitz, 4 October 2022)**

**Figure 7.3 Plastic pollution at the mouth of the iNhlabane Estuary. (Photo: J Adams, 4 October 2022)**

**Figure 7.4 Lower / mouth reaches of the iNhlabane Estuary. (Photo: J Adams, 7 October 2022)**

## 7.2 MACROPHYTES

At the barrage / dam wall that separates the iNhlabane Estuary from the dam / previous estuarine lake the aquatic invasive plant *Pistia stratiotes* (water cabbage) was floating on the surface water. Also present was large submerged beds of the invasive aquatic macrophyte *Ceratophyllum demersum* that is associated with slow flowing, freshwater eutrophic habitats. Pondweed *Stuckenia pectinata* was also present as well as the floating invasive *Lemna minor* (duckweed) (**Figure 7.5 - 7.7**).

**Figure 7.5 Pooled stagnant water at the mouth of the iNhlabane Estuary. Bulrush, reeds, lilies and pondweed dominant. (Photo: J Adams, 4 October 2022)**

**Figure 7.6 The barrage / dam wall that separates the iNhlabane Estuary from the dam / previous estuarine lake. Aquatic invasive plant *Pistia stratiotes* (water cabbage) floating on the surface water. (Photo: J Adams)**

**Figure 7.7 Large submerged beds of the invasive aquatic macrophyte *Ceratophyllum demersum* that is associated with slow-flowing, freshwater eutrophic habitats were present at the iNhlabane barrage (Photo: J Adams, 4 October 2022)**

## 7.3 SEDIMENT SAMPLING

Sediment samples were collected from one site at the iNhlabane Estuary (See **Appendix A**). Vegetated areas could not be accessed for sampling at the upper reaches site near the bridge. Site 1 was located adjacent to the estuary channel in a flat seepage area (28.65883°S; 32.25862°E). The estuary was closed at the time of sampling on Tuesday 4 October 2022. At Site 1, four cores were sampled from reeds and sedges (*Phragmites australis*, *Typha capensis*). Other species present included *Paspalum vaginatum* and *Centella* sp. The sediment was predominantly sandy and compaction ranged from 0 - 2 cm.

## 7.4 INVERTEBRATES

All samples are yet to be analysed (**Figure 7.8** for site locations). The system is no longer functioning as an estuary, visible invertebrates sampled were all freshwater insects (*Diptera, Zygoptera*). Also noted were gastropods *Physa* and *Biomphalaria* which are the intermediate snail hosts for *Schistosoma,* widespread alien invasive *Tarebia granifera* on the subtidal sediment surface and giant Hirudinea (still to be identified) among the macrophytes of the lower reaches *(***Figure 7.9***).*

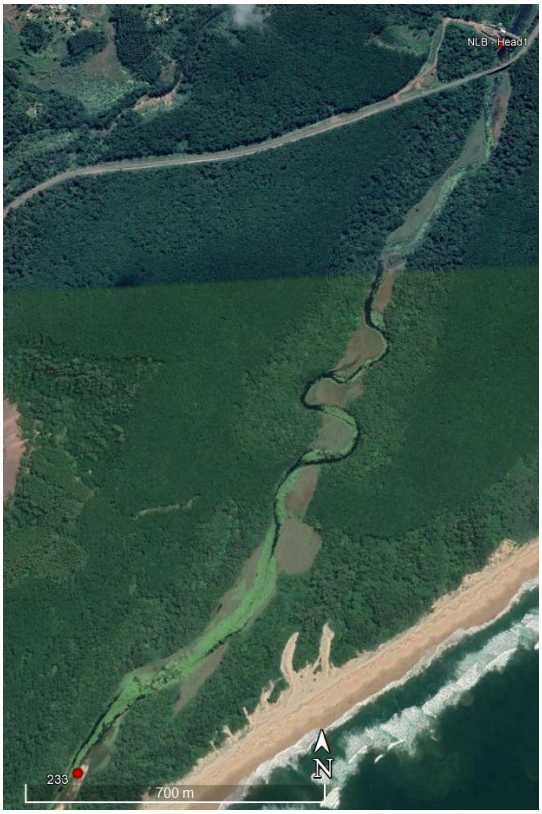


**Figure 7.8 Invertebrate fauna, sediment and physico-chemical stations 410/2022 at iNhlabane Estuary (Photo: F MacKay)**

**Figure 7.9 Bilharzia vectors were abundant in the lower reaches of the estuary and freshwater *Hirudinea* (Photos: J Adams, 4 October 2022)**

## 7.5 FISH

Only three species of fish were sampled, all freshwater taxa tolerant of poor water quality. No estuarine functionality remaining. See **Appendix C** for a summary of fish species caught during the trip.

## 7.6 SUMMARY

- Mouth Closed.
- Significant further decline in condition.

- Very high unnatural sand dune has formed in mouth indicating years of flow depravation.
- No connection to the sea. Mouth has not been open in years.
- EWR cannot have been released in years. System was completely fresh as indicated by leeches, water lilies and tadpoles.
- Extensive loss of open water area due to macrophyte growth.
- Water body infested with bilharzia snail vectors.
- No flow over the weir. Fishway non-functional.
- No estuarine functionality remains in what was once an important estuarine lake in the region due to freshwater flow depravation.
- Only three species of fish were sampled, all freshwater taxa tolerant of poor water quality.
- Extensive infestation by alien invasive *Terebia granifera* snails.
- Other macroinvertebrates sampled seemed only to be various dragonfly larvae supporting no current estuarine function.
- System is now used for livestock watering (evidence around lower estuary margins), further degrading water quality and nutrients allowing proliferation of macrophytes which have closed off the middle reaches (see satellite imagery).

# 8 ISIYAYA ESTUARY

## 8.1 WATER QUALITY AND MICROALGAE

On Wednesday 5 October 2022 the estuary was visited at the mouth. The water trickled fresh between the dunes but was not connected to the sea. Freshwater (salinity < 1) and biologically stressful dissolved oxygen (< 5 mg $l^{-1}$) conditions were present throughout the estuary. An isolated shallow pool near the mouth (Site 1) exhibited brackish (salinity *ca.* 2.5) and supersaturated dissolved oxygen (> 11 mg $l^{-1}$) conditions, as well as extensive benthic microalgal growth (**Table 8.1**).

**Table 8.1 *In situ* water quality observations iSiyaya Estuary (05 10 2022) (Mouth state - closed)**

| Station | Coordinates | Time Sampled | Depth | Salinity | Conduc-Tivity (mS/cm) | Temp-erature (°C) | pH | NTU | DO (mg/l) | DO (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28°57'47.35"S31° 46'3.14"E | 10h05 | 0 | 2.42 | 4.54 | 24.10 | 9.38 | 2.36 | 11.25 | 135.70 |
| 2 | 28°57'51.39"S31° 45'53.87"E | 10h25 | 0 | 0.82 | 1.62 | 23.50 | 8.20 | 3.86 | 5.07 | 59.90 |
| | | | 0.5 | 0.82 | 1.63 | 23.30 | 8.16 | 6.57 | 4.96 | 58.40 |
| 3 | 28°58'0.37"S 31°45'35.57"E | 10h45 | 0 | 0.75 | 1.49 | 23.70 | 8.18 | 10.04 | 4.58 | 54.30 |
| 4 | 28°58'10.60"S31° 45'18.40"E | 13h50 | 0 | 0.31 | 0.64 | 23.34 | 7.29 | 37.62 | 4.84 | 57.70 |
| | | | 1.5 | 0.31 | 0.65 | 21.76 | 6.76 | 47.25 | 2.59 | 29.60 |

**Figure 8.1 iSiyaya Estuary mouth showing the high dune buildup at mouth and low water levels (Photo: Riaan Weitz, 5 October 2022)**

**Figure 8.2 iSiyaya Estuary mouth area, start of dense reeds; little open water surface area. (Photo: Riaan Weitz, 5 October 2022)**

See **Appendix B** for more detail on physico-chemical data collected as part of invertebrates sampling collected using a YSI multi probe.

## 8.2 MACROPHYTES

Casuarina trees occurred on the east bank and the west bank was steep and colonized by dune vegetation. Grassy banks consisted of *Paspalum vaginatum* with some sharp rush *Juncus kraussii*. Small patches of filamentous green algae occurred in the lower reaches. Just upstream from the mouth (~650 m) dense stands of reeds, sedges and bulrush occurred. Where there were open water lilies were present and other aquatic plants such as *Persicaria decipiens*. The estuary was also accessed via the dunes at a site 1.18 km upstream from the mouth. Here swamp forest was present. Team member's photos from the wood bridge site showed flooded *Barringtonia racemosa* and some die-back possibly due to high water level. Here there was evidence of silt input possibly from upstream mining activities. The estuary has a long history of catchment disturbance that has resulted in sedimentation, shallowing and expansion of reeds, sedges and swamp forest; little open water surface area remains. *Barringtonia racemosa* and *Hibiscus tiliaceus* swamp forest are also encroaching as a result of the shallowing and freshening of the estuary (**Figure 8.3 - 8.7**).

**Figure 8.3 iSiyaya Estuary upstream from mouth; shallow freshwater conditions as indicated by the lilies (Photo: J Adams, 5 October 2022)**

**Figure 8.4** ***Barringtonia racemosa*** **seedling competing for space and light from surrounding reeds and sedges at the iSiyaya Estuary. This is a swamp forest tree commonly known as the powderpuff tree. (Photo: J Adams, 5 October 2022)**

**Figure 8.5** **Bulrush*, Typha sp.* indicates fresh, standing or slow-flowing waters at iSiyaya Estuary (Photo: J Adams, 5 October 2022)**

**Figure 8.6 Upstream site of the iSiyaya Estuary indicating flooded and dying *Barringtonia racemosa*, swamp forest trees (Photo: J Adams, 5 October 2022)**

**Figure 8.7 Swamp forest (*Barringtonia racemosa*) in the middle reaches of the iSiyaya Estuary (Photo: J Adams, 5 October 2022)**

## 8.3 SEDIMENT SAMPLING

Sediment samples were collected from one site at the iSiyaya Estuary (See **Appendix A**). Vegetated areas could not be accessed for sampling at the upper reaches site near the bridge or along the estuary channel. Site 1 was located adjacent to the estuary channel on the northern bank (28.96444°S; 31.76450°E). The estuary was closed at the time of sampling on Wednesday, 5 October 2022. At Site 1, four cores were sampled from reeds and sedges (*Schoenoplectus brachyceras*, *Juncus kraussi*). Some *Triglochin* sp. was also present. The sediment was predominantly sandy with no compaction occurring on the cores.

## 8.4 INVERTEBRATES

All samples are yet to be analysed (**Figure 8.8** for site locations). Visible fauna included macrocrustaceans *Varuna litterata* (swimming crab) and *Kraussillichirus kraussi* (sand prawn) (**Figure 8.9**) which are remnant estuarine indicative, whereas all other visible aquatic invertebrates were Insecta given the brackish/fresh conditions along the system (salinity 2.39 at the closed mouth). Invertebrate bycatch from fish seines were retained for identification.


**Figure 8.8 Invertebrate fauna, sediment and physico-chemical stations 4/10/2022 at iSiyaya Estuary (Photo: F MacKay)**

**Figure 8.9 Investigating sand mounds and burrows for sand prawn *Kraussillichirus kraussi* specimens in the lower iSiyaya Estuary (Photo: S Jordaan 5 October 2022)**

## 8.5 FISH

A total of 18 species of fish were sampled in the lower reaches which compares well with the 13 recorded in previous studies. Low species diversity is typical of a predominantly closed estuary. The relatively high species count in the current survey was likely influenced by the fish in the lower reaches being concentrated into small ponds at the mouth, remnants of the larger system which were effectively acting as refugia in very low water level conditions. See **Appendix C** for a summary of fish species caught during the trip.

## 8.6 BIRDS

Very few waterbirds were present. Access to this estuary for waterbird counting is restricted due to the low water levels. No existing or past waterbird counts exist for this estuary in the Coordinated

Waterbird Counts (CWAC) database. The high turbidity due to mine siltation would be highly negative for visual piscivorous waterbird species and also likely highly negative for invertebrate feeders if the substrate is smothered by this silt. See **Appendix D** for a summary of bird species observed during the trip.

## 8.7 SUMMARY

- Mouth Closed.
- Declining further in condition.
- Very little flow reaches the estuary.
- Only small stagnant pools were observed in the mouth area. Very high turbidity was observed in the middle and upper reaches linked to possible upstream slimes dam input and contamination - to be confirmed with satellite imagery.
- This said, a total of 18 species of fish were sampled and compares well with previous studies.
- The relatively low species count in this and earlier studies are typical of a predominantly closed estuary. Very few waterbirds were present.
- The high turbidity due to mine siltation is highly negative for visual piscivorous waterbird species and also likely highly negative for invertebrate feeders if the substrate is smothered by this silt.

# 9 uMLALAZI ESTUARY

## 9.1 WATER QUALITY AND MICROALGAE

The lower reaches of the estuary were marine and well-oxygenated, while the mid- to upper reaches (Site 2 and 3) were characterised by vertically stratified salinity profiles (i.e., saltier water underlying brackish surface waters) and bottom-water hypoxia (< 2 mg $l^{-1}$). Several oxygen-deprived zones noted (particularly in mid-lower reaches) in the bottom water column layer (<3% saturation) (**Table 9.1**).

**Table 9.1 *In situ* water quality observations uMlalazi Estuary (06 10 2022) (Mouth state - open)**

| Station | Coordinates | Time | Depth (m) | Salinity | Conduc-tivity (mS/cm) | Temp. (°C) | pH | NTU | DO (mg/l) | DO (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28°56'34.40"S 31°49'2.97"E | 10h50 | 0 | 33.04 | 50.40 | 24.80 | 8.09 | 4.59 | 104.30 | 7.17 |
| | | | 1 | 33.07 | 50.45 | 24.50 | 8.14 | 5.67 | 105.60 | 7.30 |
| 2 | 28°57'17.42"S 31°46'36.32"E | 11h50 | 0 | 23.08 | 36.54 | 25.60 | 8.29 | 10.58 | 110.30 | 8.87 |
| | | | 1 | 23.80 | 37.52 | 25.30 | 8.25 | 10.90 | 100.40 | 7.34 |
| | | | 2 | 31.51 | 48.29 | 23.70 | 7.89 | 48.80 | 18.00 | 1.27 |
| 3 | 28°56'8.96"S 31°46'50.80"E | 12h30 | 0 | 19.77 | 31.81 | 26.87 | 7.95 | 6.20 | 106.20 | 7.88 |
| | | | 1.25 | 24.59 | 38.67 | 24.72 | 7.83 | 16.90 | 38.50 | 2.86 |

See **Appendix B** for more detail on physico-chemical data collected as part of invertebrates sampling collected using a YSI multi probe.

**Figure 9.1 uMlalazi Estuary mouth open to the sea (Photo: J Adams, 7 October 2022)**

## 9.2 MACROPHYTES

From the launch site downstream stringy filamentous green algae was abundant possibly indicating nutrient enrichment. This is a perfect site for long term monitoring of mangroves due to lack of pressures such as harvesting and cattle browsing. White mangrove and black mangrove were dominant with recruitment throughout the estuary. Stands of different age structures

indicating a regenerating forest was found in the lower, middle and upper reaches of the estuary. Mangroves were most extensive in the middle reaches where intertidal and floodplain habitat occurs. According to Taylor (2020) the mangrove extent is 40 ha. Mangroves did not occur in the estuary prior to the 1930's and artificial mouth breaching created suitable intertidal conditions for mangrove expansion. The estuary also has important salt marsh and reed and sedge habitats (**Figure 9.2 - 9.5**).

**Figure 9.2 Small black mangrove trees with seedlings and filamentous green algae among the white mangrove aerial roots at the uMlalazi Estuary (Photo: J Adams, 6 October 2022)**

**Figure 9.3 Exposed root system of black mangroves that line the uMlalazi Estuary water channel indicates some erosion (Photo: J Adams, 7 October 2022)**

## 9.3 SEDIMENT SAMPLING

Sediment samples were collected from 3 sites at the uMlalazi Estuary (See **Appendix A**). Site 1 was located adjacent to the estuary channel (28.95348°S; 31.77404°E), Site 2 was located within

the same area but further within the mangrove forest (28.95434°S; 31.77329°E), and Site 3 was located towards the landward edge where additional vegetation types were present (28.94592°S; 31.77752°E). The estuary was open at the time of sampling. Sites 1 and 2 were sampled on 5 October, and Site 3 was sampled on 06 October. At Site 1, four cores were sampled from mangroves (*Bruguiera gymnorrhiza* and *Avicennia marina*). The sediment was sandy at the surface, but then compact mud / clay along most of the core. No compaction was recorded. At Site 2, four cores were sampled from mangroves (*Bruguiera gymnorrhiza* and *Avicennia marina*). There were bare ground patches in between the stands of trees where the sediment was compact and cracked at the surface. The sediment was predominantly muddy with no compaction recorded. At Site 3, four cores were sampled each from salt marsh (*Triglochin* sp., *Salicornia tegetaria*, and *Sporobolus virginicus*), and reeds and sedges (*Phragmites australis*, *Schoenoplectus brachyceras*, and *Juncus kraussii*). There was open mudflat between the mangroves (*Avicennia marina*) and the reeds and sedges. The cores were muddy and clay-like with no compaction recorded. Sediment samples were not collected from the mangroves here as the compact sediment in the reeds and sedges damaged the corer, preventing further use for the remainder of the day.

## 9.4 INVERTEBRATES

All samples are yet to be analysed (**Figure 9.4** for site locations). Visible fauna included macrocrustaceans *Scylla serrata* (giant mud swimming crab) (**Figure 9.5**) and *Ashtoret lunaris* (moon crab). Penaeidae prawns, *Penaeus indicus* (Indian white prawn) and *P. monodon* (Giant tiger prawn) are using the system as a nursery area. Notable in the infauna samples thus far is the burrowing ocypodid crab, *Paratylodiplax blephariskios*. This small crab is endemic to the southeast coast of southern Africa where it forms an important component of the muddy estuaries (where it occurs). Twenty years ago, it was prolific in St Lucia but has not been noted there since then. Invertebrate bycatch from fish seines were retained for identification.


**Figure 9.4 Invertebrate fauna, sediment and physico-chemical stations at uMlalazi Estuary on 6/10/2022 (Photo: F MacKay)**

**Figure 9.5 Large female mud crab *Scylla serrata* caught as invertebrate bycatch in fishing seines, lower uMlalazi Estuary (Photo: F Mackay, 6 October 2022)**

## 9.5 FISH

Very high fish species diversity was observed at this estuary, with for example, 46 fish species recorded during our one-day visit. Previous studies recorded a total of 58 species in the estuary. The system represents a very important nursery area in the region. It will be very important to maintain its present baseflows (prevent mouth closure) and water quality (i.e. no low oxygen levels) to ensure functionality and ecosystem services. See **Appendix C** for a summary of fish species caught during the trip. A number of Illegal gillnets were found in system.

## 9.6 BIRDS

A fairly comprehensive waterbird count was done from the Arc inflatable. Quite high numbers of Palearctic waders, especially Common Sandpiper – reflecting the muddy substrate which this species prefers. A single Eurasian Curlew was also recorded. The count information will be compared with CWAC data for the site. Small roost of Swift Terns at the mouth. See **Appendix D** for a summary of birds species observed during the trip.

## 9.7 SUMMARY

- Mouth open.
- In a good condition, but some concern over water quality.
- Several oxygen-deprived zones noted (particularly in mid-lower reaches) in the bottom water column layer (<3% saturation).
- Upper reaches show increasing livestock influences (cattle/goats) and possible informal sand mining.
- Healthy mangroves and salt marsh habitat.
- Some macroalgal growth in the middle reaches. Very high species diversity, with for example 46 fish species recorded. Very important nursery area in the region.
- High numbers of Palearctic waders, especially Common Sandpiper – reflect the muddy substrate.

# 10 aMATIGULU/INYONI ESTUARY

## 10.1 WATER QUALITY

On Friday 7 October 2022 the aMatikulu Estuary was accessed from the Dokodweni beach site near the mouth. The sea was overtopping into the perched estuary (**Figure 10.1**). Shallow conditions limited phytoplankton and water quality sampling to the confluence (Site 3; **Figure 10.1**) of the aMatigulu and iNyoni systems. The lower and middle reaches were characterised by well-mixed brackish conditions (salinity 12–16), with fresher conditions (salinity *ca*. 3) observed at the confluence (**Table 10.1**).

**Table 10.1 *In situ* water quality observations aMatigulu/iNyoni Estuary (07 10 2022) (Mouth state - closed with overwash on high tide, low water levels in the estuary)**

| Station | Coordinates | Time Sampled | Depth | Salinity | Conduc-tivity (mS/cm) | Temp. (°C) | pH | NTU | DO (mg/l) | DO (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29°4'53.33"S; 31°38'41.87"E | 13h40 | 0 | 16.20 | 26.22 | 23.03 | 8.22 | 1.16 | 98.20 | 7.58 |
| | | | 0.5 | 18.49 | 29.82 | 23.04 | 8.22 | 1.32 | 97.30 | 7.52 |
| | | | 1.25 | 18.55 | 29.92 | 23.05 | 8.20 | 1.54 | 97.00 | 7.50 |
| 2 | 29° 5'38.74"S; 31°37'48.33"E | 13h15 | 0 | 12.78 | 21.28 | 22.78 | 8.28 | 2.24 | 98.20 | 7.84 |
| | | | 1 | 13.50 | 22.23 | 22.78 | 8.28 | 2.27 | 98.10 | 7.83 |
| 3 | 29°6'40.88"S; 31°37'2.68"E | 12h45 | 0 | 3.25 | 7.39 | 22.65 | 8.60 | 16.90 | 88.90 | 7.29 |
| | | | 0.5 | 3.45 | 7.69 | 22.65 | 8.60 | 20.20 | 87.70 | 7.21 |

See **Appendix B** for more detail on physico-chemical data collected as part of invertebrates sampling collected using a YSI multi probe.

**Figure 10.1 Mouth of aMatigulu/iNyoni Estuary overtopping from the sea (Photo: Fiona Mackay, 7 October 2022)**

## 10.2 MACROPHYTES

The lower reaches were characterized by sandy banks with little vegetation. Large *Casuarina* trees occurred downstream of the launch site and there was some erosion. The same filamentous green algae (*Chaetomorpha*?) as that found in the Mlalazi Estuary was abundant in the lower reaches. Some pondweed (*Stuckenia pectinata*) occurred as patches in the lower and upper reaches. The estuary was shallow up to the first bend with gill nets across the channel. Both the Nyoni and straight channel of the Matikulu to the N2 were chocked up with sediment with no boat

access. The confluence of the two systems is approximately 5 km from the mouth. Reeds, sedges and grassy banks characterized the north / east bank. The west / south banks were steep and colonized by the dune species *Scaevoli thunbergii.* Patches of saline grasses *Sporobolus virginicus* and *Paspalum vaginatum* occurred along the banks. The dominant sedge was *Schoenoplectus scirpioides* and reed *Phragmites australis*.

## 10.3 SEDIMENT SAMPLING

Sediment samples were collected from one site at the aMatigulu/iNyoni Estuary (See **Appendix A**). Site 1 was located adjacent to the estuary channel (29.10299°S; 31.61998°E) on the northern bank. This was the only accessible site for sampling the representative vegetation. The upper reaches could not be accessed by boat due to low water levels and the formation of a sand bank at the confluence point. Closer to the mouth conditions were predominantly sandy with very limited adjacent habitat. The estuary was sampled on 7 October 2022. At Site 1, four cores were sampled from reeds and sedges (*Phragmites australis* and *Schoenoplectus scirpioides*). The site had evidence of disturbance by cattle. The sediment was predominantly sandy, with an organic layer at the surface that had high water content, and then anoxic conditions down the core. No compaction was recorded for the cores.

## 10.4 INVERTEBRATES

All samples are yet to be analysed (**Figure 10.2** for site locations). Visible fauna included an exceptionally high density of alien invasive *Tarebia granifera* snails from the mid-reaches of the system until where boat passage was no longer possible due to the shallow depths (upstream of the confluence of the iNyoni system). The lower estuary subtidal sediments were covered with extensive growth of an unidentified filamentous algae (**Figure 10.3**). Until further laboratory analysis, it is not known how this influences the infauna communities. High densities of *Kraussillichirus kraussi w*ere noted in all sandy, shallow subtidal sediments where algae were absent. Invertebrate bycatch from fish seines were retained for identification.


**Figure 10.2 Invertebrate fauna, sediment and physico-chemical stations at aMatigulu/iNyoni Estuary on 7/10/2022 (Photo: F MacKay)**

**Figure 10.3 Filamentous algae growth on large areas of mid-lower subtidal sediments of the aMatigulu/iNyoni Estuary (Photo: B McKelvey, 7 October 2022)**

## 10.5 FISH

Previous studies recorded a total of 54 species in the estuary as opposed to 15 in our 1-day visit. This is possibly a function of low water levels following a recent breaching of the estuary. Sampling was also restricted to the low half of the system with the upper reaches inaccessible due to shallow water and macrophyte growth. See **Appendix C** for a summary of fish species caught during the trip. Several Illegal gillnets were observed in the system.

## 10.6 BIRDS

Even higher number of Palearctic waders than at uMlalazi, including Bar-tailed Godwit. Large numbers of White-fronted Plovers and Sanderlings reflecting sandy nature of substrate. Large numbers of waterfowl (ducks and geese) in upper reaches, reflecting large expanses of submerged vegetation highly favoured as a food source. Count information will be compared with CWAC data for the site – counts seemed very high on the day. See **Appendix D** for a summary of birds species observed during the trip.

## 10.7 SUMMARY

- System was closed with overwash from the sea at low water levels.
- Estuary in relatively good condition, but a possible decline in condition.
- Housing developments expanding in lower reaches (iNgonyama Trust land), evidence of increased nutrification (lower 3/4 km of sediment surface covered with filamentous algae.
- Observed significant areas of submerged macrophyte and filamentous algae.
- Pending water quality results, but blooms can be developing when water level is low after a mouth breaching event.
- Benthic inverts very high numbers of invasive snail *Terebia granifera*.

- Previous studies recorded a total of 54 fish species in the estuary as opposed to 15 during this field trip.
- High numbers of Palearctic waders, including Bar-tailed Godwit. Large numbers of White-fronted Plovers and Sanderlings reflecting sandy nature of substrate. Large numbers of waterfowl (ducks and geese) in upper reaches, reflecting large expanses of submerged vegetation highly favoured as a food source.

# 11 ACKNOWLEDGEMENTS

Riaan Weitz and Anesu Machite are thanked for their assistance in the field. Dr Taryn Riddin completed the vegetation mapping and Shulamy Ntsoeu, the sediment analysis in the laboratory. In addition, the full DFFE team is thanked for their assistance in sampling fish and assisting with logistics (boats and nets).
DWS is thanked for their assistance with organising access and assistance in the field.

(Photo: Riaan Weitz)

# 12 REFERENCES

Bate, G.C. and Heelas. 1975. Studies on the nitrate nutrition of two indigenous Rhodesian grasses. *J. Appl. Ecol.* ***12*** 941-952.

Nusch, E.A. 1980. Comparison of Different Methods for Chlorophyll and Phaeopigment Determination. Archiv für Hydrobiologie-Beiheft Ergebnisse der Limnologie **14**: 14-36.

Parsons, T.R., Maita, Y. and Lalli, C.M. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis.* Pergamon Press, New York. 173 pp.

Taylor R. 2020. Mangrove colonisation of the Mlalazi Estuary, South Africa: a response to artificial breaching. *African Journal of Aquatic Science* **45**: 109-120.

Taylor R. 2016. Dynamics of the macrophyte vegetation of the Mgobezeleni floodplain and estuary. *South African Journal of Botany* **107**: 170-178.

# 13 APPENDIX A: SEDIMENT CORES FOR CARBON ANALYSIS

Kosi Estuary Site 1 - Mangroves

Kosi Estuary Site 1 – Reeds and Sedges

Kosi Estuary Site 1 – Salt marsh

Kosi Estuary Site 2 - Mangroves

Kosi Estuary Site 2 – Reeds and Sedges

Kosi Estuary Site 3 - Mangroves

Kosi Estuary Site 3 – Reeds and Sedges

uMgobezeleni Estuary Site 1 – Swamp forest

uMgobezeleni Estuary Site 1 – Reeds and sedges / mosaic + dead mangrove

uMgobezeleni Estuary Site 2 – Swamp forest

iNhlabane Estuary Site 1 – Reeds and sedges

iSiyaya Estuary Site 1 – Reeds and sedges

uMlalazi Estuary Site 1 – Mangroves

uMlalazi Estuary Site 2 – Mangroves

uMlalazi Estuary Site 3 – Salt marsh

uMlalazi Estuary Site 3 – Reeds and sedges

aMatigulu / iNyoni Estuary Site 1 – Reeds and sedges

# 14 APPENDIX B: PHYSICO-CHEMICAL DATA COLLECTED AS PART OF INVERTEBRATES SAMPLING (ORI) COLLECTED WITH YSI MULTI PROBE

## Kosi 29 Sep – 1 Oct 2022

| Date | Site ID | Longitude (DD) | Latitude (DD) | Time | Water column position[1] | Temp. | DO (mg/l) | DO (%) | Sp.con (µS/cm) | pH | Salinity (ppt) | TDS (mg/l) | Tur-bidity (NTU) | Depth (m) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29/09/2022 | KB-NHL4 | 32.825403 | -26.961751 | 11:19 | T | 26.350 | 8.70 | 109.2 | 9809.0 | 8.31 | 5.51 | 6375.780 | 0.00 | 0.000 | 154.6 |
| | | | | 11:20 | B | 25.302 | 8.77 | 110.4 | 9810.0 | 8.31 | 5.51 | 6377.140 | 0.00 | 1.100 | 156.7 |
| | | | | 11:21 | M | 25.351 | 8.71 | 109.4 | 9813.0 | 8.32 | 5.51 | 6377.670 | 0.00 | 0.610 | 157.2 |
| | KB-NHL3 | 32.807704 | -26.985083 | 12:09 | T | 26.447 | 7.84 | 100.6 | 9868.0 | 8.32 | 5.54 | 6414.250 | 0.00 | 0.000 | 160.7 |
| | | | | 12:10 | B | 26.447 | 7.86 | 100.7 | 9868.0 | 8.33 | 5.54 | 6414.280 | 0.00 | 0.750 | 160.9 |
| | | | | 12:11 | M | 26.464 | 7.84 | 100.5 | 9863.0 | 8.33 | 5.54 | 6414.000 | 0.00 | 0.410 | 161.1 |
| | KB-NHL2 | 32.845680 | -27.004491 | 14:15 | T | 24.986 | 9.03 | 112.9 | 10319.0 | 8.25 | 5.82 | 6708.170 | 0.00 | 0.000 | 167.7 |
| | | | | | B | 24.990 | 9.02 | 112.9 | 10320.0 | 8.27 | 5.82 | 6707.980 | 0.00 | 1.590 | 168.4 |
| | | | | | M | 24.986 | 9.04 | 113.0 | 10321.0 | 8.27 | 5.82 | 6708.140 | 0.00 | 0.810 | 169.1 |
| 30/09/2022 | KB-NHL1 | 32.852967 | -26.956540 | 16:07 | T | 25.898 | 8.86 | 112.6 | 10289.0 | 8.38 | 5.80 | 6687.290 | 0.00 | 0.000 | 154.6 |
| | | | | | B | 25.876 | 8.89 | 112.9 | 10291.0 | 8.40 | 5.80 | 6689.360 | 0.00 | 0.562 | 153.5 |
| | KB-MAK1 | 32.859054 | -26.924752 | 11:37 | T | 26.049 | 6.57 | 89.7 | 28430.0 | 8.18 | 17.48 | 18466.610 | 0.00 | 0.000 | 153.4 |
| | | | | | B | 26.065 | 6.60 | 89.6 | 28583.0 | 8.09 | 17.63 | 18595.710 | 1.14 | 0.680 | 154.4 |
| | | | | | M | 25.989 | 6.47 | 88.1 | 28584.0 | 8.03 | 17.58 | 18673.440 | 0.00 | 0.305 | 155.3 |
| | KB-MAK2 | 32.864602 | -26.928865 | 11:59 | T | 26.453 | 6.16 | 84.2 | 27980.0 | 7.99 | 17.18 | 18187.420 | 0.00 | 0.000 | 160.9 |
| | | | | | B | 26.630 | 7.29 | 99.7 | 28906.0 | 8.06 | 17.79 | 18766.200 | 1.81 | 1.198 | 160.1 |
| | | | | | M | 26.475 | 6.54 | 89.9 | 28224.0 | 8.00 | 17.38 | 18346.440 | 0.18 | 0.499 | 160.2 |
| | KB-MAK3 | 32.861957 | -26.933478 | 13:15 | T | 27.331 | 7.68 | 105.6 | 25313.0 | 8.21 | 15.38 | 16454.320 | 0.00 | 0.000 | 156.0 |
| | | | | | B | 27.343 | 7.75 | 106.6 | 25307.0 | 8.16 | 15.37 | 16445.320 | 0.70 | 0.584 | 157.1 |
| | KB-MPU1 | 32.860923 | -26.937710 | 14:13 | T | 26.769 | 8.26 | 109.8 | 18931.0 | 8.18 | 11.20 | 12304.730 | 0.00 | 0.000 | 155.5 |
| | | | | | B | 26.769 | 8.30 | 110.3 | 18930.0 | 8.17 | 11.20 | 12304.750 | 0.00 | 0.606 | 157.1 |
| | KB-MPU2 | 32.857456 | -26.948065 | 14:36 | T | 26.447 | 7.84 | 103.6 | 18798.0 | 8.13 | 11.12 | 12217.350 | 0.00 | 0.000 | 162.1 |
| | | | | | B | 26.474 | 7.89 | 104.4 | 18798.0 | 8.13 | 11.12 | 12218.940 | 0.00 | 0.758 | 162.2 |
| | KB-MPU3 | 32.847472 | -26.945701 | 14:58 | T | 26.808 | 6.12 | 81.4 | 18241.0 | 7.57 | 10.75 | 11856.820 | 0.00 | 0.000 | 164.3 |
| | | | | | B | 26.812 | 6.09 | 80.9 | 18244.0 | 7.58 | 10.76 | 11860.760 | 0.00 | 0.726 | 163.8 |
| | KB-CONFL4 | 32.845611 | -26.950278 | 10:20 | T | 25.449 | 4.67 | 60.6 | 17157.0 | 7.28 | 10.09 | 11157.980 | 0.01 | 0.000 | 165.8 |
| | | | | | B | 25.408 | 4.53 | 58.5 | 17232.0 | 7.26 | 10.13 | 11201.850 | 0.95 | 1.169 | 163.8 |
| | | | | | M | 25.424 | 4.54 | 58.7 | 17235.0 | 7.26 | 10.13 | 11203.650 | 0.32 | 0.560 | 163.1 |

| Date | Site ID | Longitude (DD) | Latitude (DD) | Time | Water column position[1] | Temp. | DO (mg/l) | DO (%) | Sp.con (µS/cm) | pH | Salinity (ppt) | TDS (mg/l) | Tur-bidity (NTU) | Depth (m) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01/10/2022 | KB-CONFL1 | 32.856459 | -26.901706 | 09:28 | T | 25.600 | 6.04 | 80.5 | 25241.0 | 7.56 | 14.51 | 15900.000 | 0.33 | 0.000 | 166.8 |
| | | | | 09:30 | B | 26.252 | 6.07 | 82.6 | 27962.0 | 7.69 | 17.25 | 18236.301 | 0.34 | 0.478 | 166.8 |
| | KB-EST | 32.871075 | -26.896281 | 11:22 | M | 26.821 | 6.67 | 97.9 | 44000.0 | 7.97 | 28.28 | 28596.996 | 0.46 | 0.500 | 161.5 |
| | KB-Mouth | 32.878433 | -26.894297 | 13:05 | T | 27.486 | 7.49 | 111.0 | 43735.0 | 8.14 | 28.12 | 28422.003 | 0.05 | 0.000 | 157.9 |
| | | | | 13:06 | B | 27.523 | 7.52 | 111.4 | 43701.0 | 8.12 | 28.08 | 28389.257 | 0.12 | 1.200 | 157.4 |
| | | | | 13:07 | M | 27.537 | 7.53 | 111.6 | 43616.0 | 8.12 | 28.02 | 28341.872 | 0.05 | 0.600 | 157.6 |
| | KB-Lake Zilonde | 32.867386 | -26.873286 | 16:33 | M | 26.113 | 5.88 | 72.8 | 243.3 | 7.02 | 0.11 | 158.452 | 3.31 | 0.300 | 126.6 |

Water column position: T: Top, M: Middle, B: bottom

## uMgobezeleni 03/10/2022

| Site ID | Longitude (DD) | Latitude (DD) | Time | Water column position | Temp-erature (˚C) | DO (mg/l) | DO (%) | Sp.con (µS/cm) | pH | Salinity (ppt) | TDS (mg/l) | Turbidity (NTU) | Depth (m) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MGO-Mouth | 32.678541 | -27.540403 | 09:45 | T | 24.281 | 5.11 | 61.1 | 988.0 | 7.00 | 0.49 | 644.760 | 0.80 | 0.000 | 199.2 |
| | | | | B | 24.385 | 2.81 | 35.0 | 8730.0 | 6.79 | 4.94 | 5726.590 | 4.49 | 0.826 | 212.6 |
| MGO-Mid1 | 32.677854 | -27.540722 | 10:34 | T | 24.871 | 5.09 | 61.9 | 1410.0 | 7.08 | 0.70 | 917.016 | 2.20 | 0.000 | 175.7 |
| | | | | B | 24.574 | 4.33 | 52.1 | 1708.0 | 7.00 | 0.87 | 111.202 | 7.78 | 0.887 | 174.3 |
| MGO-Mid2 | 32.677028 | -27.541263 | 10:56 | T | 24.206 | 2.98 | 35.4 | 546.0 | 6.97 | 0.28 | 361.780 | 0.96 | 0.000 | 167.8 |
| | | | | B | 23.821 | 2.18 | 26.4 | 2306.0 | 6.70 | 0.99 | 1419.850 | 3.27 | 0.960 | 185.5 |
| | | | | M | 24.080 | 2.65 | 30.2 | 619.0 | 6.90 | 0.29 | 391.240 | 0.85 | 0.500 | 155.5 |
| MGO-Head | 32.676472 | -27.541254 | 11:43 | T | 25.223 | 2.67 | 32.6 | 488.2 | 6.94 | 0.23 | 315.091 | 0.47 | 0.000 | 161.1 |
| | | | | B | 24.440 | 0.87 | 12.1 | 358.4 | 7.12 | 20.56 | 22710.785 | 5.31 | 1.500 | 185.4 |
| | | | | M | 24.009 | 2.08 | 24.8 | 1308.0 | 7.03 | 0.62 | 820.653 | 1.12 | 0.700 | 149.2 |
| Waypoint 229 | 32.652864 | -27.531410 | 15:29 | T | 27.089 | 8.25 | 103.7 | 368.1 | 7.97 | 0.17 | 239.538 | 5.27 | 0.000 | 145.5 |
| | | | | B | 27.077 | 7.86 | 98.8 | 368.6 | 7.43 | 0.18 | 239.970 | 5.90 | 1.914 | 39,2? |
| | | | | M | 27.010 | 8.21 | 103.3 | 368.2 | 7.95 | 0.17 | 239.335 | 5.99 | 1.177 | 53.8 |
| MGO-Lake1 | 32.664328 | -27.528091 | 15:42 | T | 26.601 | 8.85 | 110.2 | 370.0 | 8.29 | 0.18 | 240.512 | 4.32 | 0.000 | 84.3 |
| | | | | B | 26.513 | 8.71 | 109.1 | 369.8 | 8.21 | 0.18 | 240.408 | 5.81 | 1.225 | 89.5 |
| | | | | M | 26.509 | 8.78 | 108.9 | 369.9 | 8.26 | 0.18 | 240.480 | 4.68 | 0.663 | 92.4 |
| MGO-Lake2 | 32.657193 | -27.528782 | 16:20 | T | 26.862 | 8.06 | 100.8 | 366.6 | 7.78 | 0.17 | 238.307 | 4.20 | 0.000 | 113.4 |
| | | | | B | 26.580 | 7.35 | 92.7 | 365.9 | 7.57 | 0.17 | 237.830 | 13.38 | 2.300 | 95.1 |
| | | | | M | 26.785 | 7.77 | 97.2 | 366.2 | 7.66 | 0.17 | 238.020 | 4.97 | 0.806 | 106.9 |

## iNhlabane 04/10/2022

| Site ID | Longitude (DD) | Latitude (DD) | Time | Water column position | Temp-erature (˚C) | DO (mg/l) | DO (%) | Sp.con (µS/cm) | pH | Salinity (ppt) | TDS (mg/l) | Turbidity (NTU) | Depth (m) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NLB-Mouth | 32.258322 | -28.659127 | 16:24 | T | 23.183 | 3.40 | 41.4 | 1136.0 | 7.58 | 0.56 | 738.087 | 1.28 | 0.000 | 201.9 |
| | | | | B | 23.173 | 2.99 | 35.1 | 1136.0 | 7.57 | 0.56 | 738.108 | 3.50 | 0.500 | 198.1 |
| NLB-Head | 32.269152 | -28.641466 | 17:37 | T | 23.133 | 4.21 | 49.5 | 1120.0 | 7.51 | 0.56 | 728.080 | 1.09 | 0.000 | 192.5 |
| | | | | B | 23.034 | 2.71 | 32.2 | 1112.0 | 7.45 | 0.55 | 722.686 | 8.06 | 2.053 | 174.3 |
| | | | | M | 23.125 | 3.80 | 44.3 | 1119.0 | 7.53 | 0.56 | 727.583 | 1.20 | 1.290 | 170.6 |

## iSiyaya 05/10/2022

| Site ID | Longitude (DD) | Latitude (DD) | Time | Water column position | Temp-erature (˚C) | DO (mg/l) | DO (%) | Sp.con (µS/cm) | pH | Salinity (ppt) | TDS (mg/l) | Turbidity (NTU) | Depth (m) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SYY-Mouth | 31.768025 | -28.963187 | 09:50 | M | 23.394 | 11.58 | 135.0 | 4485.0 | 8.80 | 2.39 | 2915.560 | 8.15 | 0.200 | 176.8 |
| SYY-Mid1 | 31.765254 | -28.964063 | 11:15 | M | 26.653 | 8.26 | 103.7 | 1628.0 | 7.77 | 0.82 | 1058.480 | 5.33 | 0.150 | 172.7 |
| Waypoint 236 | 31.764976 | -28.964287 | 11:35 | T | 25.494 | 5.66 | 69.2 | 1618.0 | 7.40 | 0.81 | 1052.249 | 10.41 | 0.000 | 178.3 |
| | | | | B | 25.246 | 5.30 | 64.9 | 1617.0 | 7.27 | 0.81 | 1050.248 | 14.22 | 0.829 | 178.6 |
| SYY-Mid2 | 31.764458 | -28.964462 | 11:59 | T | 23.672 | 3.20 | 38.0 | 1599.0 | 7.10 | 0.80 | 1039.992 | 9.60 | 0.000 | 169.5 |
| | | | | B | 23.470 | 2.86 | 33.8 | 1597.0 | 7.05 | 0.80 | 1038.252 | 11.20 | 0.800 | 166.0 |
| SYY-Mid3 | 31.754984 | -28.969595 | 13:52 | T | 23.341 | 4.84 | 57.7 | 637.0 | 7.29 | 0.31 | 414.335 | 37.62 | 0.000 | 167.7 |
| | | | | B | 21.764 | 2.59 | 29.6 | 646.0 | 6.76 | 0.31 | 419.972 | 47.25 | 1.593 | 88.0 |
| | | | | M | 22.005 | 3.17 | 36.1 | 620.0 | 6.76 | 0.30 | 402.368 | 47.77 | 0.734 | 103.6 |

## uMlalazi 06/10/2022

| Site ID | Longitude (DD) | Latitude (DD) | Time | Water column position | Temp-erature (˚C) | DO (mg/l) | DO (%) | Sp.con (µS/cm) | pH | Salinity (ppt) | TDS (mg/l) | Turbidity (NTU) | Depth (m) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S2a | 31.775900 | -28.954518 | 10:25 | T | 24.840 | 7.48 | 103.0 | 36390.0 | 7.89 | 22.97 | 22361.212 | 16.27 | 0.000 | 196.0 |
| | | | | B | 23.817 | 0.61 | 8.9 | 47715.0 | 7.39 | 31.06 | 30980.121 | 57.08 | 2.076 | 208.4 |
| | | | | M | 24.371 | 6.99 | 94.9 | 30077.0 | 7.83 | 23.49 | 24102.998 | 15.91 | 1.007 | 198.0 |
| S2 | 31.783650 | -28.951166 | 10:58 | T | 24.941 | 7.97 | 110.1 | 37097.0 | 8.05 | 23.48 | 24115.957 | 10.74 | 0.000 | 187.1 |
| | | | | B | 24.000 | 6.93 | 95.1 | 39779.0 | 7.98 | 25.43 | 25875.123 | 16.77 | 1.100 | 189.4 |
| | | | | M | 24.793 | 7.88 | 108.3 | 37223.0 | 8.00 | 23.56 | 24190.001 | 11.71 | 0.650 | 188.0 |
| S1a | 31.794985 | -28.948575 | 12:08 | T | 25.135 | 8.01 | 113.5 | 42495.0 | 8.11 | 27.32 | 27621.148 | 9.11 | 0.000 | 191.7 |
| | | | | B | 24.683 | 7.62 | 107.9 | 44306.0 | 8.06 | 28.29 | 28696.495 | 11.05 | 1.096 | 179.3 |
| | | | | M | 24.982 | 7.98 | 112.9 | 43523.0 | 8.08 | 28.03 | 29321.254 | 9.27 | 0.601 | 181.4 |
| S1 | 31.807617 | -28.944187 | 12:51 | T | 23.442 | 7.27 | 104.7 | 53221.0 | 8.12 | 35.16 | 34595.673 | 21.09 | 0.000 | 190.5 |
| | | | | B | 23.442 | 7.26 | 104.4 | 53226.0 | 8.09 | 35.15 | 34591.927 | 34.24 | 1.386 | 188.3 |
| | | | | M | 23.426 | 7.28 | 104.7 | 53243.0 | 8.09 | 35.17 | 34608.341 | 17.78 | 0.606 | 187.7 |
| S4a | 31.755368 | -28.930136 | 14:37 | T | 27.144 | 7.54 | 100.7 | 18275.0 | 7.73 | 10.78 | 11880.457 | 2.87 | 0.000 | 188.0 |
| | | | | B | 27.674 | 3.01 | 43.7 | 29643.0 | 7.24 | 18.22 | 19241.418 | 2.57 | 1.699 | 194.0 |
| | | | | M | 27.209 | 7.34 | 98.0 | 18537.0 | 7.76 | 10.93 | 12034.363 | 3.39 | 0.685 | 183.5 |
| Waypoint 239 | 31.749866 | -28.919495 | 15:30 | T | 28.307 | 7.80 | 104.4 | 13127.0 | 8.61 | 7.32 | 8467.001 | 4.05 | 0.000 | 179.9 |
| | | | | B | 28.933 | 5.58 | 79.0 | 22120.0 | 7.27 | 13.25 | 14529.730 | 1.97 | 0.860 | 168.9 |
| | | | | M | 28.401 | 7.51 | 101.6 | 15071.0 | 7.63 | 8.50 | 9557.341 | 3.08 | 0.400 | 171.8 |
| Waypoint 240 | 31.743704 | -28.919421 | 15:45 | T | 27.585 | 5.94 | 76.9 | 7319.0 | 7.38 | 4.00 | 4761.640 | 6.25 | 0.000 | 165.3 |
| | | | | B | 28.248 | 3.22 | 44.6 | 18693.0 | 6.96 | 11.07 | 12179.406 | 2.46 | 1.399 | 175.8 |
| | | | | M | 28.204 | 4.69 | 62.9 | 14398.0 | 7.13 | 8.54 | 9488.216 | 4.80 | 0.568 | 165.8 |
| S3a | 31.770155 | -28.932533 | 16:26 | T | 27.232 | 8.50 | 118.4 | 29688.0 | 7.94 | 18.36 | 19390.464 | 6.37 | 0.000 | 184.5 |
| | | | | B | 25.665 | 6.97 | 95.6 | 34231.0 | 7.84 | 21.52 | 22276.899 | 15.88 | 1.285 | 185.5 |
| | | | | M | 27.147 | 8.45 | 117.8 | 30649.0 | 7.96 | 19.24 | 22058.321 | 6.57 | 0.683 | 182.9 |
| S3 | 31.779057 | -28.935512 | 17:09 | T | 26.042 | 7.84 | 108.5 | 33028.0 | 7.91 | 20.63 | 21469.717 | 10.99 | 0.000 | 183.7 |
| | | | | B | 25.270 | 1.52 | 22.0 | 36677.0 | 7.47 | 23.41 | 24018.363 | 35.38 | 1.810 | 183.6 |
| | | | | M | 25.983 | 7.45 | 103.0 | 33118.0 | 7.90 | 20.65 | 21504.893 | 15.53 | 0.939 | 176.8 |

## aMatigulu/iNyoni 7/10/2022

| Site ID | Longitude (DD) | Latitude (DD) | Time | Water column position | Temp-erature (˚C) | DO (mg/l) | DO (%) | Sp.con (µS/cm) | pH | Salinity (ppt) | TDS (mg/l) | Turbidity (NTU) | Depth (m) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAG-Mouth22 | 31.657275 | -29.073255 | 11:45 | T | 22.263 | 7.71 | 101.1 | 35745.0 | 7.95 | 22.57 | 23229.748 | 0.62 | 0.000 | 221.3 |
| | | | | B | 22.235 | 7.94 | 104.0 | 36567.0 | 7.97 | 23.05 | 23740.804 | 0.70 | 0.964 | 216.5 |
| | | | | M | 22.265 | 7.72 | 101.2 | 35703.0 | 7.95 | 22.57 | 23210.374 | 0.75 | 0.522 | 215.1 |
| MAG1 | 31.643396 | -29.082663 | 12:21 | T | 22.891 | 7.52 | 97.3 | 29825.0 | 7.94 | 18.48 | 19383.000 | 1.36 | 0.000 | 214.1 |
| | | | | B | 23.145 | 6.93 | 92.0 | 34915.0 | 7.94 | 21.99 | 22704.999 | 1.16 | 1.923 | 213.0 |
| | | | | M | 22.889 | 7.50 | 97.0 | 29878.0 | 7.96 | 18.52 | 19421.203 | 1.54 | 0.972 | 210.0 |
| MAG2 | 31.629245 | -29.094280 | 13:05 | T | 22.630 | 7.84 | 98.2 | 22613.0 | 7.95 | 13.66 | 14691.958 | 2.24 | 0.000 | 205.0 |
| | | | | B | 22.638 | 7.83 | 98.1 | 22576.0 | 7.95 | 13.63 | 14673.355 | 2.27 | 1.023 | 203.5 |
| | | | | M | 22.699 | 7.88 | 98.9 | 22525.0 | 7.96 | 13.54 | 14618.532 | 2.16 | 0.583 | 202.3 |
| MAG3 | 31.620229 | -29.106753 | 13:51 | T | 22.274 | 8.42 | 100.6 | 11746.0 | 8.17 | 6.71 | 7636.704 | 8.20 | 0.000 | 193.1 |
| | | | | B | 22.283 | 8.42 | 100.7 | 11763.0 | 8.19 | 6.73 | 7648.831 | 12.30 | 1.272 | 193.6 |
| | | | | M | 22.277 | 8.43 | 100.8 | 11755.0 | 8.20 | 6.72 | 7640.633 | 7.91 | 0.534 | 193.8 |
| MAG4 | 31.613837 | -29.112226 | 14:50 | T | 22.899 | 7.26 | 85.9 | 5112.0 | 8.48 | 2.73 | 3313.320 | 18.80 | 0.000 | 190.8 |
| | | | | B | 22.942 | 7.16 | 84.7 | 5156.00 | 8.49 | 2.78 | 3352.200 | 36.70 | 0.523 | 190.7 |

# 15 APPENDIX C: SUMMARY OF FISH SPECIES CAUGHT ON THE FIELD VISIT

## Fish species list

| Scientific name | Mlalazi | Matigulu | iSiyaya | Nhlabane | Mgobezeleni | Kosi | Occurrence |
|---|---|---|---|---|---|---|---|
| *Abudefduf sordidus* | | | | | | 1 | 1 |
| *Acanthopagrus vagus* | 1 | | 1 | | 1 | 1 | 4 |
| *Ambassis gymnocephalus* | 1 | | | | | 1 | 2 |
| *Ambassis natalensis* | 1 | | | | 1 | 1 | 3 |
| *Ambassis ambassis* | 1 | 1 | 1 | | 1 | 1 | 5 |
| *Anguilla mossambica (?)* | | | | | | 1 | 1 |
| *Argyrosomus japonicus* | 1 | | | | | | 1 |
| *Arothron immaculatus* | 1 | | | | | | 1 |
| *Atherinomorus lacunosus* | | | | | | 1 | 1 |
| *Awaous aeneofuscus* | 1 | | 1 | | | | 2 |
| *Bothus pantherinus* | 1 | 1 | | | | | 2 |
| *Caranx papuensis* | 1 | | | | 1 | | 2 |
| *Caranx sexfasciatus* | | | | | | 1 | 1 |
| *Chanos chanos* | | | | | | 1 | 1 |
| *Clarias gariepinus* | | | | | | 1 | 1 |
| *Croilia mossambica* | | | | | | 1 | 1 |
| *Drepane longimana* | 1 | | | | | | 1 |
| *Diplodus sargus* | | 1 | | | | | 1 |
| *Eleotris fusca* | 1 | | | | | | 1 |
| *Enteromius viviparus* | | | 1 | | 1 | | 2 |
| *Favonigobius reichei* | | | | | | 1 | 1 |
| *Gerres acinaces* | | | | | | 1 | 1 |
| *Gerres filamentosus* | 1 | | | | | 1 | 2 |
| *Gerres methueni* | 1 | | | | 1 | 1 | 3 |
| *Gilchristella aestuaria* | 1 | | | | | | 1 |
| *Glossogobius biocellatus* | 1 | | | | | | 1 |
| *Glossogobius callidus* | 1 | | 1 | | | | 2 |
| *Glossogobius giuris* | 1 | | | | | 1 | 2 |
| *Herclotichthyes quadrimaculatus* | | | | | | 1 | 1 |
| *Hilsa kelee* | 1 | | | | | | 1 |
| *Lacustricola myaposea* | | | | 1 | 1 | | 2 |
| *Leiognathus equula* | 1 | 1 | | | | | 2 |
| *Chelon alata* | | | | | 1 | | 1 |
| *Chelon dumerilii / persicus* | 1 | | | | | | 1 |
| *Chelon macrolepis* | 1 | 1 | | | 1 | | 3 |
| *Lutjanus argentimaculatus* | | | | | | 1 | 1 |
| *Lutjanus fulviflamma* | | | | | | 1 | 1 |
| *Micropterus punctulatus* | | | | | 1 | | 1 |
| *Monodactylus argenteus* | 1 | | 1 | | | 1 | 3 |
| *Mugil cephalus* | 1 | 1 | | | 1 | | 3 |
| *Pseudomyxus capensis* | 1 | 1 | 1 | | 1 | 1 | 5 |
| *Oligolepis acutipennis* | 1 | | | | | | 1 |
| *Oligolepis keiensis* | 1 | | | | | | 1 |
| *Oreochromis mossambicus* | | | 1 | | | 1 | 2 |
| *Platycephalus indicus* | 1 | | | | | | 1 |
| *Pomadasys commersonnii* | 1 | 1 | | | 1 | | 3 |
| *Pomadasys kaakan* | 1 | | | | | | 1 |
| *Pomadasys olivaceum* | 1 | | | | | | 1 |
| *Pomatomus saltatrix* | 1 | | | | | | 1 |
| *Pseudocrenilabrus philander* | | | 1 | 1 | | | 2 |
| *Pseudorhombus arsius* | | 1 | | | | | 1 |
| *Rhabdosargus holubi* | 1 | 1 | 1 | | | | 3 |

| Scientific name | Mlalazi | Matigulu | iSiyaya | Nhlabane | Mgobezeleni | Kosi | Occurrence |
|---|---|---|---|---|---|---|---|
| *Rhabdosargus thorpei* | 1 | 1 | | | | | 2 |
| *Rhabdosargus sarba* | 1 | | | | | | 1 |
| *Scomberoides lysan* | 1 | | | | | | 1 |
| *Silhouettea sibayi* | | 1 | | | | 1 | 2 |
| *Sillago sihama* | 1 | 1 | | | | | 2 |
| *Solea turbynei* | 1 | | | | | | 1 |
| *Sphyraena jello* | 1 | | | | | | 1 |
| *Stolephorus holodon* | 1 | | | | | | 1 |
| *Stolephorus spp.* | 1 | | | | | | 1 |
| *Syngnathus sp.* | 1 | | | | | | 1 |
| *Terapon jarbua* | | 1 | | | 1 | 1 | 3 |
| *Thryssa setirostris* | 1 | | | | | | 1 |
| *Thryssa vitrirostris* | 1 | | | | | 1 | 2 |
| *Coptodon rendalli* | 1 | | 1 | | | | 2 |
| *Tilapia sparrmanii* | | | | 1 | 1 | | 2 |
| *Osteomugil cunnesius* | 1 | 1 | 1 | | 1 | | 4 |
| *Osteomugil robustus* | 1 | | 1 | | 1 | | 3 |
| *Crenimugil seheli* | | | | | 1 | | 1 |
| **Total taxa** | **46** | **15** | **13** | **3** | **18** | **25** | **70** |
| **Total historical** | **58** | **54** | **18** | | **14** | **18** | **85** |

# 16 APPENDIX C: SUMMARY OF BIRD COUNTS

Details of waterbirds recorded at iSiyaya estuary on 5 October 2022.

| Species primary name | Species tertiary name | ADU ID | Date | Time | Latitude | Longitude | Notes | Count | Altitude |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10/5/2022 | 9:50:33 | -28.96337 | 31.7671 | Start count | | 1 |
| African Pied Wagtail | *Motacilla aguimp* | 685 | 10/5/2022 | 9:50:41 | -28.96337 | 31.7671 | | 2 | 1 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/5/2022 | 9:57:38 | -28.96325 | 31.76773 | | 1 | 1 |
| Cape Wagtail | *Motacilla capensis* | 686 | 10/5/2022 | 10:01:58 | -28.96334 | 31.76674 | | 1 | 2 |
| African Fish Eagle | *Haliaeetus vocifer* | 149 | 10/5/2022 | 10:02:13 | -28.96334 | 31.76674 | | 1 | 2 |
| Three-banded Plover | *Charadrius tricollaris* | 238 | 10/5/2022 | 10:05:06 | -28.96367 | 31.76598 | | 1 | 4 |
| Intermediate Egret | *Ardea intermedia* | 60 | 10/5/2022 | 10:23:13 | -28.96566 | 31.7634 | | 1 | 6 |
| Cape Wagtail | *Motacilla capensis* | 686 | 10/5/2022 | 10:27:09 | -28.96609 | 31.76283 | | 1 | 6 |
| Palm-nut Vulture | *Gypohierax angolensis* | 112 | 10/5/2022 | 10:34:15 | -28.96612 | 31.76185 | | 1 | 4 |
| Woolly-necked Stork | *Ciconia episcopus* | 77 | 10/5/2022 | 10:54:58 | -28.967 | 31.75943 | | 1 | 3 |
| | | 0 | 10/5/2022 | 14:31:46 | -28.96865 | 31.75425 | End count | | 16 |

Details of waterbirds recorded at uMlalazi Estuary on 6 October 2022.

| Species primary name | Species tertiary name | ADU ID | Date | Time | Latitude | Longitude | Notes | Count | Altitude |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10/6/2022 | 10:59:28 | -28.95195 | 31.77574 | Start count | | 3 |
| White-breasted Cormorant | *Phalacrocorax lucidus* | 47 | 10/6/2022 | 11:04:29 | -28.95439 | 31.77972 | | 1 | 3 |
| Eurasian Whimbrel | *Numenius phaeopus* | 268 | 10/6/2022 | 11:05:30 | -28.95412 | 31.78008 | | 1 | 1 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 11:05:40 | -28.95412 | 31.78008 | | 1 | 1 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 11:07:09 | -28.95365 | 31.78085 | | 1 | 7 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 11:08:34 | -28.95275 | 31.78146 | | 1 | 3 |
| Common Greenshank | *Tringa nebularia* | 263 | 10/6/2022 | 11:10:42 | -28.95226 | 31.78247 | | 1 | 1 |
| Eurasian Whimbrel | *Numenius phaeopus* | 268 | 10/6/2022 | 11:10:49 | -28.95226 | 31.78247 | | 2 | 1 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 11:11:04 | -28.95226 | 31.78247 | | 1 | 1 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 11:11:20 | -28.95226 | 31.78247 | | 2 | 1 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 11:15:05 | -28.95122 | 31.78338 | | 1 | -43 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 11:15:15 | -28.95122 | 31.78338 | | 1 | -43 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 11:18:14 | -28.94964 | 31.78566 | | 1 | 5 |
| Eurasian Curlew | *Numenius arquata* | 267 | 10/6/2022 | 11:26:14 | -28.94733 | 31.79799 | | 1 | 12 |
| Eurasian Whimbrel | *Numenius phaeopus* | 268 | 10/6/2022 | 11:26:23 | -28.94733 | 31.79811 | | 2 | 3 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 11:37:21 | -28.94421 | 31.81266 | | 1 | 3 |
| Eurasian Whimbrel | *Numenius phaeopus* | 268 | 10/6/2022 | 11:38:30 | -28.94401 | 31.8134 | | 5 | 3 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 11:38:42 | -28.94398 | 31.8135 | | 1 | 3 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 11:44:26 | -28.94303 | 31.81747 | | 1 | 14 |
| Greater Crested Tern | *Thalasseus bergii* | 298 | 10/6/2022 | 11:49:07 | -28.94303 | 31.8175 | | 35 | 2 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/6/2022 | 12:06:16 | -28.94413 | 31.81291 | | 1 | 3 |
| Eurasian Whimbrel | *Numenius phaeopus* | 268 | 10/6/2022 | 12:11:32 | -28.94405 | 31.80961 | | 1 | 3 |
| Common Greenshank | *Tringa nebularia* | 263 | 10/6/2022 | 12:11:40 | -28.94405 | 31.80961 | | 1 | 3 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/6/2022 | 12:11:48 | -28.94405 | 31.80961 | | 2 | 3 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 12:18:50 | -28.9457 | 31.8035 | | 1 | -8 |
| Giant Kingfisher | *Megaceryle maxima* | 395 | 10/6/2022 | 12:24:40 | -28.94795 | 31.79857 | | 1 | 2 |
| Eurasian Whimbrel | *Numenius phaeopus* | 268 | 10/6/2022 | 12:26:49 | -28.94836 | 31.79782 | | 8 | 2 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 12:31:31 | -28.94973 | 31.79252 | | 1 | 3 |
| Common Greenshank | *Tringa nebularia* | 263 | 10/6/2022 | 12:32:48 | -28.94945 | 31.79183 | | 1 | 3 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 12:33:04 | -28.9493 | 31.79187 | | 1 | 3 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 12:37:19 | -28.95004 | 31.787 | | 1 | 3 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 12:41:52 | -28.95291 | 31.78298 | | 1 | 2 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 12:42:58 | -28.9538 | 31.78214 | | 2 | -8 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 12:45:06 | -28.95515 | 31.77946 | | 1 | 5 |
| Hadada Ibis | *Bostrychia hagedash* | 84 | 10/6/2022 | 12:46:01 | -28.95539 | 31.77818 | | 6 | 2 |

| Species primary name | Species tertiary name | ADU ID | Date | Time | Latitude | Longitude | Notes | Count | Altitude |
|---|---|---|---|---|---|---|---|---|---|
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 12:46:42 | -28.95526 | 31.7772 | | 1 | 1 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 12:51:06 | -28.95216 | 31.77401 | | 1 | -8 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 12:58:29 | -28.94967 | 31.77535 | | 1 | -3 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 12:58:56 | -28.9495 | 31.77581 | | 1 | 2 |
| Giant Kingfisher | *Megaceryle maxima* | 395 | 10/6/2022 | 12:59:03 | -28.94946 | 31.77604 | | 1 | 2 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 13:03:31 | -28.94774 | 31.78124 | | 1 | 2 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 13:05:50 | -28.94598 | 31.78384 | | 1 | 2 |
| Common Ringed Plover | *Charadrius hiaticula* | 233 | 10/6/2022 | 13:06:33 | -28.94532 | 31.78449 | | 2 | 2 |
| African Fish Eagle | *Haliaeetus vocifer* | 149 | 10/6/2022 | 13:10:22 | -28.9406 | 31.78543 | | 1 | 2 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 13:11:02 | -28.93998 | 31.78493 | | 1 | 1 |
| Little Egret | *Egretta garzetta* | 59 | 10/6/2022 | 13:14:50 | -28.93632 | 31.78103 | | 1 | 2 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:15:44 | -28.93585 | 31.78014 | | 1 | 2 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:17:22 | -28.93547 | 31.77822 | | 1 | 2 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:20:48 | -28.93374 | 31.774 | | 1 | 2 |
| African Pied Wagtail | *Motacilla aguimp* | 685 | 10/6/2022 | 13:27:43 | -28.933 | 31.76915 | | 2 | -3 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:29:51 | -28.93418 | 31.76736 | | 1 | -22 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/6/2022 | 13:30:07 | -28.93417 | 31.76726 | | 1 | -13 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:33:09 | -28.93598 | 31.76523 | | 1 | 2 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 13:33:59 | -28.93646 | 31.76465 | | 1 | 1 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:34:51 | -28.93687 | 31.76377 | | 1 | 3 |
| Woolly-necked Stork | *Ciconia episcopus* | 77 | 10/6/2022 | 13:39:13 | -28.93699 | 31.76089 | | 1 | 2 |
| Unidentified | *Unidentified* | 0 | 10/6/2022 | 13:39:49 | -28.93671 | 31.76078 | Topmost point reached | X | 0 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:43:07 | -28.93742 | 31.76176 | | 1 | 2 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/6/2022 | 13:44:47 | -28.93684 | 31.76323 | | 2 | 0 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/6/2022 | 13:45:00 | -28.93657 | 31.76336 | | 2 | 2 |
| Egyptian Goose | *Alopochen aegyptiaca* | 89 | 10/6/2022 | 13:53:56 | -28.93235 | 31.77099 | | 2 | 3 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:54:34 | -28.93243 | 31.77177 | | 1 | 3 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 13:54:45 | -28.93242 | 31.772 | | 1 | 3 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/6/2022 | 13:55:11 | -28.93259 | 31.7724 | | 1 | 3 |
| Wood Sandpiper | *Tringa glareola* | 264 | 10/6/2022 | 14:01:18 | -28.93467 | 31.77829 | | 1 | 0 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 14:09:06 | -28.93841 | 31.78468 | | 1 | 0 |
| Malachite Kingfisher | *Corythornis cristatus* | 397 | 10/6/2022 | 14:14:05 | -28.94205 | 31.78659 | | 1 | 2 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 14:16:23 | -28.94361 | 31.78638 | | 1 | 14 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 14:16:57 | -28.94378 | 31.78611 | | 1 | 2 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/6/2022 | 14:19:52 | -28.94602 | 31.78485 | | 1 | 0 |
| | | 0 | 10/6/2022 | 14:34:09 | -28.95004 | 31.77485 | End count | X | -37 |

Details of waterbirds recorded at aMatigulu/iNyoni Estuary on 7 October 2022.

| Species primary name | Species tertiary name | ADU ID | Date | Time | Latitude | Longitude | Notes | Count | Altitude |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 10/7/2022 | 11:47:30 | -29.0809 | 31.64414 | Start count | X | 2 |
| White-breasted Cormorant | *Phalacrocorax lucidus* | 47 | 10/7/2022 | 11:57:41 | -29.08292 | 31.64239 | | 3 | 2 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 12:00:30 | -29.08397 | 31.64158 | | 2 | 0 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 12:03:40 | -29.0851 | 31.63985 | | 2 | -11 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 12:04:58 | -29.0857 | 31.63918 | | 2 | 0 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 12:07:40 | -29.08717 | 31.6379 | | 2 | 2 |
| Western Osprey | *Pandion haliaetus* | 172 | 10/7/2022 | 12:09:03 | -29.08767 | 31.63752 | | 1 | 3 |
| Blacksmith Lapwing | *Vanellus armatus* | 245 | 10/7/2022 | 12:09:24 | -29.08763 | 31.63763 | | 2 | 2 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/7/2022 | 12:14:37 | -29.09076 | 31.63491 | | 1 | 2 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/7/2022 | 12:18:59 | -29.0927 | 31.6326 | | 1 | 0 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/7/2022 | 12:21:28 | -29.09361 | 31.63188 | | 2 | -2 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/7/2022 | 12:24:55 | -29.0943 | 31.63038 | | 2 | 2 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/7/2022 | 12:26:50 | -29.09487 | 31.62953 | | 1 | 2 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 12:29:35 | -29.09609 | 31.62852 | | 1 | 0 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 12:31:21 | -29.09696 | 31.6276 | | 2 | 2 |
| Sanderling | *Calidris alba* | 255 | 10/7/2022 | 12:44:26 | -29.10403 | 31.62277 | | 25 | 1 |
| Ruddy Turnstone | *Arenaria interpres* | 232 | 10/7/2022 | 12:44:39 | -29.10403 | 31.62277 | | 5 | 1 |
| Bar-tailed Godwit | *Limosa lapponica* | 266 | 10/7/2022 | 12:44:50 | -29.10403 | 31.62277 | | 3 | 1 |
| Common Sandpiper | *Actitis hypoleucos* | 258 | 10/7/2022 | 12:45:31 | -29.10383 | 31.62301 | | 2 | 1 |
| Woolly-necked Stork | *Ciconia episcopus* | 77 | 10/7/2022 | 13:11:16 | -29.10872 | 31.62047 | | 1 | 1 |
| Common Greenshank | *Tringa nebularia* | 263 | 10/7/2022 | 13:21:26 | -29.1113 | 31.61775 | | 1 | 0 |
| Sanderling | *Calidris alba* | 255 | 10/7/2022 | 13:21:43 | -29.1113 | 31.61775 | | 24 | 0 |
| Common Ringed Plover | *Charadrius hiaticula* | 233 | 10/7/2022 | 13:21:57 | -29.1113 | 31.61775 | | 7 | 0 |
| Curlew Sandpiper | *Calidris ferruginea* | 251 | 10/7/2022 | 13:22:10 | -29.11128 | 31.6178 | | 1 | 1 |
| African Pied Wagtail | *Motacilla aguimp* | 685 | 10/7/2022 | 13:22:21 | -29.11128 | 31.6178 | | 2 | 1 |
| African Darter | *Anhinga rufa* | 52 | 10/7/2022 | 13:34:02 | -29.11296 | 31.6155 | | 4 | 0 |
| Blacksmith Lapwing | *Vanellus armatus* | 245 | 10/7/2022 | 13:40:18 | -29.11332 | 31.616 | | 2 | 0 |
| Hadada Ibis | *Bostrychia hagedash* | 84 | 10/7/2022 | 13:40:31 | -29.11327 | 31.61604 | | 2 | 1 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 13:47:08 | -29.11475 | 31.6147 | | 1 | 0 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/7/2022 | 13:55:34 | -29.1165 | 31.61256 | | 2 | 4 |
| African Fish Eagle | *Haliaeetus vocifer* | 149 | 10/7/2022 | 13:55:44 | -29.11658 | 31.61241 | | 2 | 4 |
| White-breasted Cormorant | *Phalacrocorax lucidus* | 47 | 10/7/2022 | 13:58:55 | -29.11757 | 31.61161 | | 4 | 4 |
| Egyptian Goose | *Alopochen aegyptiaca* | 89 | 10/7/2022 | 13:59:43 | -29.11752 | 31.61171 | | 1 | 4 |
| Spur-winged Goose | *Plectropterus gambensis* | 88 | 10/7/2022 | 14:05:44 | -29.11786 | 31.61114 | | 4 | 5 |
| Yellow-billed Duck | *Anas undulata* | 96 | 10/7/2022 | 14:14:07 | -29.11783 | 31.61108 | | 3 | 4 |

| Species primary name | Species tertiary name | ADU ID | Date | Time | Latitude | Longitude | Notes | Count | Altitude |
|---|---|---|---|---|---|---|---|---|---|
| Yellow-billed Duck | *Anas undulata* | 96 | 10/7/2022 | 14:17:02 | -29.11771 | 31.61116 | | 9 | 5 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/7/2022 | 14:17:16 | -29.11771 | 31.61116 | | 2 | 5 |
| Spur-winged Goose | *Plectropterus gambensis* | 88 | 10/7/2022 | 14:18:28 | -29.11762 | 31.61119 | | 5 | 6 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/7/2022 | 14:20:58 | -29.11776 | 31.61108 | | 6 | 4 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/7/2022 | 14:32:24 | -29.11679 | 31.61219 | | 1 | 2 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 14:38:06 | -29.11549 | 31.61316 | | 1 | 0 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/7/2022 | 15:00:10 | -29.11233 | 31.61374 | | 1 | 1 |
| Caspian Tern | *Hydroprogne caspia* | 290 | 10/7/2022 | 15:01:03 | -29.11226 | 31.61343 | | 1 | 0 |
| Hadada Ibis | *Bostrychia hagedash* | 84 | 10/7/2022 | 15:01:30 | -29.11213 | 31.61347 | | 2 | 1 |
| Goliath Heron | *Ardea goliath* | 56 | 10/7/2022 | 15:19:02 | -29.11189 | 31.61096 | | 1 | 6 |
| African Jacana | *Actophilornis africanus* | 228 | 10/7/2022 | 15:21:33 | -29.11189 | 31.61102 | | 6 | 6 |
| Common Greenshank | *Tringa nebularia* | 263 | 10/7/2022 | 15:21:42 | -29.11189 | 31.61098 | | 1 | 1 |
| Common Ringed Plover | *Charadrius hiaticula* | 233 | 10/7/2022 | 15:23:50 | -29.11188 | 31.61098 | | 18 | 1 |
| Blacksmith Lapwing | *Vanellus armatus* | 245 | 10/7/2022 | 15:24:13 | -29.11188 | 31.61098 | | 2 | 1 |
| Curlew Sandpiper | *Calidris ferruginea* | 251 | 10/7/2022 | 15:24:26 | -29.11188 | 31.61098 | | 1 | 1 |
| Egyptian Goose | *Alopochen aegyptiaca* | 89 | 10/7/2022 | 15:28:48 | -29.11191 | 31.61091 | | 13 | 1 |
| Spur-winged Goose | *Plectropterus gambensis* | 88 | 10/7/2022 | 15:30:49 | -29.11187 | 31.61097 | | 54 | 7 |
| White-faced Whistling Duck | *Dendrocygna viduata* | 100 | 10/7/2022 | 15:34:04 | -29.11191 | 31.61091 | | 103 | 11 |
| Yellow-billed Duck | *Anas undulata* | 96 | 10/7/2022 | 15:36:51 | -29.11187 | 31.61095 | | 100 | 1 |
| Common Ringed Plover | *Charadrius hiaticula* | 233 | 10/7/2022 | 15:37:07 | -29.11187 | 31.61095 | | 2 | 1 |
| Common Greenshank | *Tringa nebularia* | 263 | 10/7/2022 | 15:37:15 | -29.11187 | 31.61095 | | 1 | 1 |
| Wood Sandpiper | *Tringa glareola* | 264 | 10/7/2022 | 15:39:17 | -29.11187 | 31.61093 | | 1 | 1 |
| Red-billed Teal | *Anas erythrorhyncha* | 97 | 10/7/2022 | 15:40:53 | -29.11173 | 31.61119 | | 30 | -4 |
| Common Ringed Plover | *Charadrius hiaticula* | 233 | 10/7/2022 | 15:42:30 | -29.11184 | 31.61097 | | 2 | 1 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/7/2022 | 15:44:16 | -29.11187 | 31.61095 | | 8 | 1 |
| African Darter | *Anhinga rufa* | 52 | 10/7/2022 | 15:44:23 | -29.11187 | 31.61095 | | 4 | 1 |
| Great Egret | *Ardea alba* | 58 | 10/7/2022 | 15:44:48 | -29.11187 | 31.61095 | | 1 | 1 |
| Malachite Kingfisher | *Corythornis cristatus* | 397 | 10/7/2022 | 15:45:30 | -29.11189 | 31.61102 | | 1 | 0 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/7/2022 | 15:45:38 | -29.11192 | 31.61092 | | 1 | 1 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 15:47:58 | -29.11187 | 31.61095 | | 2 | 1 |
| Spur-winged Goose | *Plectropterus gambensis* | 88 | 10/7/2022 | 15:48:09 | -29.11187 | 31.61095 | | 5 | 1 |
| Hadada Ibis | *Bostrychia hagedash* | 84 | 10/7/2022 | 15:50:38 | -29.11191 | 31.61096 | | 2 | 1 |
| Little Grebe | *Tachybaptus ruficollis* | 6 | 10/7/2022 | 15:50:56 | -29.11189 | 31.61097 | | 1 | 1 |
| Western Cattle Egret | *Bubulcus ibis* | 61 | 10/7/2022 | 16:00:59 | -29.1114 | 31.61637 | | 30 | 0 |
| Common Greenshank | *Tringa nebularia* | 263 | 10/7/2022 | 16:02:26 | -29.11004 | 31.6175 | | 1 | 1 |
| Common Ringed Plover | *Charadrius hiaticula* | 233 | 10/7/2022 | 16:02:47 | -29.10953 | 31.61768 | | 1 | 1 |
| Ruff | *Calidris pugnax* | 256 | 10/7/2022 | 16:09:56 | -29.10701 | 31.61965 | | 5 | 0 |
| Little Stint | *Calidris minuta* | 253 | 10/7/2022 | 16:15:39 | -29.10672 | 31.61915 | | 5 | 29 |

| Species primary name | Species tertiary name | ADU ID | Date | Time | Latitude | Longitude | Notes | Count | Altitude |
|---|---|---|---|---|---|---|---|---|---|
| Common Ringed Plover | *Charadrius hiaticula* | 233 | 10/7/2022 | 16:17:19 | -29.10675 | 31.61918 | | 20 | 1 |
| Eurasian Whimbrel | *Numenius phaeopus* | 268 | 10/7/2022 | 16:17:29 | -29.10675 | 31.61918 | | 1 | 1 |
| Blacksmith Lapwing | *Vanellus armatus* | 245 | 10/7/2022 | 16:17:39 | -29.10675 | 31.61918 | | 2 | 1 |
| Yellow-billed Duck | *Anas undulata* | 96 | 10/7/2022 | 16:19:12 | -29.10679 | 31.61918 | | 15 | 10 |
| White-faced Whistling Duck | *Dendrocygna viduata* | 100 | 10/7/2022 | 16:19:30 | -29.10679 | 31.61918 | | 2 | 10 |
| Red-billed Teal | *Anas erythrorhyncha* | 97 | 10/7/2022 | 16:19:41 | -29.10679 | 31.61918 | | 1 | 10 |
| Curlew Sandpiper | *Calidris ferruginea* | 251 | 10/7/2022 | 16:22:42 | -29.10683 | 31.61916 | | 5 | 0 |
| Reed Cormorant | *Microcarbo africanus* | 50 | 10/7/2022 | 16:25:40 | -29.10681 | 31.61916 | | 25 | 2 |
| Little Egret | *Egretta garzetta* | 59 | 10/7/2022 | 16:36:20 | -29.10064 | 31.62454 | | 1 | 1 |
| Little Egret | *Egretta garzetta* | 59 | 10/7/2022 | 16:37:55 | -29.09838 | 31.62604 | | 1 | -1 |
| Pied Kingfisher | *Ceryle rudis* | 394 | 10/7/2022 | 16:39:33 | -29.09501 | 31.62812 | | 1 | 0 |
| White-fronted Plover | *Charadrius marginatus* | 235 | 10/7/2022 | 16:51:34 | -29.08229 | 31.64305 | | 1 | 2 |
| Sanderling | *Calidris alba* | 255 | 10/7/2022 | 16:53:01 | -29.08194 | 31.64319 | | 13 | 2 |
| | | 0 | 10/7/2022 | 17:17:09 | -29.0812 | 31.64408 | End count | X | 13 |