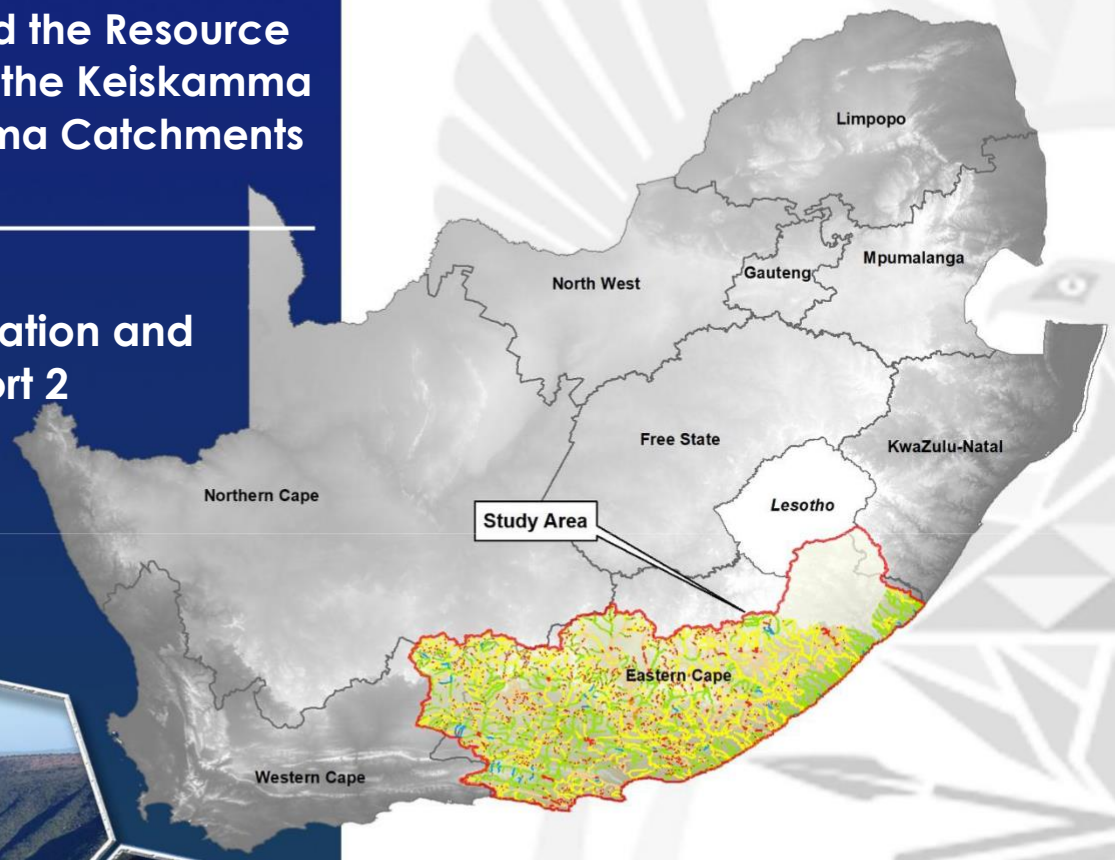
DEPARTMENT OF WATER AND SANITATION

Determination of Water Resource Classes, Reserve and the Resource Quality Objectives in the Keiskamma and Fish to Tsitsikamma Catchments

WP11354
Estuary Site Verification and Survey Report 2



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DOCUMENT INDEX

Reports as part of this project:

Bold type indicates this report

INDEX	REPORT NUMBER	REPORT TITLE
1.0	WEM/WMA7/00/CON/RDM/0121	Inception Report
2.0	WEM/WMA7/00/CON/RDM/0222	Water Resources Information, Gap Analysis and Models Report
3.0	WEM/WMA7/00/CON/RDM/0322	Status quo and delineation of Integrated Units of Analysis Report
4.0	WEM/WMA7/00/CON/RDM/0422	Resource Units Prioritisation Report
5.0	WEM/WMA7/00/CON/RDM/0522	Wetland Survey Report
6.0	WEM/WMA7/00/CON/RDM/0622	Groundwater Survey Report
7.0	WEM/WMA7/00/CON/RDM/0722	River Field Survey Report 1
8.0	WEM/WMA7/00/CON/RDM/0822	Linking the Socio-Economic and Ecological Value and Condition of the Water Resource/s
9.0	WEM/WMA7/00/CON/RDM/0922	Basic Human Needs Report
10.0	WEM/WMA7/00/CON/RDM/1022	Estuary Survey Report 1
11.0	WEM/WMA7/00/CON/RDM/1122	Groundwater PES and Quantification of the Reserve Report
12.0	WEM/WMA7/00/CON/RDM/1223	Wetland Eco-categorisation Report
13.0	WEM/WMA7/00/CON/RDM/1323	Final Groundwater Report
14.0	WEM/WMA7/00/CON/RDM/1423	Estuary Site Verification and Survey Report 1
15.0	**WEM/WMA7/00/CON/RDM/1523**	**Estuary Site Verification and Survey Report 2**
16.0	WEM/WMA7/00/CON/RDM/1623	Final Wetlands Report
17.0	WEM/WMA7/00/CON/RDM/1723	River's Eco-categorisation Report – Volume 1
18.0	WEM/WMA7/00/CON/RDM/1823	River's Eco-categorisation Report – Volume 2
19.0	WEM/WMA7/00/CON/RDM/1923	Ecological Water Requirements (EWR) quantification for rivers Report

INDEX	REPORT NUMBER	REPORT TITLE
20.0	WEM/WMA7/00/CON/RDM/2024	Ecological Base Configuration Scenario Report
21.0	WEM/WMA7/00/CON/RDM/2124	Scenario's Report

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

BHN	Basic Human Needs
CD: WEM	Chief Directorate: Water Ecosystems Management
CSIR	Council for Scientific and Industrial Research
CWAC	Coordinated Waterbird Count
DFFE	Department of Forestry, Fisheries and the Environment
DO	Dissolved Oxygen
DO%	Percentage Oxygen Saturation
DWS	Department of Water and Sanitation
EFZ	Estuarine Functional Zone
EWR	Ecological Water Requirements
IUA	Integrated Units of Analysis
MAR	Mean Annual Runoff
NBA	National Biodiversity Act
NMU	Nelson Mandela University
NWA	National Water Act
NTU	Turbidity
PES	Present Ecological State
RDM	Resource Directed Measures
RQOs	Resource Quality Objectives
RU	Resource Unit
SAIAB	South African Institute for Aquatic Biodiversity
SAEON	South African Environmental Observation Network
SOM	Sediment organic matter
WMA	Water Management Area
WRCS	Water Resource Classification System

1. INTRODUCTION

1.1 Background

The National Water Act, 1998 (No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without affecting the functioning of water resource systems. To achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the implementation of Resource Directed Measures (RDM). These measures are protection-based and include Water Resource Classification, determination of the Reserve and setting the associated Resource Quality Objectives (RQOs). These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources, while allowing economic development.

The provision of water required for the maintenance of the natural functionality of the ecosystem and provision of Basic Human Needs (BHN) is the only right to water in the National Water Act (No. 36 of 1998) (NWA). The other water users from a strategic use who are second in line to other water users are subject to formal gazetted General Authorization and water use authorization as per Section 21 of the NWA.

The Chief Directorate: Water Ecosystems Management (CD: WEM) has initiated a study for the determination of Water Resource Classes, Reserve and associated Resource Quality Objectives for the identified significant water resources in the Keiskamma, Fish to Tsitsikamma catchments. The water resource components included for this study are rivers, wetlands, groundwater and estuaries. The Reserve determination include both the water quantity and quality of Ecological Water Requirements (EWR) and Basic Human Needs (BHN). This will ensure the availability of water required to protect aquatic systems and provide the human basic needs for those directly dependent on these water resources.

1.2 Purpose of this study

The Keiskamma and Fish to Tsitsikamma catchments within the Mzimvubu to Tsitsikamma Water Management Area (WMA7) are amongst many water stressed catchments in South Africa. These areas are important for conservation and have recognisable protected areas, natural heritage, cultural and historical sites that require protection. However, water use from surface as well as groundwater for agricultural and domestic purposes are high, especially in the more arid catchments, impacting on the availability of water resources for the protection of the aquatic ecosystems. Industrial practices and domestic water use are on the rise in some of these catchments, especially around the major towns and cities. Water transfers into the study area from adjacent WMAs and within the study area as well as the numerous storage dams, change the flow patterns, impacting on each estuary’s physical habitats and biota.

Thus, the main purpose and aim of the study is to:

- Implement the Water Resource Classification System (WRCS) (Regulation 810, 2010) to determine the Water Resource Classes;
- Follow the integrated framework (DWS, 2017),
- Undertake the 7-step process to determine and set RQOs, and
- Determine the Reserve for the water resources of the study area.

This will ultimately assist the Department of Water and Sanitation (DWS) in the management of the water resources in the study area by prescribing the required protection measures to meet the Ecolgoical Category with its associated Eco-specifications, that need to be captured within eh set RQOs for the RU or estuary. This will aid in making informed decisions regarding the authorisation of future water use and the magnitude of the impacts of proposed developments.

1.3 Purpose of this report

This report provides an overview of the estuary surveys undertaken from 30 November to 6 December 2023 (water quality, microalgae, macrophytes and birds) and 23 to 25 April 2024 (water quality, microalgae, macrophytes and birds). An additional survey is being planned for the macroinvertebrates, particularly on the Gamtoos Estuary, once the system settled following the recent flood event that took place in June 2024. The survey programmes are provided in Appendix A of this report.

The report provides information for each priority estuary Resource Unit (RU) identified in the Keiskamma, Fish to Tsitsikamma catchment areas for this study, coupled with the Reserve level assessment for the associated river reach.

It must be noted that this report does not include any data analysis or interpretation, this information will be provided within the subsequent deliverables namely:

- Deliverable 4.3.24: Estuaries EcoCategorisation report;
- Deliverable 4.3.15: Report on quantification of the EWR for estuaries; and
- Deliverable 4.3.28: Final estuary report.

2. FIELD METHODOLOGY AND FIELD SURVEYS

2.1 Water Quality

The water quality and microalgae were sampled at eight estuaries during two field trips to assess the present state condition (Appendix A). Sampling stations were selected to encapsulate spatial variability along the length of each study estuary, i.e., mouth to upper reaches. However, at some estuaries, upper sampling stations were limited by shallow water depths or infrastructure such as bridges. Field surveys were conducted in the Xora (5 sites), Mbashe (6 sites), Great Kei (6 sites), Tyolomnqa (7 sites), Keiskamma (7 sites), Kowie (7 sites), Kariega (7 sites), and Bushmans (7 sites) estuaries.

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 (NTU). Measurements were recorded at specified depth intervals from the surface to the bottom-waters to capture any vertical gradients. For inorganic nutrient analyses (orthophosphate, ammonium, and total oxidised nitrogen), sub-surface, middle, 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_{43}-), ammonium (NH_{4+}), and total oxidised nitrogen (NO_x = NO_3- and NO_{2-}) concentrations will be determined using standard spectrophotometric methods.

2.2 Microalgae

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 µg 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 hours 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.

2.3 Macrophytes

For each estuary, the distribution of macrophytes was noted from the mouth to the upper reaches of the estuary. Geotagged photos were taken and exported to a Google Earth .kml file using GeoSetter and the date as the identifier. This allowed for the assessment of changes

over time, both in the past as well as providing a baseline for future studies. Geotagged field notes were taken to refine the preliminary macrophyte maps prepared before the field trip. This is the ground-truthing component for the vegetation mapping. Pressures were noted to inform the present ecological status assessment for the macrophytes.

Dominant macrophyte species were identified in relation to abiotic variables i.e. distribution along salinity and elevation gradient. This informs the ecological water requirement assessment. Specimens of unknown plant species were collected and pressed for later identification. Many of the geotagged photos were uploaded onto the iNaturalist platform to serve as historical evidence of species locality and extent.

2.4 Macroinvertebrates

Invertebrates occupy a range of distinct niches according to ecology and lifestyle within an estuary and these require specialised spatio-temporal sampling techniques to quantity. This community of organisms is also naturally variable and responsive to change, necessitating multiple repeat sampling occasions under both steady and dynamic estuarine mouth states to accurately capture the community variability. Typically the invertebrates should be sampled across all sites where water quality parameters are collected, over multiple seasons to account for recruitment dynamics and other ontological natural variability beyond estuarine state conditions. Field parameters that should be collected at each site in addition to water quality are sediment organic content and granulometry (grain size distribution) since these are key drivers of many macroinvertebrate species.

Typically, the invertebrate community within an estuary can be subdivided into four prominent macrofaunal components, each with different dominant features and drivers: plankton, benthos, hyperbenthos and intertidal. Meiofaunal invertebrates (i.e. passing through a 350 µm mesh but retained on a 63 µm mesh), although an important component especially at the interface of the microbial and microalgal foodweb are not considered in this assessment.
Zooplankton undergo diel vertical migration within the water column and are most abundant and accessible nocturnal. Given sampling protocols and logistical concerns around safety, the zooplankton were not targeted in this assessment.

Benthic invertebrates are sampled using a variety of sediment coring techniques, depending on the burrowing depth of the organisms. In this assessment, benthic invertebrates were sampled directly using fixed-volume sediment samplers (e.g., 300 cm^2 Lamotte dredge grab for intertidal and shallow subtidal sampling, or a hand-operated 80 cm prawn suction pump) or indirectly using surface burrow counts related to identifiable species-specific features of the burrowing organisms.

The hyperbenthos, or those invertebrates dwelling at the sediment interface but also nektonic in the water column, are typically sampled using sweep nets or benthic sleds that capture those organisms just off of the sediment surface. In this assessment, the hyperbenthos as well as epibenthic invertebrates associated with structures such as seagrass were sampled using a sweep net of 1mm mesh size dragged over a fixed distance (10m) at some estuaries.

Intertidal invertebrates are typically sampled using a combination of direct and indirect methods as above.

Invertebrates are well documented as indicator species because they accurately reflect ecosystem and resource/habitat conditions. In other words, proxies such as eutrophication, extent of subtidal sand banks, or macrophytes conditions are well correlated variables that can effectively be used to determine the community and abundance conditions of macroinvertebrates. Consequently, in this assessment given the appropriate timeframes a heavy reliance is made on proxy datasets, using best available ecological knowledge of the drivers affecting macroinvertebrates within South African dynamic microtidal estuaries. This proxy approach, together with the quantitative and semi-quantitative sampling approaches defined above, provide a broad brush view of macroinvertebrate dynamics which can be supplemented by ad hoc field observations such as photographs of key or unusual specimens or state conditions.

2.5 Fish

A seine-net (wings 30 m x 1.7 m x 15 mm bar mesh, with 5 mm bar mesh purse and 1 m of 5 mm bar mesh in the wings on either side of the bag) was used to sample the littoral fish community of the five estuaries between the mouth and the upper reaches. Seine-netting was carried out during daylight hours. The seine-net was deployed using a small row-boat, placed in a semi-circle formation offshore and subsequently hauled ashore by four people.

Fish collected in the seine-net at each sampling site were sorted, identified, measured (mm total length) and then returned to the system (alive whenever possible).

2.6 Birds

Bird counts were made of all waterbirds present or as defined by those species listed in the annual Coordinated Waterbird Count (CWAC) surveys (available publicly at: https://cwac.birdmap.africa/index.php), and incidental observations were made of non-waterbird avifauna. Given that the avifauna community is naturally responsive to migratory patterns of species, the month of sampling is a crucial indicators of which resident or transitory species are expected at a system.

Where possible bird counter(s) was the first team members to approach any particular area, so as to get an accurate estimate of the waterbird assemblage prior to any birds taking flight. Given the extent of the waterbodies surveys had to be done by boat. Birds were counted with the aid of a combination of binoculars (Nikon 8x42 Monarch) and a tripod-mounted spotting scope (Celestron 12-36x60 Landscout). All estuaries were ideally surveyed from the mouth to the middle-upper reaches, encompassing the same sites as for Water Quality.

Each area was delineated based on the possible size for identification observable through the binoculars/scope of small waders and the observer would then move beyond this area to the next adjacent patch of the estuary using a spatial reference point to not double-count individual

birds. A full estimate of the larger species (e.g., flamingos, avocets, coots) was made from boat while smaller waders were often counted in sectional areas as described above.

Whenever waterbird identification was in doubt, field notes were taken of key features or geo-referenced photographs taken for post-hoc verification of bird identity.

3. PRIORITY RESOURCE UNITS AND RESERVE LEVEL ASSESSMENT CONDUCTED DURING THE FIELD SURVEY

The following estuaries were sampled as part of the field surveys to date (**Table 3-1** and **Figure 3-1**).

Table 3-1: Estuary Sites per IUA

IUA No.	IUA Description	RU No.	Estuary System	Quaternary catchment	Priority
IUA_P01	P primary catchment	E_RU09	Kariega	P30C	Rapid
		E_RU16	Bushmans	P20A	Desktop PES
		E_RU17	Kowie	P40C	Desktop PES
IUA_R01	Keiskamma	E_RU10	Keiskamma	R10M	Rapid
IUA_S03	Lower Great Kei	E_RU12	Great Kei	S70F	Intermediate
IUA_T02	Lower Mbashe	E_RU13	Mbashe	T13E	Intermediate
IUA_R01	Keiskamma	-	Tyolomnqa	R40C	Desktop PES
IUA_T04	Pondoland coastal	E_RU14	Xora	T80D	Desktop PES
IUA_KL01	Kromme from Kromme Dam to estuary and Gamtoos	E_RU04	Gamtoos	L90C	Intermediate
		E_RU05	Kabeljous	K90G	Rapid

Figure 3-1: The estuaries visited during the estuarine field survey in December 2023 and April 2024

4. ESTUARY SURVEY TEAMS

Table 4-1 includes a list of specialists who conducted the survey, along with a team of DWS members for capacity-building purposes.

Table 4-1: Estuary survey team

Specialist Name	Affiliation	Specialist
Survey Part 1: 30 November – 6 December 2023		
Prof. Lara van Niekerk	CSIR	Physical processes, hydrodynamics, water quality
Prof. Janine Adams	NMU	Macrophytes
Dr Daniel Lemley	NMU	Microalgae and water quality
Dr Taryn Riddin	NMU	Macrophytes (mapping)
Rachel Kibble	NMU	Birds
Riaan Weitz	NMU	Soil Carbon, aerial photographs, skipper
Survey Part 2: 22-25 April 2024		
Prof. Lara van Niekerk	CSIR	Physical processes, hydrodynamics, water quality
Prof. Janine Adams	NMU	Macrophytes
Dr Daniel Lemley	NMU	Microalgae
Dr Gavin Rishworth	NMU	Invertebrates, birds
Rachel Kibble	NMU	Birds
Riaan Weitz	NMU	Soil Carbon, aerial photographs, skipper
Survey Part 3: 13-24 & 27 May 2024		
Prof. Nikki James	SAIAB	Fish
Prof. Stephen Lamberth	DFFE	Fish & Fisheries
Thembani Mkhize	SAIAB	Fish Student
Corne Erasmus	DFFE	Fish, skipper

Carlo Williams	DFFE	Fish
Capacity Building / Stakeholders		
Lawrence Mulangaphuma	DWS	Directorate: Water Resource Classification
Rendani Makhwedzha	DWS	Directorate: Reserve Determination
Ncamza Dweni	DWS	Regional Office
Elliot Weni	DWS	Regional Office
Priscah Lakane	NMU	PhD student (microalgae, macrophytes, alien invasive plants)

5. ESTUARY SURVEY: DECEMBER 2023

5.1 Xora Estuary

Sample Date	01/12/2023	Reserve Level Assessment	Desktop PES
Estuary Name	Xora Estuary	IUA	IUA_T04
No. of sites	Entire Estuary	IUA description	Pondoland coastal
Estuary Type	Predominantly Open	Prioritised RU	E_RU14
Altitude (m.a.s.l.)	0	Quaternary catchment	-
Longitude	28.995585	Latitude	-32.15863389
PES (NBA, 2018)	A/B	Conditions during sampling	Transition state
Components currently impacting PES	Fish		
Ecological Importance	Important		

Site Description:

- Biogeographical region: Subtropical
- Catchment area (km^2): 442
- Reference MAR (m^3x10^6): 52.99
- Seasonality of rainfall: Early Summer
- Marine upwelling zone: No
- Important Fish Nursery: Medium
- Estuary length: 9.8 km

Site impacts:

- Low - Flow reduction pressure;
- Low - Pollution pressure;
- Low - Loss of habitat/transformation of banks;
- Medium to High - Grazing pressure;
- High - Fishing pressure;
- Medium - Invasive Alien Plants; and
- Mining on banks.

Components sampled/observed:

- Mouth configuration;

- Physical Habitat;
- Water quality;
- Microalgae;
- Macrophytes;
- Invertebrate; and
- Birds.

Hydrodynamics and Physical Processes:

The mouth was wide open with good tidal exchange. The upper estuary showed signs of limited freshwater input.

The riparian area was in a near-natural state with very little disturbance of physical processes.

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 5-1** for the location of survey sites.

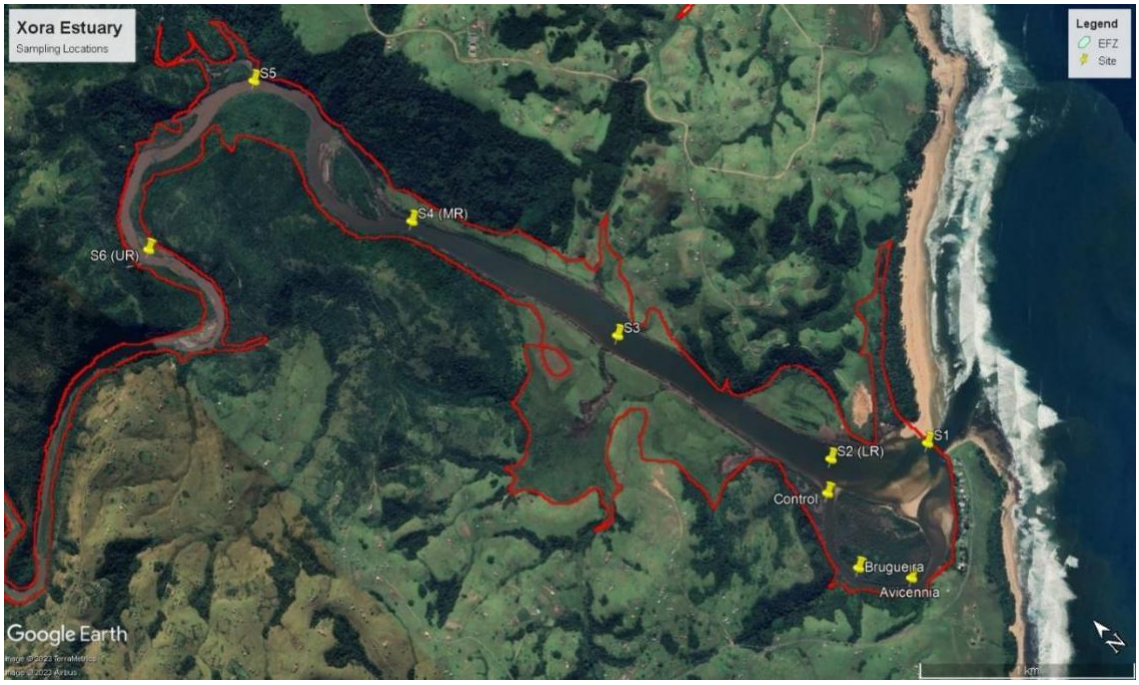

Figure 5-1: Map of Water Quality and Microalgae sites for the Xora Estuary field survey - November 2023

Table 5-1 lists *in situ* water quality measurements were taken during the field trip. Nutrient samples will be processed by SAEON/NMU laboratory.

Salinity conditions in the estuary were predominantly marine, however vertically stratified conditions (i.e., saltier water underlying brackish surface waters) characterised the middle and upper reaches (Site 4 and 5). However, the stratification was limited to a thin layer of mesohaline water at the surface (< 0.25 m depth) and marine conditions (salinity > 33) characterising the water column from 0.5 m depths to the bottom.

Dissolved oxygen concentrations were typical of well-oxygenated conditions (>6 mg/L) throughout the estuary, and turbidity was low (NTU < 10).

Table 5-1: Xoral Estuary *in situ* water quality measurements

01/12/23	Time	Co-ordinates	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	12h25	32° 9'28.82"S; 28°59'41.16"E	0	34.22	103.30	7.24	8.29	23.20	3.44
			0.5	34.23	103.20	7.24	8.29	23.20	3.47
			1	34.23	102.90	7.22	8.29	23.20	3.82
			1.5	34.35	101.00	7.10	8.28	23.00	4.07
Site 2	12h00	32° 9'21.93"S; 28°59'26.38"E	0	32.40	106.30	7.46	8.28	23.80	3.79
			0.5	32.62	106.00	7.43	8.28	23.80	5.59
			1	32.80	105.60	7.40	8.28	23.70	5.98
			1.5	33.44	104.80	7.34	8.27	23.30	7.13
			1.7	35.13	100.40	7.14	8.26	22.20	10.91
Site 3	11h25	32° 8'46.74"S; 28°59'15.23"E	0	33.25	104.10	7.28	8.27	23.70	4.72
			0.5	34.76	104.30	7.43	8.30	22.10	3.22
			1	35.55	103.00	7.39	8.29	21.60	8.32
			1.5	35.56	102.40	7.35	8.29	21.50	8.66
			2	35.57	102.10	7.34	8.30	21.40	9.03
Site 4	11h00	32° 8'13.86"S; 28°59'1.08"E	0	12.77	100.50	7.62	8.22	25.80	6.44
			0.25	24.12	101.00	7.69	8.14	24.80	6.71
			0.5	33.03	96.40	6.75	8.17	23.50	3.96
			1	34.01	97.70	6.84	8.20	23.40	5.75
			1.2	34.22	97.30	6.82	8.20	23.30	7.21
Site 5	10h40	32° 7'49.29"S; 28°59'2.50"E	0	12.82	99.40	7.54	8.22	25.70	6.31
			0.25	26.02	99.80	7.43	8.16	23.80	3.98
			0.5	32.79	85.00	5.97	8.12	23.60	1.61
			1	33.13	82.20	5.79	8.11	23.30	1.94
			1.5	33.41	84.50	5.97	8.14	23.20	2.45
			2	33.43	83.80	5.90	8.13	23.20	3.73
			2.5	33.44	83.00	5.84	8.11	23.20	11.90

Macrophytes:

Sampling took place on 1 December 2023. Macrophytes occurred mainly in the lower reaches where intertidal areas are larger, particularly around the island. In the middle to upper reaches banks are steep and vegetated with terrestrial vegetation while the intertidal areas are narrow. Mangroves species present were *Avicennia marina, Bruguiera gymnorrhiza,* and *Rhizophora mucronata*. These were sparse due to harvesting and cattle trampling and browsing, with visible browse lines. Mangrove recruitment was observed on the island with numerous seedlings and saplings present. Freshwater species like *Hibiscus tiliaceus* intermingle with mangroves on the island. In the middle reaches mangroves are limited to a single row along the banks because of the narrow intertidal banks and cattle impacts. Salt marsh (C*otula coronopifolia, Cotula filifolia, Sarcocornia* spp*., Sporobolus virginicus, Stenotaphrum secundatum, Juncus kraussii, Juncus rigidus, Triglochin* spp*., Bassia diffusa*) formed carpets of monospecies in places, some of which were flowering. *Cotula coronopifolia* in the upper reaches indicates brackish conditions. Salt marsh intermingles with mangroves in the lower reaches and reeds and sedges in the middle to upper reaches. Intertidal salt marsh is limited due to the steep topography. The seagrass *Zostera capensis* occurred in the lower reaches. Reeds and sedges were represented by mostly the sedge *Schoenoplectus scirpoides*. Terrestrial vegetation was represented by Scarp Forest and Transkei Coastal Belt, overhanging the estuary in places. There was a rocky sill indicating the upper reaches of the estuary where cattle were crossing.

The dominant pressures observed were mangrove harvesting (that leads to gaps in the canopy) and browsing by cattle which leads to denuded banks and bank erosion. Chopping of mangroves on the island was prevalent. Sand mining occurred near the mouth on the east bank causing wind blown dust.




Macroinvertebrates:

Field observations for macroinvertebrates for this estuary are made from process-driven metrics of habitat condition and ex-situ assessment of field information and photographs or data. The estuary is in a marine dominated, but transition state with marine connectivity. Noticeable trampling of intertidal and supratidal marsh by cattle browsing, as well as harvesting of mangroves (both incurring sediment desiccation pressures). Reported high fishing pressures, likely reducing top-down pressures on macroinvertebrates. Impacts on macroinvertebrates, particularly brachyurans (crabs) that are common within mangroves habitats, would be a reduction in abundance and diversity following sediment compression and desiccation. Marine connection would facilitate active recruitment of species such as *Scylla serrata* (mud crab) and *Upogebia africana* (mud prawn). Likely a marine dominated zooplankton community, with reported high turbidity in estuary favouring benthic fauna. Island in lower reaches is likely a refuge for macroinvertebrates since cattle browsing pressure expectedly lower, therefore trampling effects are reduced.

Birds:

On the 01 December at 9:10, the team arrived at the Xora Estuary, then drove up the estuary by boat, starting at the mouth and then slowly returning. The wind was strong near the mouth but higher up the estuary it was more sheltered. On arrival, there was a mixture of approximately 300 Common and Little Terns which were initially bunched on the sand at the mouth (**Table 5-2**). When we returned, they had flown to a sand bar in the estuary where they were diving and feeding in the shallow waters (**Figure 5-2**). White-breasted Cormorants were amongst them. Throughout the estuary, four Yellow-billed Kites were seen flying above the estuary and forested areas. Two Knysna Turacos were seen flying between trees on the shaded forested northeastern bank. A shallow rocky area hindered us from going higher up the estuary. Pied Kingfishers were seen in the upper reaches of

the estuary and there were holes in the adjacent banks. A Pygmy Kingfisher was also seen flying between overhanging tree branches. Around the island area, Crowned Hornbills were seen in flight and two Yellow-billed Ducks were observed swimming in the sheltered channel of the island. A Southern Boubou was heard from the boat and two egrets were seen flying, but due to the distance, they were unable to be identified. Throughout the day, the wind was strong and may have influenced the bird activity.

Figure 5-2: Terns at the mouth (top) and later seen active in the Xora Estuary (bottom).

Table 5-2: Xora Estuary bird counts

Common name	Count
African pygmy kingfisher	1
blacksmith lapwing	2
Cape cormorant	1
Cape wagtail	2
common greenshank	7
common tern	300
crowned hornbill	2
Darked capped bulbul	2
fork-tailed drongo	2
giant kingfisher	1

hadeda ibis	1
Knysna Torraco	2
lesser striped swalllow	4
pied kingfisher	5
unidentified egret	2
whitebreasted cormorant	6
yellow-billed duck	2
yellow-billed kite	4

5.2 Mbashe Estuary

Sample Date	02/12/2024	Reserve Level Assessment	Intermediate
Estuary Name	Mbashe Estuary	IUA	IUA_T02
No. of sites	Entire Estuary	IUA description	Lower Mbashe
Estuary Type	Large Fluvially Dominated	Prioritised RU	E_RU13
Altitude (m.a.s.l.)	0	Quaternary catchment	T13E
Longitude	28.901901	Latitude	-32.249985
PES (NBA, 2018)	B	Conditions during sampling	Transition state
Components currently impacting PES	Fish		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Subtropical
- Catchment area (km^2): 6 052
- Reference MAR (m^3x10^6): 801.8
- Seasonality of rainfall: Mid/Late Summer
- Marine upwelling zone: No
- Important Fish Nursery: High
- Estuary length: 18.6 km

Site impacts:

- Low – Flow reduction pressure;
- Low – Pollution pressure;
- Low – Habitat loss/Transformation of banks;
- Very High – Fishing pressure;
- High – Grazing/cattle browsing; and
- High – Alien/translocated fish.

Components sampled/observed:

- Mouth configuration;
- Physical Habitat;
- Water quality;
- Microalgae;
- Macrophytes;
- Macroinvertebrates; and

- Birds

Hydrodynamics and Physical Processes:

The mouth was wide open with good tidal exchange. Some stratification in the upper water column due to freshwater input. The estuary was in a transition state from Marine to Brackish/Fresh State.

The riparian area was near-natural with limited disturbance of physical processes. Some bank erosion was present where cattle made paths.

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 5-3** for the location of survey sites.

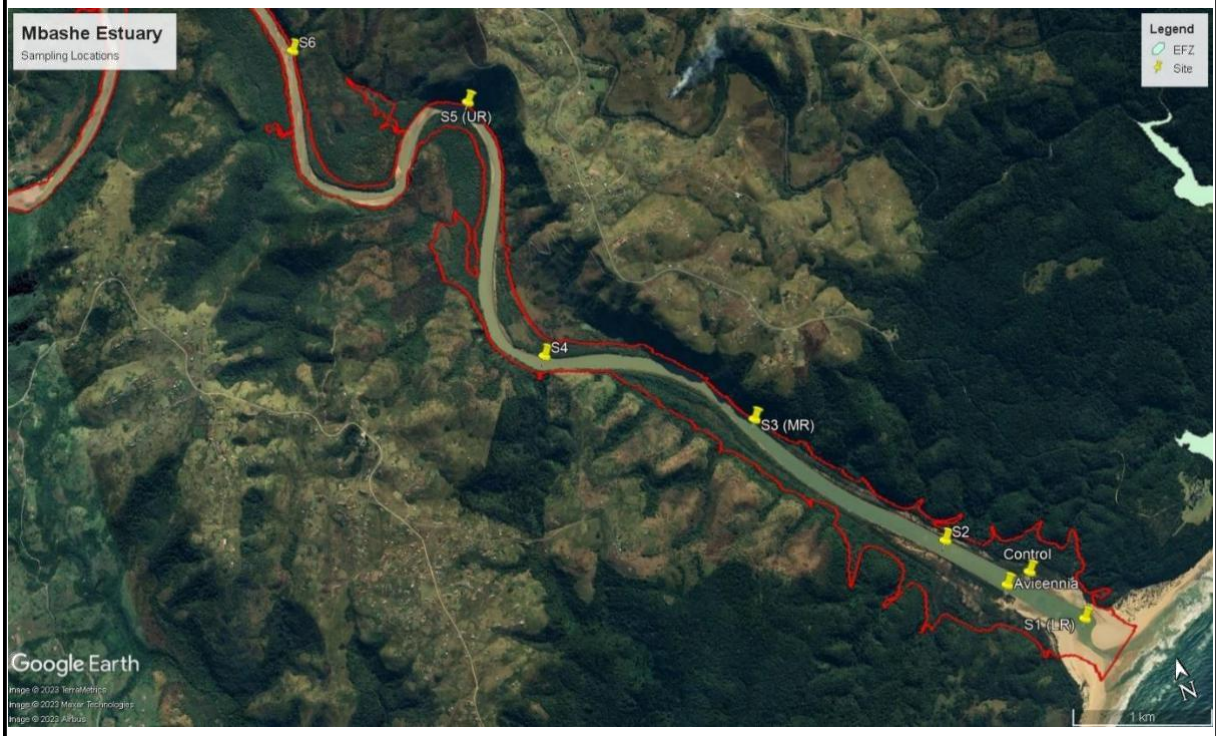

Figure 5-3: Map of Water Quality and Microalgae sites for the Mbashe Estuary field survey - November 2023

Table 5-3 list *in situ* water quality measurement were taken during the field trip. Nutrient samples will be processed by SAEON/NMU laboratory.

The estuary displayed distinct longitudinal and vertical salinity gradients. More specifically, mesohaline (< 10) surface waters persisted throughout the lower and middle reaches (Site 1-4), with marine conditions (> 30) persisting at depth. Marine intrusion into the upper reaches was evidenced by brackish (salinity ca. 17) bottom-waters being observed at Site 5. However,

Site 6 was characterised by well-mixed freshwater conditions (salinity < 0.15). Well-oxygenated conditions (>6 mg/L) were observed throughout the estuary, with the exception of Site 3 where hypoxia (<2 mg/L) was recorded in the bottom-waters. Turbidity increased from the mouth (NTU ~ 10) to the upper (NTU ~ 30) reaches.

Table 5-3: Mbashe Estuary *in situ* water quality measurements

02/12/2023	Time	Co-ordinates	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	12h50	32°14'50.03"S; 28°54'0.28"E	0	5.86	103.00	8.13	8.40	26.00	8.54
			0.25	7.83	102.50	8.16	8.39	22.90	9.60
			0.5	27.40	100.00	7.50	8.26	20.30	12.25
			1	34.45	97.20	7.44	8.12	18.70	14.30
Site 2	12h20	32°14'26.41"S; 28°53'33.24"E	0	4.25	99.10	7.93	8.40	25.30	15.04
			0.25	26.90	98.30	7.25	8.15	24.40	14.13
			0.5	33.45	98.20	7.22	8.11	20.50	12.22
			1	35.18	92.60	7.16	8.11	17.60	16.70
			1.6	35.20	92.90	7.16	8.10	17.60	37.60
Site 3	12h00	32°13'44.83"S; 28°52'49.41"E	0	3.96	93.20	7.55	8.38	25.00	16.97
			0.5	12.62	90.60	7.16	8.17	22.90	16.76
			0.75	33.13	87.90	6.56	8.13	21.50	24.08
			1	34.62	84.60	6.47	8.11	19.50	39.00
			1.2	34.58	25.70	1.84	8.08	18.40	39.00
Site 4	11h25	32°13'16.66"S; 28°51'58.93"E	0	3.40	95.70	7.77	8.37	24.90	27.70
			0.5	3.46	94.80	7.69	8.36	24.90	27.60
			0.75	19.61	85.30	6.49	8.06	23.40	27.12
			1	28.36	82.70	6.08	8.04	23.30	27.08
			1.4	31.96	81.40	5.90	7.99	22.30	19.36
Site 5	10h20	32°12'13.49"S; 28°51'58.57"E	0	0.38	96.80	8.00	8.58	24.90	29.64
			0.5	0.66	96.10	7.94	8.56	24.80	30.67
			1	0.68	95.30	7.87	8.55	24.80	30.70
			1.5	16.01	86.20	6.41	8.12	24.30	15.13
			1.9	17.84	65.10	4.87	8.05	24.20	19.01
Site 6	10h55	32°12'24.29"S; 28°51'19.55"E	0	0.14	98.50	8.10	8.52	25.20	30.10
			0.5	0.14	98.30	8.09	8.52	25.20	31.14
			1	0.14	98.20	8.09	8.52	25.20	30.72
			2	0.14	98.30	8.09	8.52	25.20	31.43
			3	0.14	98.50	8.10	8.52	25.20	30.94
			4	0.14	98.30	8.11	8.52	25.20	30.26

Macrophytes:

Field work took place on 2 December 2023. Mangroves (*Avicennia marina and Bruguiera gymnorrhiza*) occur in the lower reaches of the Mbashe Estuary, intermingling with the invasive shrub *Tamarisk ramosissima* and saline grasses. The effects of previous losses of habitat due to sedimentation (11 ha of mangroves due to a sea storm in 2009) were observed with the change in local topology and hydrology resulting in the occurrence of terrestrial species

invading mangrove and salt marsh. Mobile sands smothering the mangroves were observed on the south bank. There was an interesting mix of sedges and mangroves indicating fresh/brackish conditions near the mouth. Narrow intertidal areas result in limited intertidal salt marsh habitat. Species present were *Triglochin* spp*., Juncus kraussii, Cotula* spp*., Salicornia* spp. and the saline grasses *Sporobolus virginicus* and *Stenotaphrum secundatum*. Steep cliffs occur on the south bank in the middle reaches.

Pressures include bank erosion in the middle to upper reaches, mainly from cattle browsing and clearing of peripheral vegetation by subsistence fisherman to gain access to the river. At the mouth vehicle tracks were observed through the salt marsh. Alien vegetation included *Tamarisk ramosissima, Lanatana camara, Solanum mauritianum* and *Sesbania punicea*. Presence of these species indicated a high level of bank / riparian zone disturbance.

Macroinvertebrates:

Field observations for macroinvertebrates for this estuary are made from process-driven metrics of habitat condition and ex-situ assessment of field information and photographs or data. Estuary is in a fluvially dominated, but transition, state with marine connectivity, as evidenced by well-established halocline. Extensive and mobile sand in lower reaches, high grain size, likely reducing benthic macroinvertebrate abundance and diversity (clear relationship between grain size and macrobenthos). High level of trampling of intertidal and supratidal marsh by cattle browsing, as well as harvesting of mangroves (both incurring sediment desiccation pressures). Reported high fishing pressures, likely reducing top-down pressures on macroinvertebrates. Impacts on macroinvertebrates, particularly brachyurans (crabs) that are common within mangroves habitats, would be a reduction in abundance and diversity following sediment compression and desiccation. Marine connection would facilitate active recruitment of species such as *Scylla serrata* (mud crab) and *Upogebia africana* (mud prawn). High freshwater influence and fluvially dominated state would not optimise for zooplankton community, with reported high turbidity in estuary likely favouring benthic rather than planktonic macrofauna.

Birds:

The weather was overcast with a slight breeze at Mbashe during sampling on the 2nd of December (**Table 5-4**). Cape Starlings were seen in nearby trees of the coastal forest and two Green Wood Hoopoes flew across the estuary making their iconic call. A Pied Kingfisher was seen hovering and diving into the water (**Figure 5-4a**) and Pygmy Kingfishers were seen flying between overhanging branches along the estuary. Spectacled Weavers and Thick-billed Weavers were seen in and around their nests made in the *Phragmites australis*. Whimbrel, Common Greenshank, Common Sandpipers, Three-banded Plovers and White-fronted Plovers were seen feeding at the mouth in the intertidal area (**Figure 5-**4b, **c)**. An African Black Duck was seen with five juveniles floating in the lower reaches of the estuary (**Figure 5-4d**). Here, two adult Egyptian Geese were floating with 7 smaller babies. Two Blacksmith Lapwings were calling in the mangrove area where they likely had a nest (**Figure 5-4e**). Dark Capped Bulbuls were seen flying between the trees on the banks. Cape Wagtails were seen in the lower reaches of the estuary and Western Cattle Egrets were seen alongside cattle walking along the banks (**Figure 5-4f**). An African Fish Eagle was seen in a nest in the lower estuary.

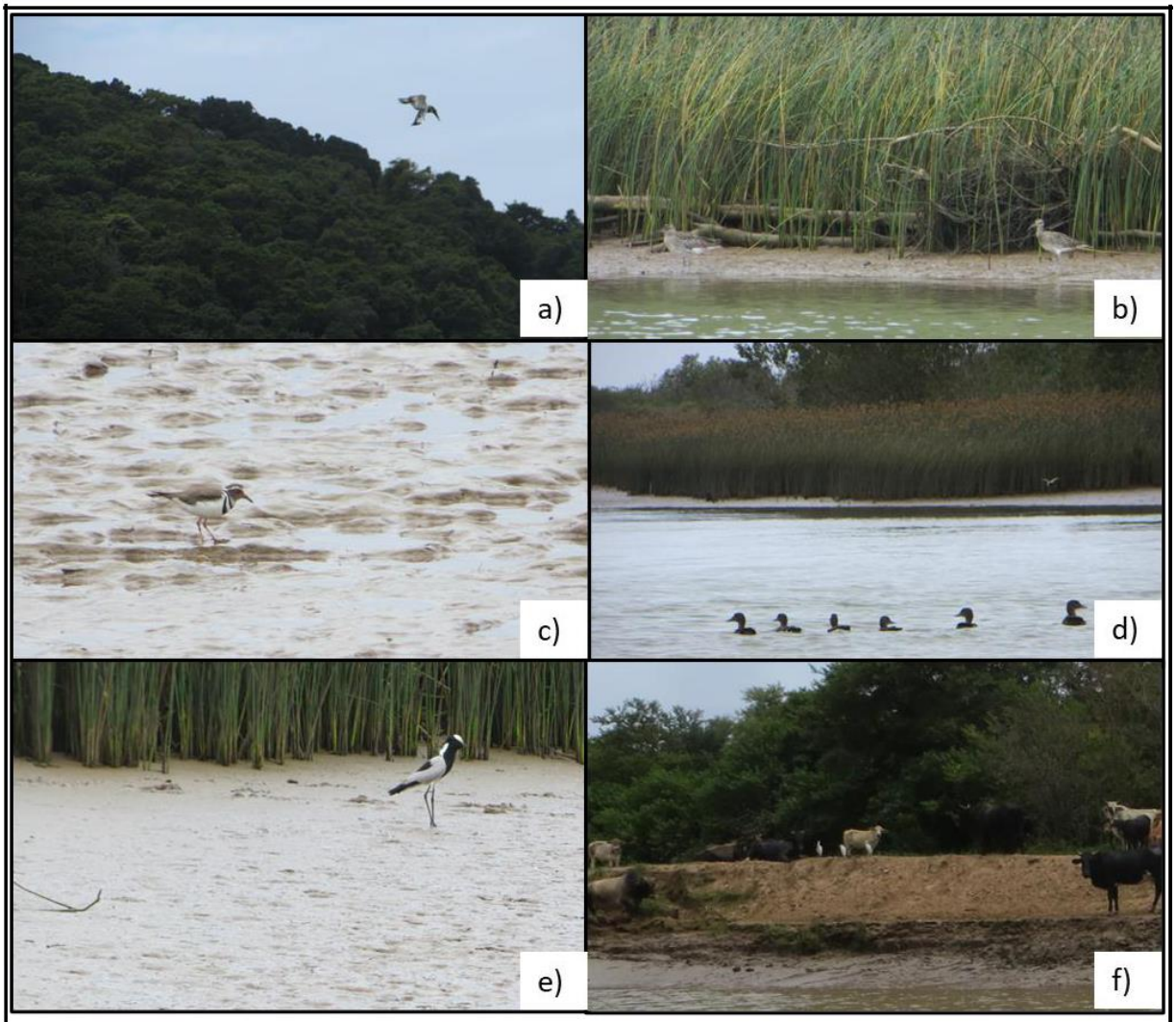

Figure 5-4: A number of birds seen in the Mbashe Estuary. A) Pied Kingfisher hovering over the water, b) Whimbrels along the bank, c) Three-banded Plover, d) juvenile African Black Ducks with an adult, e) Blacksmith Lapwing, f) Western Cattle Egret alongside cattle.

Table 5-4: Mbashe Estuary bird counts

Common name	Counts
African black duck	6
African fish eagle	1
African pygmy kingfisher	4
Alpine swift	10
Blacksmith lapwing	5
Cape (glossy) starling	5
Cape wagtail	5
Common greenshank	15
Common ringed plover	1
Common sandpiper	5
Darked capped bulbul	2

Egyptian goose	9
Fork-tailed drongo	1
Green wood hoopoe	2
Jackal buzzard	1
Little stint	4
Pied kingfisher	2
Red-eyed dove	1
Sanderling	4
Spectacled weaver	51
Three banded plover	10
Thick-billed weaver	3
Trumpeter hornbill	2
Whimbrel	15
White-breasted cormorant	1
White-fronted plover	26
Yellow-billed duck	2
Yellow-billed kite	5

5.3 Great Kei Estuary

Sample Date	03/12/2024	Reserve Level Assessment	Intermediate
Estuary Name	Great Kei Estuary	IUA	IUA_S03
No. of sites	Entire Estuary	IUA description	Lower Great Kei
Estuary Type	Large Fluvially Dominated	Prioritised RU	E_RU12
Altitude (m.a.s.l.)	0	Quaternary catchment	S70F
Longitude	28.385964	Latitude	-32.67988694
PES (NBA, 2018)	C	Conditions during sampling	Transition state
Components currently impacting PES	Hydrology, Fish		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 20 469
- Reference MAR (m^3x10^6): 954.927
- Seasonality of rainfall: Late Summer
- Marine upwelling zone: No
- Important Fish Nursery: High
- Estuary length: 17.6 km

Site impacts:

- Very High - Flow reduction pressure;
- Low - Pollution pressure;
- Low - Habitat loss/Transformation of banks pressure;
- High - Fishing pressure;
- Very High - Alien fish; and
- High - Cattle grazing/browsing pressure.

Components sampled:

- Mouth configuration;
- Physical Habitat;
- Water quality;
- Microalgae;
- Macrophytes; and
- Birds

Hydrodynamics and Physical Processes:

The mouth was open with a good tidal exchange. Some stratification in the upper water column due to freshwater input. The estuary was in a transition state from Marine to Brackish/Fresh State.

Riparian area was near-natural with very little disturbance of physical processes.

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 5-5** for the location of survey sites.

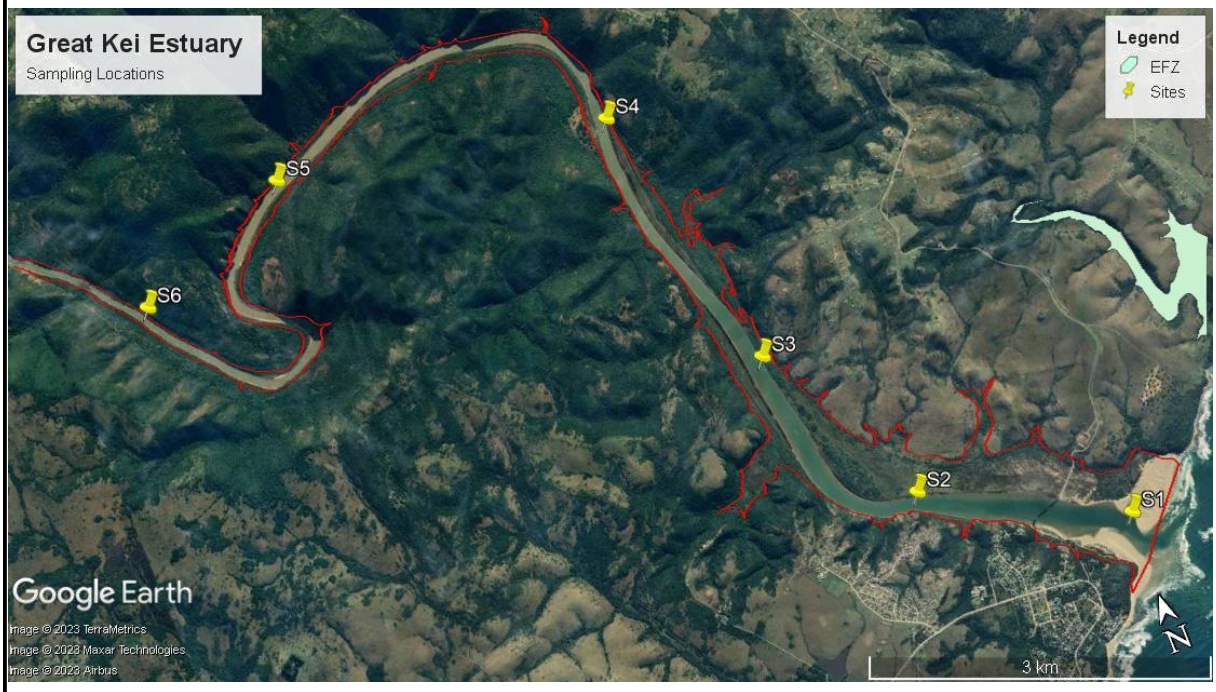

Figure 5-5: Map of Water Quality and Microalgae sites for the Great Kei Estuary field survey - November 2023

Table 5-5 lists *in situ* water quality measurements that were taken during the field trip. Nutrient samples will be processed by SAEON/NMU laboratory.

The estuary displayed similar salinity distribution profiles as observed in the Mbashe Estuary, On Wednesday 5 December the estuary was visited at the mouth. Accordingly, mesohaline (5-18) surface waters persisted throughout the lower and middle reaches (Site 1-4), with marine conditions (> 30) persisting at depth. Marine intrusion into the upper reaches was evidenced by brackish (salinity ca. 12) bottom-waters being observed at Site 5. However, Site 6 was characterised by well-mixed freshwater conditions (salinity < 0.25). Dissolved oxygen conditions were typically well-oxygenated (>6 mg/L) throughout the estuary, with instances of supersaturated conditions (>120%) observed in the surface waters at Site 2 and 3 (i.e.,

indicative of a phytoplankton bloom). Turbidity increased from the mouth (NTU < 5) to the upper (NTU ~ 15) reaches.

Table 5-5: Great Kei Estuary *in situ* water quality measurements

03/12/23	Time sampled	Co-ordinates	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	16h15	32°40'37.39"S; 28°23'5.74"E	0	18.40	107.10	8.57	8.46	22.50	4.59
			0.5	33.18	101.40	8.13	8.20	17.00	0.78
			1	34.54	101.20	8.12	8.19	15.90	0.97
			1.5	34.56	101.10	8.10	8.18	16.00	1.46
			2	34.76	106.00	8.07	8.18	15.80	2.08
			2.5	34.82	103.00	8.06	8.17	15.80	3.62
Site 2	15h50	32°40'9.65"S; 28°22'1.20"E	0	14.41	122.40	9.81	8.50	22.40	7.55
			0.5	26.41	111.20	8.97	8.27	18.90	8.17
			1	30.35	110.90	8.93	8.26	18.00	8.24
			1.5	31.97	105.20	8.37	8.22	17.00	6.51
			2	32.59	103.00	8.23	8.20	16.80	6.99
			2.5	32.61	101.80	8.13	8.20	16.70	7.65
			3	33.04	99.10	7.91	8.19	16.60	12.44
			3.5	34.33	96.00	7.70	8.16	16.10	19.01
			4	34.50	95.10	7.64	8.15	15.80	20.01
Site 3	15h25	32°39'18.02"S; 28°21'29.80"E	0	5.10	122.00	10.09	8.87	24.00	9.21
			0.5	6.46	114.80	9.39	8.72	22.80	12.72
			1	29.04	92.10	7.25	8.17	18.20	11.62
			1.5	32.36	88.20	7.04	8.12	16.80	29.72
Site 4	15h12	32°37'59.41"S; 28°21'10.67"E	0	1.12	94.40	7.77	8.86	24.90	16.74
			0.5	5.13	80.80	6.59	8.47	24.10	18.94
			1	24.93	61.40	4.81	7.98	20.10	22.92
			1.5	29.32	63.70	4.99	7.97	18.70	26.29
			2	29.41	65.60	5.14	7.88	18.60	26.98
Site 5	14h42	32°37'36.23"S; 28°19'34.50"E	0	0.36	96.60	8.02	8.89	24.70	16.33
			0.5	1.45	89.80	7.48	8.87	24.50	17.09
			0.9	5.59	70.00	5.66	8.17	24.00	15.21
			1.2	12.21	47.10	3.75	7.95	23.60	14.83
Site 6	14h20	32°38'29.67"S; 28°18'53.68"E	0	0.23	105.90	8.67	9.04	25.50	14.38
			0.5	0.23	105.80	8.66	9.05	25.40	16.81
			0.8	0.23	105.60	8.65	9.05	25.40	16.90

Macrophytes:

Sampling took place on 3 December 2023. Mangroves occurred in the lower and middle reaches along the drift line. Their presence in the Kei Estuary is unusual as this is a freshwater dominated estuary. Mangroves first appeared in 2013; visible on Google Earth image and now cover 1.03 ha. Only one species, *Avicennia marina*, was found; this is a pioneer species first colonizing new habitats. Stands in the lower reaches were dead due to sediment deposition and smothering of the pneumatophores. No regeneration was observed, however

seedlings were found growing amongst salt marsh near the “pont” in the lower reaches. Mangrove stands are backed by salt marsh, represented by *Triglochin* spp., *Cotula coronopifolia, Bassia diffusa, Salicornia* spp. and saline grasses. Large areas occur on the eastern bank near the “pont” with narrow intertidal banks in the lower reaches. Reeds were represented by *Schoenoplectus scirpoides, Phragmites australis* and *Bolboschoenus maritimus* which were found to occur along the narrow banks from the mouth to the head of the estuary, indicating brackish and freshwater conditions. In places the reeds were located in front of the mangrove stands fringing the main channel; a clear indication of freshwater conditions. Thick mud was associated with the *Bolboschoenus* zone and possible erosion was observed. Macroalgae were found washed up on the sedges and salt marsh near the mouth on the east bank. Terrestrial vegetation was represented by Albany Thicket (Hamburg Dune Thicket).

Pressures observed were bank erosion due to cattle, as well as bank slumps in places due to the recent floods, and possibly boat action. Development in the form of jetties and houses occur in the lower reaches and the “pont” access road and associated people have caused degradation of the salt marsh in terms of footpaths and trampling. Cattle were observed browsing the salt marsh. Alien vegetation represented by *Arundo donax, Lantana camara, Sesbania punicea, Acacia mearnsii, Tamarisk ramosisimma* and *Ricinus communis* were observed in the middle reaches.

Macroinvertebrates:

Field observations for macroinvertebrates for this estuary are made from process-driven metrics of habitat condition and ex-situ assessment of field information and photographs or data. Estuary is in a fluvially dominated, but transition state with marine connectivity, as evidenced by well-established halocline. Highly dynamic sediment processes, evidence of erosion and flooding, causing mangrove die back with resultant transitional macrophyte-dominated states (mangrove to salt marsh) and incipient changes in macroinvertebrates. High level of trampling of intertidal and supratidal marsh by cattle browsing, as well as harvesting of mangroves (both incurring sediment desiccation pressures). Reported high fishing pressures, likely reducing top-down pressures on macroinvertebrates. Impacts on macroinvertebrates, particularly brachyurans (crabs) that are common within mangroves habitats, would be a reduction in abundance and diversity following sediment compression and desiccation, as well as transition to salt marsh dominated system. Marine connection would facilitate active recruitment of species such as *Scylla serrata* (mud crab) and *Upogebia africana* (mud prawn). High freshwater influence and fluvially dominated state would not optimise for zooplankton community, with reported high turbidity in estuary likely favouring benthic rather than planktonic macrofauna.

Birds:

The team started sampling at 13:10 on the 3rd December and ended at 17:30 (**Table 5-6**. The abundance of birds was greatest in the lower reaches of the estuary. Here, birds were active and feeding whilst White-breasted Cormorant were seen sunning themselves. Greater Crested (swift) Terns and Little Terns were present on a sand bank near the mouth of the estuary (**Figure 5-**6a). Little Terns and Pied Kingfishers were also seen flying around and occasionally driving into the water. Kelp Gulls and an Oyster Catcher was seen near the mouth. A single Black-winged Stilt was feeding amongst the plovers and Little Stints. Near the Pont were two Pied Wagtails together with Common Ringed Plovers, Three-banded Plovers and Whimbrels feeding in the intertidal area. A Hamerkop was seen walking in a stream from

a stormwater drain (Figure 5-6**b**) and Water Thick-knees were present in the foredunes. An African Fish Eagle flew near the mouth of the estuary (Figure 5-6**c**) and another was present in the middle estuary on a steep forested bank. Yellow-billed Ducks and Red-billed Teals were seen along the banks and in the water in the lower to middle estuary. Spur-winged Geese were seen on sandy bank in the upper estuary (Figure 5-6**d**). An African Harrier Hawk was seen being chased by Fork-tailed Drogo's and later it was seen perching on the rocky cliffs looking into the crevasses (**Figure 5-6e**). Red-winged Starlings were seen flying between the rocky cliffs. Throughout the estuary, Barn Swallows were seen flying around. A Giant Kingfisher was seen flying past and Brown Hooded Kingfishers were seen and heard in the upper reaches of the estuary. In the upper reaches of the estuary, trumpeter hornbills flew in groups between large trees (**Figure 5-6f**). Black Cuckoos, Southern Boubou and Knysna Turaco were heard in the floodplain but not seen. Common Greenshank was scattered throughout the estuary and Spectacled Weavers were seen in the nests along the banks in the *Phragmites australis*.

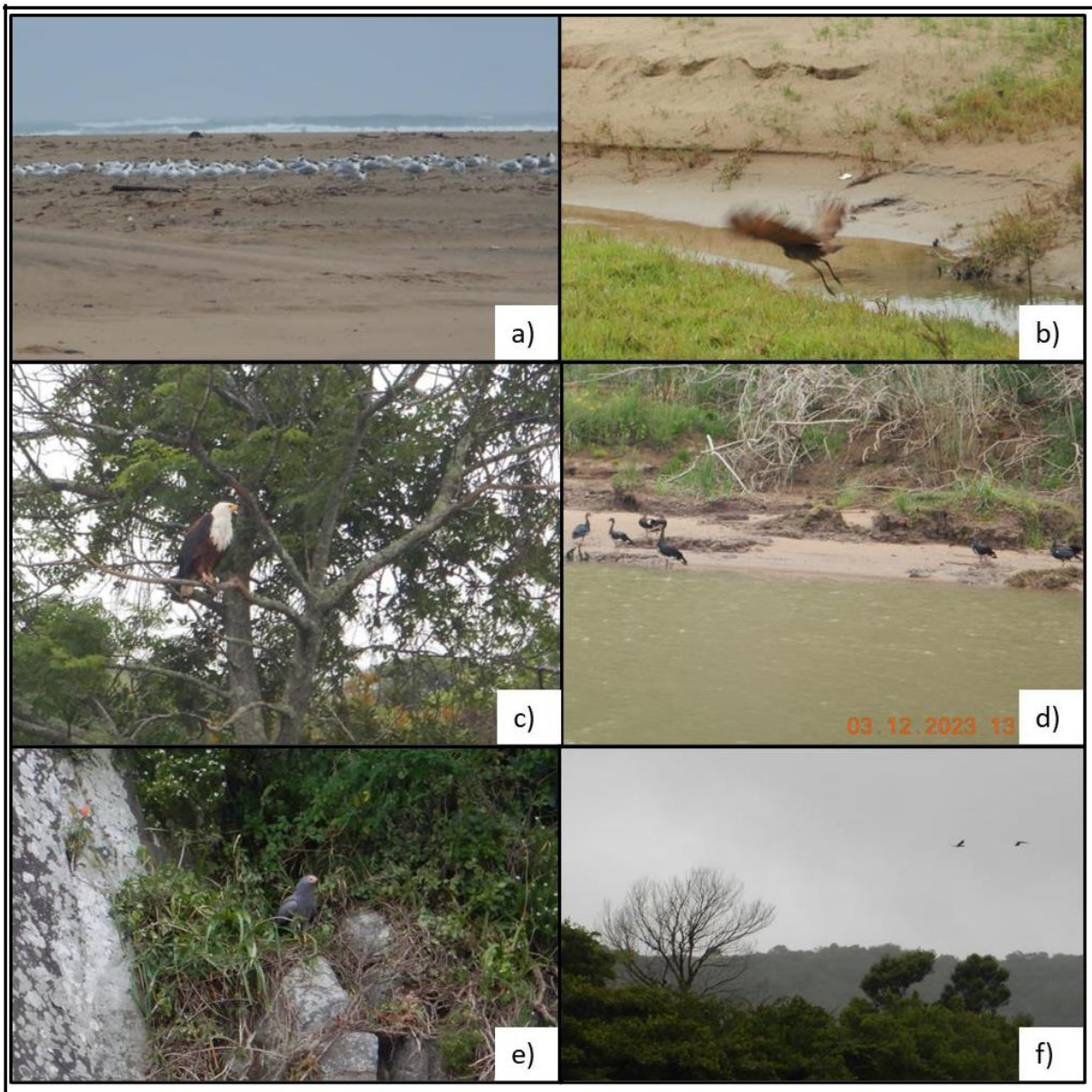

Figure 5-6: Photos of some of the birds seen in the Great Kei Estuary. A) Terns at the estuary mouth, b) a Hamerkop wading in water from a stormwater outlet, c) African Fish Eagle, d) Spur-winged Geese on a bank, e) African Harrier Hawk, f) Trumpeter Hornbill flying between trees.

Table 5-6: Great Kei Estuary bird counts

Common name	Count
African black oystercatcher	1
African fish eagle	2
African pied wagtail	3
African sacred ibis	6
Barn swallow	20

Black-headed heron	1
Blacksmith lapwing	19
Black-winged stilt	1
Brown-hooded kingfisher	3
Cape cormorant	1
Common greenshank	25
Common ringed plover	166
Curlew sandpiper	5
Egyptian goose	11
Giant kingfisher	1
Greater crested (swift) tern	94
Hadeda ibis	2
Hamerkop	1
Harrier hawk	1
Kelp gull	21
Kittlitzes plover	2
Little stint	20
Little tern	16
Pied kingfisher	2
Red-billed teal	21
Red-eyed dove	5
Red-winged starling	7
Spectacled weaver	60
Spur-winged goose	7
Trumpeter hornbill	12
Water thicknee	5
Whitebreasted cormorant	4
White-fronted plover	11
Yellow-billed duck	17
Yellow-billed kite	1

5.4 Tyolomnqa Estuary

Sample Date	04/12/2024	Reserve Level Assessment	Desktop PES
Estuary Name	Tyolomnqa Estuary	IUA	IUA_R01
No. of sites	Entire Estuary	IUA description	Keiskamma
Estuary Type	Large Temporarily Closed	Prioritised RU	-
Altitude (m.a.s.l.)	0 m	Quaternary catchment	R40C
Longitude	27.583421	Latitude	-33.22577194
PES (NBA, 2018)	B	Conditions during sampling	Transition state
Components currently impacting PES	Physical Habitat, Fish		
Ecological Importance	Important		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 417
- Reference MAR (m^3x10^6): 35.561
- Seasonality of rainfall: All year
- Marine upwelling zone: No
- Important Fish Nursery: Medium
- Estuary length: 16.7 km

Site impacts:

- Low – Flow reduction pressure;
- Low – Pollution pressure;
- Low – Habitat loss/Transformation of banks in lower reaches pressure;
- High – Fishing pressure;
- Medium – Grazing/browsing pressure; and
- High – Alien/translocated fish.

Components sampled/observed:

- Mouth configuration;
- Physical Habitat;
- Water quality;
- Microalgae;
- Macrophytes;

- Invertebrates; and
- Birds

Hydrodynamics and Physical Processes:

The mouth was open with a good tidal exchange. Some stratification in the upper water column due to freshwater input. The estuary was in a transition state from Marine to Brackish/Fresh State.

The riparian area near-natural with very little disturbance of physical processes.

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 5-7** for the location of survey sites.

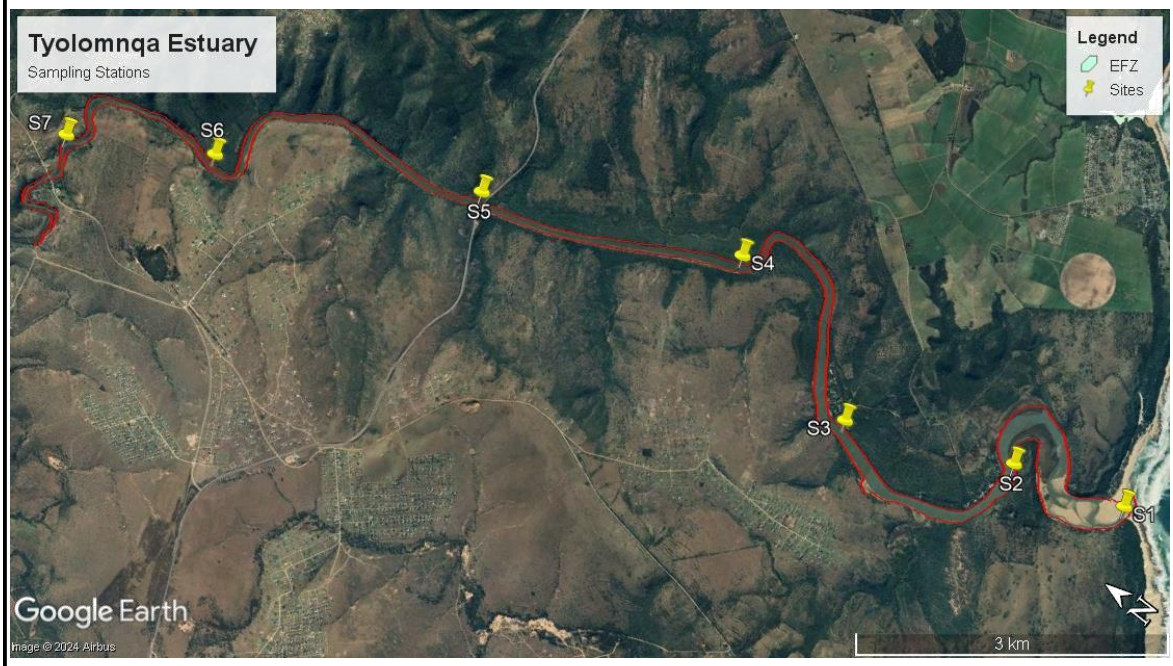

Figure 5-7: Map of Water Quality and Microalgae sites for the Tyolomnqa Estuary field survey - November 2023

Table 5-7 lists *in situ* water quality measurements that were taken during the field trip. Nutrient samples will be processed by SAEON/NMU laboratory.

A marked longitudinal salinity gradient was observed in the estuary, with well-mixed marine conditions (salinity > 34) in the lower reaches (Site 1-2) and mesohaline conditions (salinity < 8) in the upper reaches (Site 6-7). The middle reaches were largely polyhaline (range: 18-30), with marginal vertical stratification observed.

DO conditions were well-oxygenated (>5 mg/L), becoming biologically-stressful (<5 mg/L) in the upper reaches.

Turbidity increased from the mouth (NTU ~ 5) to the upper (NTU ~ 10) reaches.

Table 5-7: Tyolomnqa Estuary *in situ* water quality measurements

04/12/23	Time	Co-ordinates	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	14h10	33°13'33.38"S; 27°34'50.85"E	0	34.59	103.00	7.95	8.18	17.90	5.02
			0.5	34.59	102.90	7.93	8.18	17.90	5.13
			1	34.59	102.80	7.93	8.18	17.90	5.00
			1.5	34.59	102.60	7.91	8.18	17.90	5.28
Site 2	13h40	33°12'58.11"S; 27°34'38.00"E	0	33.54	96.60	7.30	8.12	19.30	7.27
			0.5	33.66	96.80	7.33	8.12	19.20	8.36
			1	33.75	96.60	7.32	8.12	19.00	8.39
			1.5	34.60	93.60	7.21	8.12	18.00	8.54
			1.8	34.76	92.40	7.13	8.10	17.80	15.67
Site 3	13h25	33°12'8.89"S; 27°34'12.11"E	0	29.70	93.50	6.97	8.08	21.30	10.97
			0.5	29.83	93.50	6.98	8.08	21.20	12.23
			1	31.80	88.70	6.58	8.05	21.00	18.62
Site 4	12h58	33°11'12.52"S; 27°34'36.52"E	0	23.02	86.70	6.54	8.04	23.00	10.76
			0.6	26.45	76.70	5.62	7.95	23.10	15.39
Site 5A	12h48	33°10'42.89"S; 27°34'18.92"E	0	21.09	79.10	5.96	7.97	23.60	12.32
			0.5	21.72	74.30	5.56	7.93	23.70	11.75
			1	25.82	68.60	5.04	7.90	23.30	10.79
			1.3	26.33	68.40	5.02	7.89	23.30	19.85
Site 5	12h26	33° 9'57.00"S; 27°33'55.53"E	0	16.24	80.00	6.21	7.98	23.40	10.68
			0.5	16.51	76.30	5.84	7.94	23.50	10.87
			0.8	19.31	66.80	5.04	7.90	24.00	9.93
Site 6	11h25	33° 8'45.02"S; 27°33'5.60"E	0	7.03	73.80	6.03	7.95	23.60	4.87
			0.5	7.57	68.10	5.34	7.88	23.80	6.93
			0.9	10.52	61.10	4.78	7.78	24.70	11.64
Site 7A	11h55	33° 8'8.02"S; 27°32'42.97"E	0	5.14	53.30	4.36	7.74	24.80	3.58
			0.5	6.42	40.10	3.12	7.62	25.50	4.86
			1	6.59	41.10	3.26	7.64	25.40	5.55
			1.5	6.70	41.40	3.30	7.65	25.10	10.33
			2	6.72	42.20	3.36	7.65	25.00	12.76
			2.5	6.73	41.90	3.33	7.66	25.00	14.25
			3	6.73	40.70	3.31	7.62	24.90	16.42
			3.5	6.75	39.30	3.12	7.61	24.80	18.53
Site 7	11h48	33° 8'5.08"S; 27°32'37.31"E	0	3.47	64.30	5.24	7.83	24.60	5.67

Macrophytes:

Sampling took place on 4 December 2024. Mangroves (*Avicennia marina*) occur in the lower reaches and were flowering and fruiting at the time. They seemed to be dying back in places, possibly due to recent floods and sedimentation and smothering of their pneumatophores (air roots). Associated with mangroves were stands of salt marsh represented by *Spartina maritima, Sarcocornia* spp*., Stenotaphrum secundatum, Bassia diffusa, Disphyma crassifolium, Limonium scabrum, Cotula* spp*.,* and *Triglochin* spp. Salt marsh form a clear zonation along an elevation gradient near the mouth and back channel. *Spartina maritima* forms large monospecific stands in the lower intertidal and can be seen to occur together with *Avicennia marina*, representing a mix of temperate and subtropical species. A narrow intertidal area forms in the lower reaches where typical salt marsh species occur. In the middle reaches below the R72 bridge terraces of salt marsh occur, backed by steep vegetated banks. Terrestrial vegetation is represented by Hamburg Dune Thicket and Bisho Thornveld Savanna.

The distribution of macrophytes indicate a transition zone from north to south (warm temperate to subtropical) along the coast where mangroves are encroaching into salt marsh and reed and sedge habitats. Reduced freshwater inflow and an increase in salinity would encourage this expansion; however the mangrove stands are dynamic changing in response to sediment input as well as salinity.

Pressures include trampling from footpaths on the supratidal salt marsh, browsing from cattle especially on the west bank, with development in the form of jetties and residential houses fragmenting habitat in the intertidal habitat. Natural bank erosion from wave action was observed in the lower reaches. Invasive species observed were *Opuntia ficus-indica* (Prickly pear).




Macroinvertebrates"

Field observations for macroinvertebrates for this estuary are made from process-driven metrics of habitat condition and ex situ assessment of field information and photographs or data. Estuary is in a temporarily open closed, but transition state with intermittent marine connectivity. At the time of sampling the mouth was open with good marine connection. Some evidence of a halocline. Estuary transitioning toward fresh/brackish state. Evidence of trampling of intertidal and supratidal marsh by cattle browsing. Reported high fishing pressures, likely reducing top-down pressures on macroinvertebrates. Impacts on macroinvertebrates would be a reduction in abundance and diversity following sediment compression and desiccation. The estuary is at the warm temperature sub-tropical transition, therefore both mangrove and salt marsh habitats. Transitional flux in system will result in pioneer to successional flux in macroinvertebrates, compounded by intermittent marine connectivity and resultant community flux thereby. Lack of permanent marine connection would result in contingent recruitment of species such as *Scylla serrata* (mud crab) and *Upogebia africana* (mud prawn). Lower reaches and exposed or shallow sand banks likely to facilitate high macroinvertebrate productivity, and important provision of foraging grounds for higher trophic levels. Zooplankton community likely to be typical of estuaries with intermittent marine connection, not well established and seasonally or state-driven cyclicity.

Birds:

The weather was rainy and windy during sampling at the Tyolomnqa Estuary on the 4th of December. At the launch site a Red-eyed Dove, Pied Kingfisher, Glossy Starlings and Green Wood Hoopoe were seen. Barn Swallows were seen flying throughout the day and at the mouth White-throated Swallows were seen sheltering on the beach (Figure 5-8**a**). In the middle reaches of the estuary, Egyptian Geese with a juvenile were seen as well as Grey Heron and a Great Egret (Figure 5-8**b, c**). Four Bee-eaters were seen along holes in the bank (**Figure 5-8d**) which were either Little or Swallow-tailed bee-eaters. Two Pygmy Kingfishers were also seen flying from this bank. Three Jackal Buzzards were seen, of which two were resting in a tall tree along the estuary. A Pin-tailed Wydah was seen in flight and in the upper estuary a Brown Hooded Kingfisher was seen and heard calling from the bush (**Figure 7e**). Weavers (Southern Masked and Cape) were seen flying in and out of an overhanging tree with nests (Figure 5-8**f)**. Not all birds were counted in the lower estuary due to poor visibility from the rainy weather. One large bank in particular had a number of birds feeding (Whimbrel, Greenshank, Sandpipers). Two African Fish Eagles and Kelp Gulls were seen in the bush near the mouth of the estuary. A Southern Boubou was seen darting between the coastal bush and Water Thick-knees were seen on the rocky shore. Black Cuckoos, Cape Turtle Doves, Sombre Greenbul, Burchell's Coucal and Rufous-naped Lark were heard but not seen.

Figure 5-8: A number of birds seen at Tyolomnqa Estuary. A) White-throated Swallows near the mouth, b) Grey Herons in flight, c) Great Egret, d) holes in the bank, e) Brown-hooded Kingfisher in the upper estuary, e) weavers and their nests. Table

5-8: Tyolomnqa Estuary bird counts

Common name	Counts
African fish eagle	2
African pygmy kingfisher	2
Bee-eater (little or swallow-tailed)	4
Barn swallow	57
Blacksmith lapwing	1
Brown-hooded kingfisher	1

Cape cormorant	1
Cape (glossy) starling	6
Cape wagtail	15
Cape weaver	6
Common greenshank	15
Common ringed plover	1
Common sandpiper	4
Darked capped bulbul	3
Egyptian goose	11
Fork-tailed drongo	2
Green wood hoopoe	2
Great egret	1
Greater sand polver	1
Grey heron	2
Hadeda ibis	5
Jackal buzzard	3
Kelp gull	3
Pied kingfisher	8
Pin-tailed whydah	1
Red-eyed dove	5
Red-winged starling	8
Reed cormorant	1
Southern boubou	2
Southern masked weaver	11
Speckled mousebird	2
Water thicknee	2
Whimbrel	15
White-throated swallow	13
Yellow-billed duck	4

5.5 Keiskamma Estuary

Sample Date	05/12/2024	Reserve Level Assessment	Rapid
Estuary Name	Keiskamma Estuary	IUA	IUA_R01
No. of sites	Entire Estuary	IUA description	Keiskamma
Estuary Type	Predominantly Open	Prioritised RU	E_RU10
Altitude (m.a.s.l.)	0	Quaternary catchment	R10M
Longitude	27.491233	Latitude	-33.28148
PES (NBA, 2018)	B/C	Conditions during sampling	Transition state
Components currently impacting PES	Water quality, Physical habitats, Macrophytes, Invertebrates, Fish,		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 2 696
- Reference MAR (m^3x10^6): 138.9
- Seasonality of rainfall: All Year/Late/Very Late Summer
- Marine upwelling zone: No
- Important Fish Nursery: High
- Estuary length: 22 km

Site impacts:

- Low - Flow reduction pressure;
- Medium - Pollution pressure;
- Medium - Habitat loss/Transformation of banks in lower reaches;
- High - Fishing pressure;
- High - Grazing/cattle browsing pressure; and
- High - Alien/translocated fish.

Components sampled:

- Mouth configuration;
- Physical Habitat;
- Water quality;
- Microalgae;
- Macrophytes; and
- Birds

Hydrodynamics and Physical Processes:

The mouth was open with a good tidal exchange. Some stratification in the upper water column due to freshwater input. The estuary was in a transition state from Marine to Brackish/Fresh State.

Riparian area near-natural with very little disturbance of physical processes. Some evidence of local erosion caused by cattle.

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 5-9** for the location of survey sites.

Figure 5-9: Map of Water Quality and Microalgae sites for the Keiskamma Estuary field survey - November 2023

Table 5-9 lists *in situ* water quality measurements taken during the field trip. Nutrient samples will be processed by SAEON/NMU laboratory.

The estuary displayed distinct longitudinal and vertical salinity gradients. More specifically, well-mixed marine conditions characterised the lower reaches (Site 1-2), whereas mesohaline (< 7) surface waters and polyhaline (> 20) bottom-waters persisted throughout the middle reaches (Site 4-5). Marine intrusion into the upper reaches was evidenced by mesohaline (> 5) bottom-waters being observed in the upper reaches (Site 6-7), despite freshwater conditions (salinity < 0.25) presiding in the surface waters. Well-oxygenated conditions (>6 mg/L) were observed

throughout the lower and middle reaches (Site 1-5), becoming biologically-stressful (< 4.5 mg/L) in the upper reaches. The bottom-waters in the upper reaches were also hypoxic (< 2.5 mg/L). Turbidity increased from the mouth (NTU ~ 1) to the upper (NTU ~ 60) reaches.

Table 5-9: Keiskamma Estuary *in situ* water quality measurements

05/12/23	Time	Co-ordinates	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	09h15	33°16'51.35"S; 27°29'25.21"E	0	35.47	104.10	8.12	8.22	17.00	0.75
			0.5	35.47	103.80	8.11	8.22	17.00	0.85
			1.2	35.47	103.70	8.09	8.22	17.00	0.86
Site 2	09h35	33°17'1.19"S; 27°27'48.42"E	0	27.97	102.40	8.08	8.20	19.00	10.20
			0.5	28.32	102.00	8.07	8.20	18.80	16.04
			0.8	31.20	103.40	8.14	8.20	17.90	25.01
Site 3	10h00	33°16'6.30"S; 27°27'25.66"E	0	16.61	101.40	8.12	8.18	21.70	19.73
			0.5	16.70	98.20	7.91	8.17	21.30	16.07
			1	18.63	93.00	7.54	8.16	20.30	18.84
			1.2	27.84	85.10	6.63	8.06	19.60	22.71
Site 4	10h25	33°15'28.21"S; 27°26'31.14"E	0	6.47	101.20	8.41	8.22	22.80	20.53
			0.5	6.91	98.80	8.24	8.24	22.70	19.60
			1	9.13	84.60	7.20	8.10	20.70	19.87
			1.2	18.56	69.10	5.47	7.89	20.40	19.91
			1.5	27.62	59.90	4.85	7.86	20.50	26.31
			2	27.81	58.80	4.72	7.87	20.50	28.99
Site 5	10h45	33°14'32.02"S; 27°26'13.85"E	0	3.08	93.20	7.78	8.09	23.30	5.84
			0.5	3.36	91.60	7.68	8.10	23.30	6.21
			1	6.34	74.80	6.36	7.90	21.90	10.76
			1.5	19.73	63.00	4.99	7.85	21.10	30.23
			2.2	24.49	62.00	4.77	7.81	21.20	38.45
Site 6A	11h10	33°14'12.21"S; 27°25'7.09"E	0	1.19	75.00	6.29	7.86	23.50	62.74
			0.5	1.20	72.80	6.17	7.87	23.20	62.30
			1	1.22	65.80	5.63	7.87	23.10	61.87
			1.5	10.78	42.20	3.36	7.54	22.40	19.59
			2	21.07	35.50	2.72	7.52	22.20	35.99
			2.4	21.08	33.20	2.68	7.50	22.60	36.37
Site 6	11h30	33°13'22.58"S; 27°24'56.31"E	0	0.56	75.40	6.28	7.84	24.60	62.02
			0.5	0.59	66.70	5.68	7.84	23.20	61.86
			1	0.60	64.90	5.55	7.87	23.20	61.53
			1.5	0.66	59.60	5.13	7.95	23.10	62.81
			2	17.45	33.40	2.60	7.45	22.70	22.17
			2.5	17.98	33.00	2.54	7.44	22.70	30.69
			3	18.08	32.50	2.51	7.44	22.70	34.10
Site 7A	11h45	33°12'32.49"S; 27°26'1.58"E	0	0.23	72.40	6.02	7.93	24.90	66.45
			0.5	0.23	61.80	5.22	7.93	23.40	68.85
			1	0.23	60.60	5.19	7.93	23.20	72.30
			1.5	0.25	54.60	4.71	7.86	23.10	72.64

			2	4.00	39.20	3.36	7.50	23.10	49.78
			2.5	12.78	21.90	1.72	7.24	23.00	18.31
			3	12.97	21.60	1.70	7.22	23.00	18.91
Site 7	11h55	33°11'39.48"S; 27°25'38.70"E	0	0.17	75.90	6.40	7.90	23.80	66.08
			0.5	0.17	72.30	6.13	7.88	23.60	67.49
			1	0.17	66.70	5.73	7.88	22.90	70.56
			1.5	0.17	64.70	5.57	7.89	22.80	70.43
			2	0.18	62.70	5.40	7.90	22.80	74.60
			2.5	0.22	54.70	4.76	7.85	22.80	85.60
			2.75	3.80	30.40	2.52	7.27	23.10	39.41
			3.1	5.73	24.80	2.03	7.22	23.40	32.43

Macrophytes:

Sampling took place on the 5th of December 2023. Submerged macrophytes are represented by the endangered seagrass *Zostera capensis* which occurs in the lower reaches of the estuary. Salt marsh occurs extensively in the lower reaches of the estuary where large monospecific stands of the lower intertidal grass *Spartina maritima* occurs. *Bassia diffusa, Sarcocornia* spp*., Triglochin* spp*., Juncus kraussii, Cotula* spp*., Atriplex* and saline grasses were common species observed. Large floodplain areas in a degraded state occur in the middle and upper reaches vegetated by mostly saline grasses. These are fallow lands representing intensive agricultural schemes that took place during the 1950s to the 1970s and are now trampled and grazed. Mangroves were represented by a single *Bruguiera gymnorrhiza* sapling in the *Spartina* stands. It is likely that this washed in with the tide and grew given suitable conditions as this is not a mangrove estuary. Reeds and sedges (*Schoenoplectus scirpoides, Phragmites australis*) occur where salinity drops below 20 ppt. Macroalgae washed in through the mouth was seen deposited onto salt marsh. Terrestrial habitat was represented by Albany Thicket (Hamburg Dune Thicket and Doubledrift Karroid Thicket).

Pressures observed were the trampling of salt marsh by cattle, which was not present in the fenced off areas. Trampling also caused bank erosion as cattle attempt to access the water channel. Floodplain degradation from previous cultivation in the 1950s to 1970s was observed in the lower reaches. Jetties across the salt marsh occur in the lower reaches. Seepage from developments on the western bank in the lower reaches was observed. Invasive species include *Opuntia ficus-indica*.




Macroinvertebrates:

Field observations for macroinvertebrates for this estuary are made from process-driven metrics of habitat condition and ex situ assessment of field information and photographs or data. Estuary is in a predominantly open, but transition state with marine connectivity, as evidenced by well-established halocline. High level of trampling of intertidal and supratidal marsh by cattle browsing (incurring sediment desiccation pressures). Reported high fishing pressures, likely reducing top-down pressures on macroinvertebrates. Impacts on macroinvertebrates would be a reduction in abundance and diversity following sediment compression and desiccation, as well as transition to salt marsh dominated system. Marine connection would facilitate active recruitment of species such as *Scylla serrata* (mud crab) and *Upogebia africana* (mud prawn). Turbid waters and evidence of erosion pressures would not optimise for zooplankton community, with reported high turbidity in estuary likely favouring benthic rather than planktonic macrofauna. Intertidal marsh areas and seagrass beds facilitate macroinvertebrate community, especially brachyurans and mud prawns, as a food resource for higher trophic levels.

Birds:

The weather at the Keiskamma Estuary on the 5th of December was sunny with a slight breeze and ended with gusts at midday. Near the mouth of the estuary a large group of terns were flying together which were either Little or Common Terns (Figure 5-10**a**, **Table 5-10**). Little Terns were seen flying by themselves and occasionally driving into the water. A Cape Wagtail

and a Three-banded Plover were seen close to the launch site. The mouth area was extensive and there was lots of intertidal space for birds. Two African Fish Eagles were in the lower estuary as well as a Goliath Heron (Figure 5-10**b**). Kelp Gulls were seen flying and White-breasted Cormorants were seen sunning themselves on branches or poles. Little Egret were seen throughout the estuary and one was observed catching a fish (Figure 5-10**c**). They were often seen together with cormorants. Except for the two Pied Kingfishers in the lower reaches of this estuary, no other kingfishers were seen. Cattle were present on the salt marsh banks and the occasional cattle egret was seen in the vicinity. Grey Plovers and Terek Sandpipers were seen in groups along the banks (Figure 5-10**d&e**). Whimbrels were also seen throughout the estuary often feeding or walking in the salt marsh. Common Ringed Plovers were seen in the lower-middle reach of the estuary as well as a pair with a fledgeling. Blacksmith Lapwings were seen in the middle reaches of the estuary along the bank. An African Spoonbill was seen flying over in this area. Several ducks and geese were seen in the middle reaches (**Figure 5-10f)**. This included Spur-winged Geese, Egyptian Geese, South African Shelduck, White-faced Whistling Duck and Yellow-billed Ducks. The South African Shelduck was seen with juveniles. Spectacled Weavers were seen in the *Phragmites australis* in and around their nests. Barn Swallows were seen flying around and later sitting on branches when the wind picked up. Black Winged Stilts were seen in the middle reaches of the estuary.

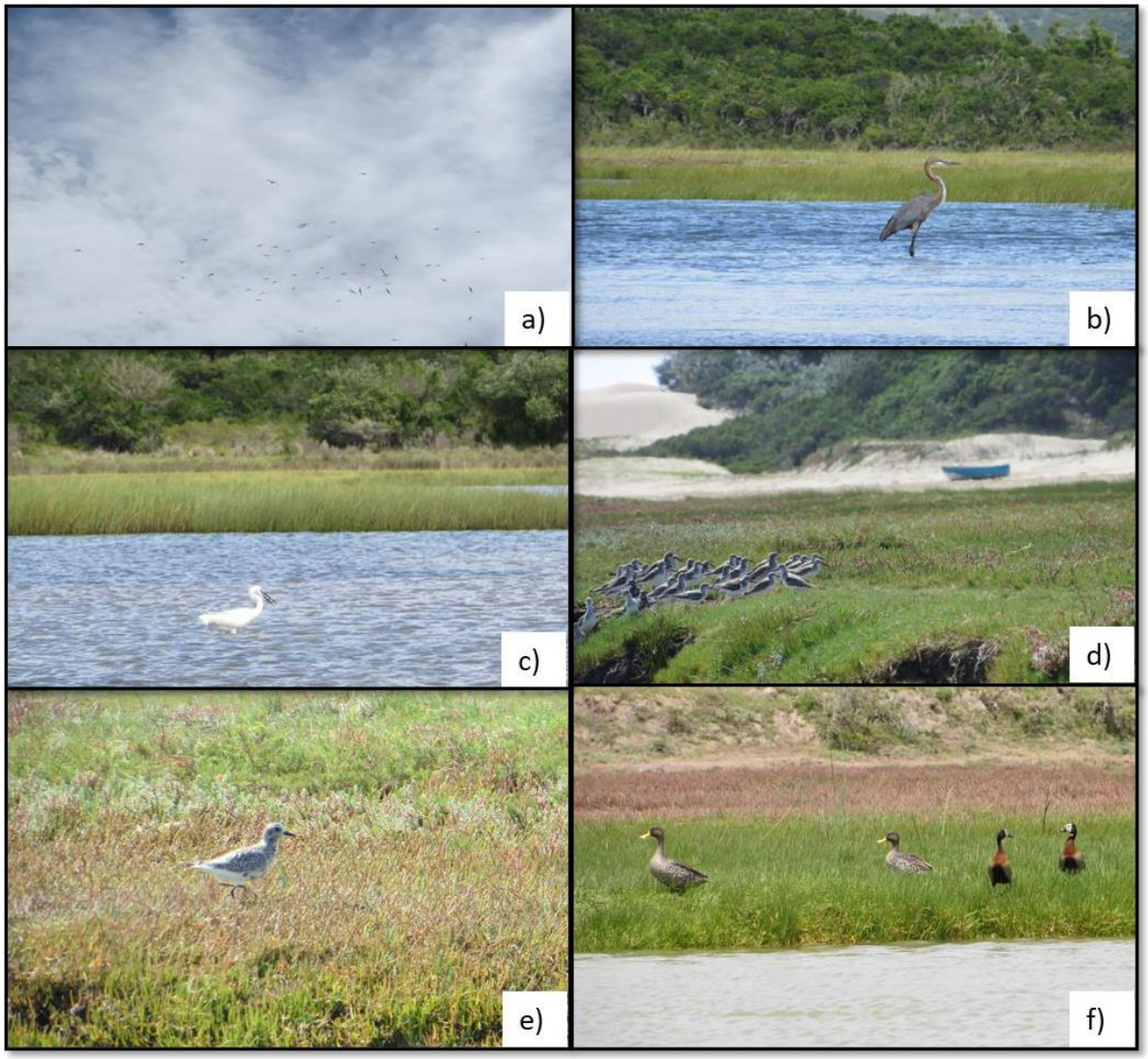

Figure 5-10: A number of birds seen in the Keiskamma Estuary a) a flock of terns, b) a Goliath Heron, c) a Little Egret fishing, d) Terek Sandpipers e) Grey Plover, f) Yellow-billed and White-faced Whistling Ducks.

Table 5-10: Keiskamma Estuary bird counts

Common name	Count
African fish eagle	2
African sacred ibis	4
African spoonbill	1
Barn swallow	17
Blacksmith lapwing	9
Black-winged stilt	3
Cape cormorant	11
Cape wagtail	6
Common greenshank	8

Common ringed plover	11
Common starling	1
Common tern	250
Curlew sandpiper	10
Egyptian goose	25
Grey plover	25
Goliath heron	1
Hadeda ibis	1
Kelp gull	4
Kittlitzes plover	3
Little egret	35
Little tern	5
Pied kingfisher	2
Reed cormorant	4
South African shelduck	22
Southern red bishop	2
Spectacled weaver	10
Spur-winged goose	17
Terek sandpiper	36
Three banded plover	1
Western cattle egret	3
Whimbrel	20
Whitebreasted cormorant	6
White faced whistling duck	2
Yellow-billed duck	8

6. ESTUARY SURVEY: APRIL 2024

6.1 Kowie Estuary

Sample Date	23/04/24	Reserve Level Assessment	Desktop PES
Estuary Name	Kowie Estuary	IUA	IUA_P01
No. of sites	Entire Estuary	IUA description	P primary catchment
Estuary Type	Predominantly Open	Prioritised RU	E_RU17
Altitude (m.a.s.l.)	0	Quaternary catchment	P40C
Longitude	26.901634	Latitude	-33.60362583
PES (NBA, 2018)	C	Conditions during sampling	Marine dominated State
Components currently impacting PES	Hydrodynamics, Physical habitat, Macrophytes, Fish		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 757
- Reference MAR (m^3x10^6): 31.816
- Seasonality of rainfall: All Year
- Marine upwelling zone: Yes
- Important Fish Nursery: High
- Stabilised mouth
- Estuary length: 19.7 km long

Site impacts:

- Low - Flow reduction pressure;
- Low - Pollution pressure;
- High - Habitat loss/Transformation of banks in lower reaches;
- High - Fishing pressure; and
- High - Alien/translocated fish.

Components sampled/observed:

- Mouth configuration;
- Physical Habitat;
- Water quality;
- Microalgae;

- Macrophytes;
- Invertebrates; and
- Birds.

Hydrodynamics and Physical Processes:

The mouth has been stabilized causing an increase in tidal exchange. This in turn would have resulted in the system becoming more saline. The estuary was in a Marine-dominated state during the sampling with very little freshwater input.

Riparian banks highly transformed in the lower reaches with significant loss of intertidal areas.

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 6-1** for the location of survey sites.

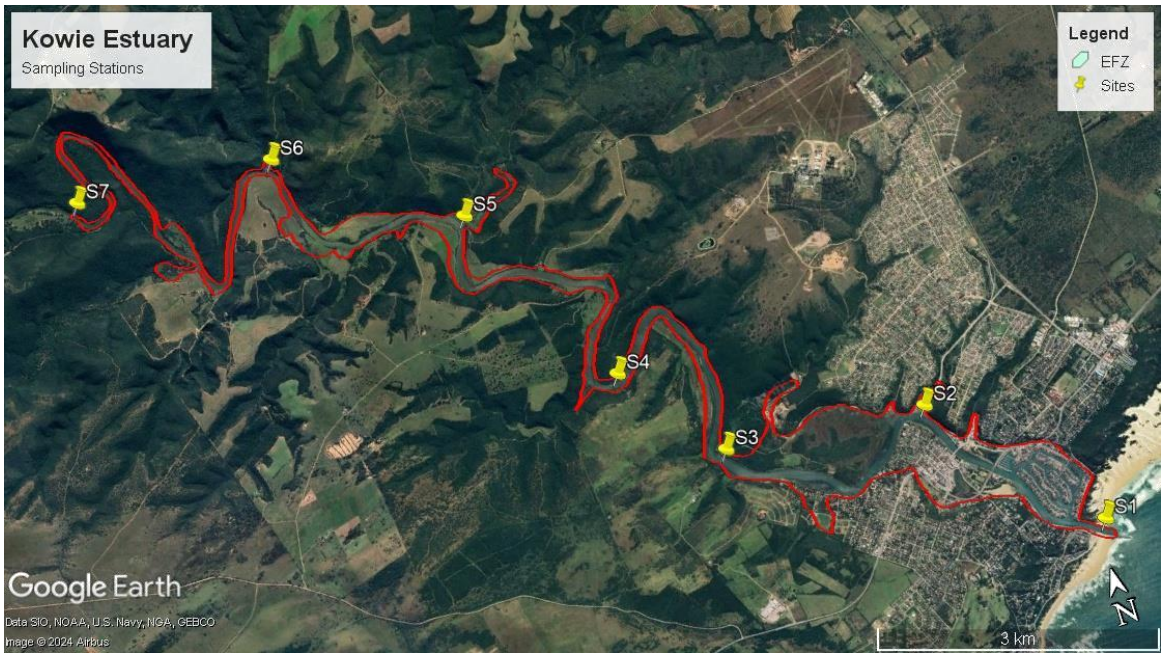

Figure 6-1: Map of Water Quality and Microalgae sites for the Kowie Estuary field survey - April 2024

Table 6-1 lists *in situ* water quality measurements taken during the field trip. Nutrient samples will be processed by SAEON/NMU laboratory.

A longitudinal salinity gradient was observed in the estuary, with vertical gradients largely absent. Salinity ranged from marine (> 30) in the lower reaches (Site 1-3) to mesohaline (ca. 12) in the upper reaches (Site 7). The middle reaches (Site 4-6) were characterised by well-mixed polyhaline conditions (salinity range: 19-28). Dissolved oxygen concentrations were

typical of well-oxygenated conditions (>5 mg/L) throughout the estuary, and turbidity increased from the mouth (NTU < 5) to the upper reaches (NTU > 10).

Table 6-1: Kowie Estuary *in situ* water quality measurements

23/04/24	Time	Co-ordinates	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	10h25	33°36'5.66"S; 26°53'53.08"E	0	34.16	87.00	6.74	8.10	17.50	3.75
			0.5	34.17	83.90	6.54	8.11	17.50	4.69
			1	34.24	83.00	6.49	8.12	17.20	4.99
			2	34.25	82.50	6.45	8.14	17.20	5.00
			3	34.41	82.30	6.47	8.14	17.00	4.81
			3.4	34.56	82.20	6.51	8.14	16.50	5.55
Site 2	11h00	33°35'14.28"S; 26°53'3.13"E	0	30.81	79.00	5.99	8.11	19.90	3.20
			0.5	32.63	78.90	5.95	8.13	19.70	4.45
			1	32.66	78.90	5.96	8.13	19.70	4.42
			2	32.69	78.90	5.96	8.13	19.60	4.66
			3	32.75	78.80	5.96	8.13	19.50	4.91
			4	32.74	79.10	5.98	8.13	19.50	5.39
			5.2	32.78	80.40	6.07	8.14	19.50	5.46
Site 3	11h30	33°35'8.49"S; 26°51'39.70"E	0	29.84	81.00	6.02	8.15	21.40	4.29
			0.5	30.02	80.00	5.97	8.15	21.10	5.22
			1	30.15	79.70	5.95	8.15	21.00	5.22
			1.5	30.18	79.70	5.96	8.15	20.90	5.89
			2	30.24	80.20	6.00	8.15	20.90	5.98
			2.25	30.34	81.40	6.08	8.15	20.80	7.88
Site 4	11h45	33°34'32.67"S; 26°51'6.22"E	0	27.49	79.30	5.97	8.14	21.40	6.36
			0.5	27.53	79.20	5.97	8.14	21.40	7.28
			1	27.53	79.10	5.96	8.14	21.40	7.07
			1.5	27.56	78.90	5.95	8.14	21.40	7.46
			2	27.57	78.70	5.94	8.14	21.30	8.03
			3	27.69	78.40	5.91	8.14	21.30	8.66
			4.3	27.70	78.40	5.91	8.14	21.30	13.93
Site 5	12h12	33°33'25.30"S; 26°50'25.21"E	0	22.65	80.30	6.18	8.17	21.70	7.98
			0.5	22.70	80.10	6.16	8.17	21.70	8.85
			1	22.73	80.10	6.17	8.17	21.70	8.87
			1.5	22.79	80.60	6.20	8.18	21.70	8.70
			1.75	22.81	81.00	6.23	8.18	21.70	11.80
Site 6	12h30	33°32'47.08"S; 26°49'15.99"E	0	19.03	79.50	6.23	8.21	21.90	10.74
			0.5	19.06	78.70	6.17	8.21	21.90	13.17
			1	19.12	78.40	6.15	8.21	21.90	13.32
			1.5	19.13	78.30	6.14	8.21	21.90	15.13
			2	19.15	78.30	6.14	8.21	21.90	16.28
			2.25	19.17	78.40	6.14	8.20	21.90	16.98
Site 7	12h48	33°32'41.48"S; 26°47'54.20"E	0	11.39	72.20	5.88	8.23	22.30	6.23
			0.5	12.77	68.00	5.55	8.21	21.90	9.08

			1	14.24	68.40	5.54	8.19	21.80	17.02

Macrophytes:

Sampling took place on the 23rd of April 2024. The endangered seagrass *Zostera capensis* was exposed on the low tide and occurs in the lower and middle reaches. Films of yellow benthic microalgae were observed on the exposed intertidal mudflats. This indicates possible signs of nutrient enrichment. Large areas of salt marsh occurred in the lower reaches where clear zonation was observed from the lower intertidal to supratidal zone (*Spartina maritima, Salicornia* spp*., Juncus* spp*. Disphyma crassifolia, Bassia diffusa* and saline grasses). Intertidal salt marsh is limited in the middle reaches due to steep banks. Reeds and sedges were represented by *Bolboschoenus maritimus* and *Phragmites australis* indicating freshwater seepage sites.

Pressures observed included inflow of stormwater from Wharf street; the associated turbidity plume was observed being pushed upstream with the tide. The exposed mudflats at low tide are affected by bait collecting and digging that is a significant pressure for the integrity of the endangered seagrass *Zostera capensis* as it has a shallow fragile root system. Browsing of intertidal and supratidal salt marsh by cattle was observed but this was not extensive. Degradation of supratidal salt marsh in areas transformed by agriculture were observed, along with presences of invasive terrestrial species and cattle grazing.




Macroinvertebrates:

Field observations for this estuary are made from direct measurements (sweep netting) of the hyperbenthos and epifauna associated with channel-fringing and creek-associated seagrass beds, as well as in situ observations. Estuary is in a predominantly open, marine-dominated, state with marine connectivity, as evidenced by well-established halocline to the upper reaches. Extensive habitat modification in the lower reaches (canalisation, marina development, recreational development – e.g., jetties) have affected the availability of intertidal habitat in the lower reaches, narrowing its extent and also ensuring a marine-dominated prevalence. This marine connection will facilitate the recruitment of estuarine-dependent species, as below. Hence macroinvertebrates closer to the mouth tend to be more typical of rocky shore marine biota. Reported high fishing pressures, likely reducing top-down pressures on macroinvertebrates. The zooplankton community would be marine dominated taxa while in the middle to upper reaches where a moderate REI zone prevails productivity would likely be increased. Extending from the mouth to middle reaches mudflats are exposed intertidally and in some areas are extensively reworked by subsistence harvesting – evidence of bait digging for *Upogebia africana* (mud prawn) and also burrow excavation for subsistence of *Scylla serrata* (mud crab) using destructive approaches like spades. This would both decrease macrofauna abundance of targeted organisms but also destabilise the mud flat and associated macrophytes causing cascade effects through to meiofauna. In the middle to upper reaches pristine areas of intertidal seagrass beds apparently unaffected by bait digging are apparent. These also supported the highest density of hyperbenthos (e.g., the shrimp

Palaemon peringueyi) of 21.9 n per m^3 compared to upper and lower reaches where *P. peringueyi* density was < 4 n per m^3. Microgastropods and other macrofauna were preserved in situ and will later be enumerated in the laboratory at Nelson Mandela University. Intertidal to supratidal marshes are impacted by trampling and cattle browsing, affecting sediment desiccation and compaction with knock-on effects on macrofauna.

Birds:

Waterbirds were sampled at fixed interval sites from the mouth to the middle/upper reaches (**Table 6-2**), beginning at 10h10 and ending at 11h14. Low tide was at 09h30. Weather was overcast and wind free. Therefore, observation conditions ideal. Expected to observe resident species and occasional over-wintering Palearctic migrants. A total of 127 waterbirds were observed across 19 species. In the lower reaches near the mouth, which is canalised and developed into a marina with extensive jetty structures, piscivorous species predominated (such as pied kingfishers, reed and Cape cormorants, grey herons, and little egrets) with waders notably in low abundance and possibly affected by the extensive bait digging, subsistence fishing and trampling of some sections of the *Zostera* intertidal beds. Water thicknees were often observed roosting amongst the jetties. Waders observed included spoonbills, whimbrels and black-winged stilts. In the middle to upper reaches typical freshwater-associated waterbirds were more prevalent, such as Egyptian geese and darters, as well as a single juvenile African fish eagle.

Table 6-2: Kowie Estuary bird counts

Name	Count
Water thicknee	8
Pied kingfisher	5
Kelp gull	5
Reed cormorant	10
Sacred ibis	8
Cape cormorant	13
Grey heron	8
Black-winged stilt	8
Egyptian goose	19
Blacksmith lapwing	13
Common ringed plover	4
Little egret	9
Spoonbill	5
Great white egret	3
Goliath heron	1
Whimbrel	4
Cattle egret	1
Darter	2
Fish eagle	1

6.2 Bushmans Estuary

Sample Date	24/04/2024	Reserve Level Assessment	Desktop PES
Estuary Name	Bushmans Estuary	IUA	IUA_P01
No. of sites	Entire Estuary	IUA description	P primary catchment
Estuary Type	Predominantly Open	Prioritised RU	E_RU16
Altitude (m.a.s.l.)	0	Quaternary catchment	P20A
Longitude	26.663622	Latitude	33.69491583
PES (NBA, 2018)	B/C	Conditions during sampling	Marine dominated State
Components currently impacting PES	Physical Habitat, Macrophytes, Fish		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 2 758
- Reference MAR (m^3x10^6): 42.86
- Seasonality of rainfall: All Year
- Marine upwelling zone: Yes
- Important Fish Nursery: High
- Estuary length: 35 km

Site impacts:

- Low – Flow reduction pressure;
- Low – Pollution pressure;
- Medium – Habitat loss/Transformation of banks in lower reaches;
- Very high – Fishing pressure; and
- High – Alien/translocated fish.

Components sampled/observed:

- Mouth configuration;
- Physical Habitat;
- Water quality;
- Microalgae;
- Macrophytes;
- Invertebrates; and

- Birds

Hydrodynamics and Physical Processes:

Mouth was open with a good tidal exchange. The estuary was in a Marine-dominated state during the sampling with very little freshwater input.

Significant riparian banks transformed in the lower reaches with some loss of intertidal areas.

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 6-2** for the location of survey sites.

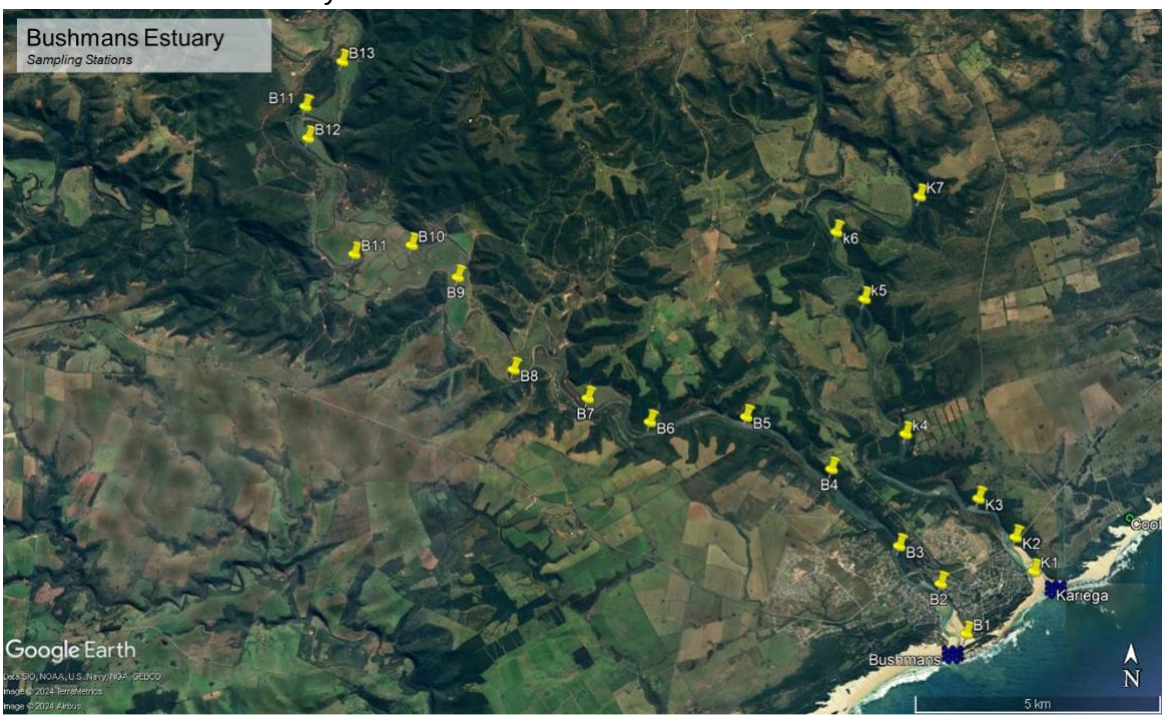

Figure 6-2: Map of Water Quality and Microalgae sites for the Bushmans Estuary field survey - April 2024

Table 6-3 lists *in situ* water quality measurements taken during the field trip. Nutrient samples are sent to NMU laboratory.

Similarly to the Kowie Estuary, a longitudinal salinity gradient was observed in the estuary and vertical gradients were absent. Accordingly, salinity ranged from marine (> 30) in the lower and middle reaches (Site 1-5) to mesohaline (ca. 17) in the upper reaches (Site 7).

Dissolved oxygen concentrations were typical of well-oxygenated conditions (>5 mg/L) throughout the estuary, with the exception of lower concentrations (~4 mg/L) in the upper reaches at Site 7.

Turbidity increased from the mouth (NTU < 4) to the upper reaches (NTU > 15).

Table 6-3: Bushmans Estuary *in situ* water quality measurements

24/04/24	Time	Co-ordinates	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	09h55	33°41'30.13"S; 26°39'45.93"E	0	34.99	94.50	7.56	8.23	15.80	3.22
			0.5	35.10	94.70	7.57	8.23	15.80	3.82
			1.4	35.14	95.10	7.60	8.24	15.80	4.01
Site 2	10h20	33°40'22.07"S; 26°38'57.72"E	0	35.01	91.20	7.11	8.27	17.20	2.22
			0.5	35.02	91.40	7.13	8.27	17.10	2.38
			1	35.02	91.80	7.17	8.27	17.00	2.40
			2	35.02	91.80	7.17	8.27	17.00	2.57
			3	35.03	92.20	7.21	8.27	17.00	2.57
			3.8	35.03	92.60	7.25	8.27	17.00	2.60
Site 3	10h45	33°39'8.94"S; 26°36'47.32"E	0	34.38	81.90	5.94	8.29	21.20	4.19
			0.5	34.38	82.10	5.96	8.29	21.20	4.51
			1	34.39	82.50	5.99	8.29	21.20	4.42
			1.5	34.39	83.20	6.04	8.29	21.20	4.66
			1.9	34.39	85.60	6.19	8.29	21.20	5.64
Site 4	11h07	33°38'30.87"S; 26°34'31.00"E	0	33.36	84.20	6.03	8.18	22.10	8.27
			0.5	33.36	84.10	6.04	8.18	22.10	9.48
			1	33.36	84.30	6.06	8.18	22.10	8.81
			2.5	33.37	84.60	6.08	8.18	22.10	8.65
			3.5	33.37	85.10	6.11	8.18	22.10	10.10
Site 5	11h32	33°37'58.43"S; 26°33'2.14"E	0	30.55	85.70	6.26	8.16	22.10	11.58
			0.5	30.58	86.00	6.28	8.16	22.10	11.80
			1	30.58	86.40	6.31	8.16	22.10	12.07
			1.9	30.60	88.30	6.43	8.17	22.10	11.60
Site 6	12h02	33°37'24.56"S; 26°31'24.22"E	0	24.10	73.70	5.57	8.16	22.30	16.16
			0.5	24.17	73.40	5.55	8.16	22.30	18.58
			1	24.24	73.70	5.57	8.16	22.30	21.34
			1.5	24.34	76.00	5.72	8.17	22.20	28.20
Site 7	12h35	33°35'7.94"S; 26°31'33.03"E	0	17.10	56.20	4.36	8.03	22.50	6.88
			0.5	17.16	54.50	4.28	8.03	22.50	9.24
			1	17.62	51.30	4.02	8.03	22.30	25.56

Macrophytes:

Sampling took place on the 24th of April 2024. The endangered seagrass *Zostera capensis* occurs in the middle and lower reaches, often together with macroalgae forming mixed

stands with *Codium tenue* and *Caulerpa filiformis*. These extensive seagrass beds have high biodiversity importance as they host rich and unique invertebrate and fish communities. The seagrass *Halophila ovalis* was also observed occurring below the *Zostera capensis* beds in deeper water. This is an important record for this seagrass as its distribution in South African estuaries is undocumented and it is likely also endangered because of human and climate change pressures. Intertidal and supratidal salt marsh occur in the lower and middle reaches of the estuary, with species such as *Spartina maritima, Atriplex* and *Salicornia* spp. observed. Reeds and sedges include *Phragmites australis, Bolboschoenus maritimus, Schoenoplectus scirpoides* and *Typha capensis*. These occur at freshwater seepage sites often associated with thick black organic sediments, possibly also an indication of land-based inputs.

Pressures include disturbance of the banks and riparian zone with jetties and residential development in the intertidal, supratidal and floodplain in places. Invasive plant species observed in the middle and upper reaches were *Opuntia ficus-indica, Eucalyptus* sp. (blue gum) and *Acacia cyclops (*rooikrans*).*

Macroinvertebrates:

Field observations for this estuary are made from direct measurements (sweep netting) of the hyperbenthos and epifauna associated with channel-fringing and creek-associated seagrass beds, as well as in situ observations. Estuary is in a predominantly open, marine-dominated, state with marine connectivity, as evidenced by well-established halocline to the upper reaches. Recreational-associated habitat modification in the lower reaches (e.g., jetties), which appears to be seasonally variable in intensity (e.g., low estuary boat use on day of sampling). Predominant effect would be in bank erosion and scouring, impact macrophyte foundational habitats. The marine connection will facilitate the recruitment of estuarine-dependent species, as below. Estuary is in a strongly marine dominated state, hence macroinvertebrates closer to the mouth tend to be more typical of rocky shore marine biota – for example, the Cape sea urchin *Parechinus angulosus* was observed within the seagrass, which is unusual for local estuaries. Reported very high fishing pressures, likely reducing top-down pressures on macroinvertebrates. The zooplankton community would be marine dominated taxa. Extending from the mouth to middle reaches mudflats are exposed intertidally and in some areas are reworked by apparently low subsistence harvesting – evidence of bait digging for *Upogebia africana* (mud prawn). This would both decrease macrofauna abundance of targeted organisms but also destabilise the mud flat and associated macrophytes causing cascade effects through to meiofauna. In the middle to upper reaches pristine areas of intertidal seagrass beds apparently unaffected by bait digging are apparent. However, the seagrass is in competition with macroalgae *Codium tenue*, likely affecting typical seagrass associated epifauna. The lowest reaches supported the highest density of hyperbenthos (e.g., the shrimp *Palaemon peringueyi*) of 46.3 n per m^3 in contrast to the middle reaches where *P. peringueyi* density was 15.0 n per m^3 and in the middle to upper reaches this declined to < 5 n per m^3. Other typical seagrass associated hyperbenthos and epifauna were observed such as the seagrass specialist isopods *Paridotea ungulata*, brachyurans such as *Hymenosoma orbiculare*, tick shells *Nassarius kraussianus* and shaggy sea hares *Bursatella leachii* in the lower reaches. Microgastropods and other macrofauna were preserved in situ and will later be enumerated in the laboratory at Nelson Mandela University. Intertidal to supratidal marshes appeared minimally impacted

by trampling and browsing, these extending into the Kariega Game Reserve. Extensive *Spartina maritima* salt marshes supporting crab populations such as *Parasesarma catenatum*, an important food resource for fishes and waterbirds such as herons observed feeding on the marsh.

Birds:

Waterbirds were sampled at fixed interval sites from the mouth to the middle/upper reaches (**Table 6-4**), beginning at 09h21 and ending at 11h30. Low tide was at 09h57. Weather was overcast and wind free. Therefore, observation conditions ideal. Expected to observe resident species and occasional over-wintering Palearctic migrants. A total of 128 waterbirds were observed across 23 species. Extensive *Zostera* beds in lower reaches fringing the main channel, with relatively low observed disturbance – recreational activities likely seasonally high, with a persistent subsistence resource harvesting influence. Fringing seagrass beds supported high numbers of piscivorous visual ambush foragers such as little and great white egrets, grey and goliath herons as well as pursuit and diving piscivores such as reed and Cape cormorants and pied kingfisher. Few waders other that black-winged stilts and whimbrels were observed. In the middle to upper reaches brown-hooded and giant kingfishers were observed, as well as waterfowl such as yellow-billed ducks and Egyptian geese. Other notable species seen were a single African fish eagle and a hamerkop.

Table 6-4: Bushmans Estuary bird counts

Name	Count
Grey heron	7
Sacred ibis	3
Kelp gull	8
Little egret	16
Great white egret	9
Pied kingfisher	8
Reed cormorant	8
Yellow-billed duck	14
Cape cormorant	2
Goliath heron	2
Giant kingfisher	2
Blacksmith lapwing	8
Fish eagle	1
Black-winged stilt	7
South african shelduck	4
Cape wagtail	7
Brown-hooded kingfisher	4
Black-headed heron	3
Hamerkop	1
Hadeda ibis	6
Common ringed plover	3
Egyptian goose	3
Whimbrel	2

6.3 Kariega Estuary

Sample Date	25/04/2024	Reserve Level Assessment	Rapid
Estuary Name	Kariega Estuary	IUA	IUA_P01
No. of sites	Entire Estuary	IUA description	P primary catchment
Estuary Type	Predominantly Open	Prioritised RU	E_RU09
Altitude (m.a.s.l.)	0	Quaternary catchment	P30C
Longitude	26.686399	Latitude	-33.68277083
PES (NBA, 2018)	C	Conditions during sampling	Marine dominated State
Components currently impacting PES	Hydrology, physical habitat, macrophytes and fish.		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 660
- Reference MAR (m^3x10^6): 21.69
- Seasonality of rainfall: All Year
- Marine upwelling zone: Yes
- Important Fish Nursery: High
- Estuary length: 20.9 km

Site impacts:

- Very High - Flow reduction pressure;
- Low - Pollution pressure;
- Medium - Habitat loss/Transformation of banks in lower reaches; and
- Medium - Fishing pressure.

Components sampled/observed:

- Mouth configuration;
- Physical Habitat;
- Water quality;
- Microalgae;
- Macrophytes;
- Invertebrates; and
- Birds

Hydrodynamics and Physical Processes:

The mouth was open with a good tidal exchange. The estuary was in a marine-dominated state during the sampling with very little freshwater input. Bridge in upper reaches bisects the upper reaches causing loss of openwater area and physical habitat.

Riparian banks significantly transformed in the lower reaches with some loss of intertidal areas.

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 6-3** for the location of survey sites.

Figure 6-3: Map of Water Quality and Microalgae sites for the Kariega Estuary field survey - April 2024

Table 6-5 lists *in situ* water quality measurements that were taken during the field trip. Nutrient samples will be processed by SAEON/NMU laboratory.

Salinity gradients were largely absent from the estuary, with homogeneous marine conditions (salinity > 30) observed from Site 1 to Site 6. Marginally polyhaline conditions (ca. 28) were observed in the surface waters at Site 7.

Dissolved oxygen concentrations were typical of well-oxygenated conditions (>5 mg/L) throughout the estuary, with the exception of lower concentrations (~4 mg/L) in the upper reaches at Site 7.

Turbidity was low (NTU < 10) throughout but increased from the mouth to the upper reaches.

Table 6-5: Kariega Estuary *in situ* water quality measurements

25/04/24	Time	Co-ordinates	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	08h45	33°40'53.56"S; 26°40'52.12"E	0	35.10	97.80	7.79	8.26	16.10	1.96
			0.5	35.10	97.80	7.79	8.26	16.10	2.22
			1	35.10	97.80	7.79	8.26	16.10	2.16
			2	35.10	97.90	7.80	8.26	16.10	2.48
Site 2	09h25	33°40'18.67"S; 26°40'27.31"E	0	35.06	98.80	7.84	8.28	16.30	2.25
			0.5	35.07	98.80	7.84	8.28	16.30	2.40
			1	35.07	98.80	7.84	8.28	16.30	2.42
			1.5	35.08	98.80	7.84	8.28	16.30	2.50
			2.3	35.08	98.80	7.85	8.28	16.20	5.66
Site 3	09h40	33°39'55.71"S; 26°39'22.73"E	0	34.88	92.10	7.17	8.23	17.30	3.37
			0.5	34.88	92.30	7.19	8.23	17.20	3.58
			1	34.88	92.60	7.21	8.24	17.20	3.56
			1.5	34.88	93.10	7.25	8.24	17.20	3.68
			2.2	34.88	94.20	7.33	8.24	17.20	3.68
Site 4	10h00	33°39'10.85"S; 26°39'1.18"E	0	34.21	78.10	5.84	8.18	19.70	4.78
			0.5	34.22	78.30	5.84	8.18	19.70	5.18
			1	34.23	78.80	5.89	8.18	19.70	5.30
			2	34.25	79.60	5.95	8.18	19.60	5.20
			3.2	34.26	81.40	6.08	8.19	19.60	7.72
Site 5	10h20	33°37'55.81"S; 26°38'20.54"E	0	33.43	76.10	5.57	8.17	21.00	5.53
			0.5	33.43	75.00	5.50	8.17	21.00	6.08
			1	33.43	75.30	5.52	8.17	21.00	6.03
			2	33.44	75.90	5.56	8.17	21.00	6.15
			3	33.44	76.80	5.63	8.17	21.00	7.12
Site 6	10h40	33°36'44.03"S; 26°37'58.25"E	0	30.54	72.10	5.31	8.05	21.10	3.85
			0.5	30.69	70.30	5.22	8.06	21.20	5.86
			1	30.73	69.80	5.18	8.06	21.20	6.45
			1.5	31.08	67.60	4.97	8.06	21.40	8.92
			2	31.21	66.10	4.88	8.07	21.40	13.11
Site 7	10h55	33°36'32.87"S; 26°39'15.35"E	0	27.75	59.40	4.48	7.92	21.70	6.16
			0.5	29.70	55.10	4.02	7.94	22.10	7.27
			1.2	29.74	52.50	3.84	7.94	22.20	14.54

Macrophytes:

Sampling took place on the 25th of April 2024. The endangered seagrass *Zostera capensis* was found along the lower, middle and upper reaches of the estuary, indicating saline water conditions. This seagrass only occurs in the upper reaches of estuaries if they are saline. A weir and road marked the upper reaches and *Z. capensis* occurred to this point. The saline

conditions are also indicated by the limited reed and sedge habitat which occurs as isolated stands of *Phragmites australis* and *Schoenoplectus scirpoides*. Salt marsh is represented by a narrow intertidal zone due to steep bank topography, and a supratidal zone, backed in places by steep banks with floodplain and terrestrial species. Salt marsh in the upper zone forms narrow 1 m bands along both banks. Species include the lower intertidal *Spartina maritima, Salicornia* spp*., Bassia diffuca, Cotula coronopifolia, Triglichin* spp*., Limonium scabrum, Juncus* spp., and saline grasses.

Pressures include bank erosion in the middle and upper reaches and invasive species (*Opuntia ficus-indica*). There were signs of bank erosion from animal movement at the adjacent game farm.

Macroinvertebrates:

Field observations for this estuary are made from direct measurements (sweep netting) of the hyperbenthos and epifauna associated with channel-fringing and creek-associated seagrass beds, as well as in situ observations. Estuary is in a predominantly open, marine-dominated, state with marine connectivity, as evidenced by well-established halocline to the upper reaches. Recreational-associated habitat modification in the lower reaches (e.g., jetties), which appears to be seasonally variable in intensity (e.g., low estuary boat use on day of sampling). Predominant effect would be in bank erosion and scouring, impacting macrophyte foundational habitats. The marine connection will facilitate the recruitment of estuarine-dependent species, as below. Estuary is in a strongly marine dominated state, hence macroinvertebrates closer to the mouth tend to be more typical of rocky shore marine biota. Reported medium fishing pressures, likely with moderate to no impact on top-down pressures on macroinvertebrates. The zooplankton community would be marine dominated taxa. Extending from the mouth to middle reaches mudflats are exposed intertidally and in some areas are reworked by apparently low subsistence harvesting – evidence of bait digging for *Upogebia africana* (mud prawn). This would both decrease macrofauna abundance of targeted organisms but also destabilise the mud flat and associated macrophytes causing cascade effects through to meiofauna. In the middle to upper reaches pristine areas of intertidal seagrass beds apparently unaffected by bait digging are apparent. The middle-upper reaches supported the highest density of hyperbenthos (e.g., the shrimp *Palaemon peringueyi*) of 105 n per m^3 in contrast to the lower reaches where *P. peringueyi* density was

< 5 n per m^3. Other typical seagrass associated hyperbenthos and epifauna were observed such as the seagrass specialist green broken-backed shrimp *Hippolyte kraussiana* and brachyurans such as *Hymenosoma orbiculare*.

Microgastropods and other macrofauna were preserved in situ and will later be enumerated in the laboratory at Nelson Mandela University. Intertidal to supratidal marshes appeared minimally impacted by trampling and browsing, these extending into the Kariega Game Reserve. Extensive *Spartina maritima* salt marshes supporting crab populations such as *Parasesarma catenatum*, an important food resource for fishes and waterbirds such as herons observed feeding on the marsh. The crabs were also observed in high abundance along the banks of the upper-middle reaches, together with occasional *Neosarmaticum africanum* burrows supratidally.

Birds:

Waterbirds were sampled at fixed interval sites from the mouth to the middle/upper reaches (**Table 6-6**), beginning at 08h32 and ending at 09h34. Low tide was at 10h24. Weather was overcast, drizzly and wind free. Therefore, observation conditions ideal. Expected to observe resident species and occasional over-wintering Palearctic migrants. A total of 113 waterbirds were observed across 25 species. Extensive *Zostera* beds in lower reaches fringing the main channel, with relatively low observed disturbance – recreational activities likely seasonally high, with a persistent subsistence resource harvesting influence. Fringing seagrass beds supported moderate numbers of piscivorous visual ambush foragers such as little and great white egrets, grey and goliath herons as well as pursuit and diving piscivores such as reed and Cape cormorants and pied kingfisher. Sandbanks at the mouth supported roosting greater crested terns and white breasted cormorants. These banks as well as occasionally within the seagrass supported some waders such as sanderlings, whimbrels and spoonbills. In the middle to upper reaches brown-hooded, half-collared, malachite and giant kingfishers were observed, as well as waterfowl such as Cape teals and Egyptian geese. Other notable species seen were darters and a single common sandpiper in the middle to upper reaches.

Table 6-6: Kariega Estuary bird counts

Common name	Count
Kelp gull	7
Cape cormorant	3
White-breasted cormorant	6
Greater crested tern	8
White-fronted plover	3
Sanderling	10
Little egret	6
Water thicknee	8
Whimbrel	2
Hadeda ibis	4
Great white egret	6
Reed cormorant	13
Malachite kingfisher	2
Blacksmith lapwing	4
Spoonbill	10
Pied kingfisher	5
Grey heron	3
Darter	2
Cape wagtail	1
Cape teal	3
Brown-hooded kingfisher	1
Common sandpiper	1
Half-collared kingfisher	1
Giant kingfisher	2
Egyptian goose	2

7. ESTUARY SURVEY: MAY 2024

7.1 Gamtoos Estuary

Sample Date	15/05/2024	Reserve Level Assessment	Intermediate
Estuary Name	Gamtoos Estuary	IUA	IUA_KL01
No. of sites	Entire Estuary	IUA description	Kromme from Kromme Dam to estuary and Gamtoos
Estuary Type	Predominantly Open	Prioritised RU	E_RU04
Altitude (m.a.s.l.)	0	Quaternary catchment	L90C
Longitude	25.034714	Latitude	-33.97042472
PES (NBA, 2018)	B/C	Conditions during sampling	Full gradient
Components currently impacting PES	Hydrology, physical habitat, water quality, macrophytes and fish.		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 34 805
- Reference MAR (m^3x10^6): 388.8
- Seasonality of rainfall: Very Late summer
- Marine upwelling zone: Yes
- Important Fish Nursery: High
- Estuary length: 22.6 km

Site impacts:

- Medium - Flow reduction pressure;
- Medium - Pollution pressure;
- High - Habitat loss; and
- High - Fishing pressure.
- High - Alien invasive plants
- Very high - Alien fish

Components sampled:

- Fish

Fish:

See **Figure 7-1** for the location of survey sites.

Figure 7-1: Map of Fish sites for the Gamtoos Estuary field survey - May 2024

Twenty-one species of fish (1960 individuals) were recorded in the Gamtoos Estuary from four seine hauls, with estuary-associated marine species collectively comprising 79% of the catch numerically and estuarine-resident species 21% of the catch. Catches were dominated by southern mullet (46%), groovy mullet (22%), speckled sandgoby (9%), estuarine roundherring (6%), Cape stumpnose (6%), prison goby (3%), Cape silverside (1%), Cape sole (1%), blackhand sole (1%), white stumpnose (1%), pickhandle barracuda (1%) and white steenbras (1%). Other species (spotted grunter, Cape halfbeak, flathead mullet, blacktail, spotted sandgoby, river goby, striped mullet, Elf and Mozambique tilapia) collectively comprised around 5% of the catch.

7.2 Bushmans Estuary

Sample Date	17-18/05/2024	Reserve Level Assessment	Desktop PES
Estuary Name	Bushmans Estuary	IUA	IUA_P01
No. of sites	Entire Estuary	IUA description	P primary catchment
Estuary Type	Predominantly Open	Prioritised RU	E_RU16
Altitude (m.a.s.l.)	0	Quaternary catchment	P20A
Longitude	26.663622	Latitude	33.69491583
PES (NBA, 2018)	B/C	Conditions during sampling	Marine dominated State
Components currently impacting PES	Physical Habitat, Macrophytes, Fish		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 2 758
- Reference MAR (m^3x10^6): 42.86
- Seasonality of rainfall: All Year
- Marine upwelling zone: Yes
- Important Fish Nursery: High
- Estuary length: 35 km

Site impacts:

- Low – Flow reduction pressure;
- Low – Pollution pressure;
- Medium – Habitat loss/Transformation of banks in lower reaches;
- Very high – Fishing pressure; and
- High – Alien/translocated fish.

Components sampled:

- Fish

Fish:

See **Figure 6-2** for the location of survey sites.

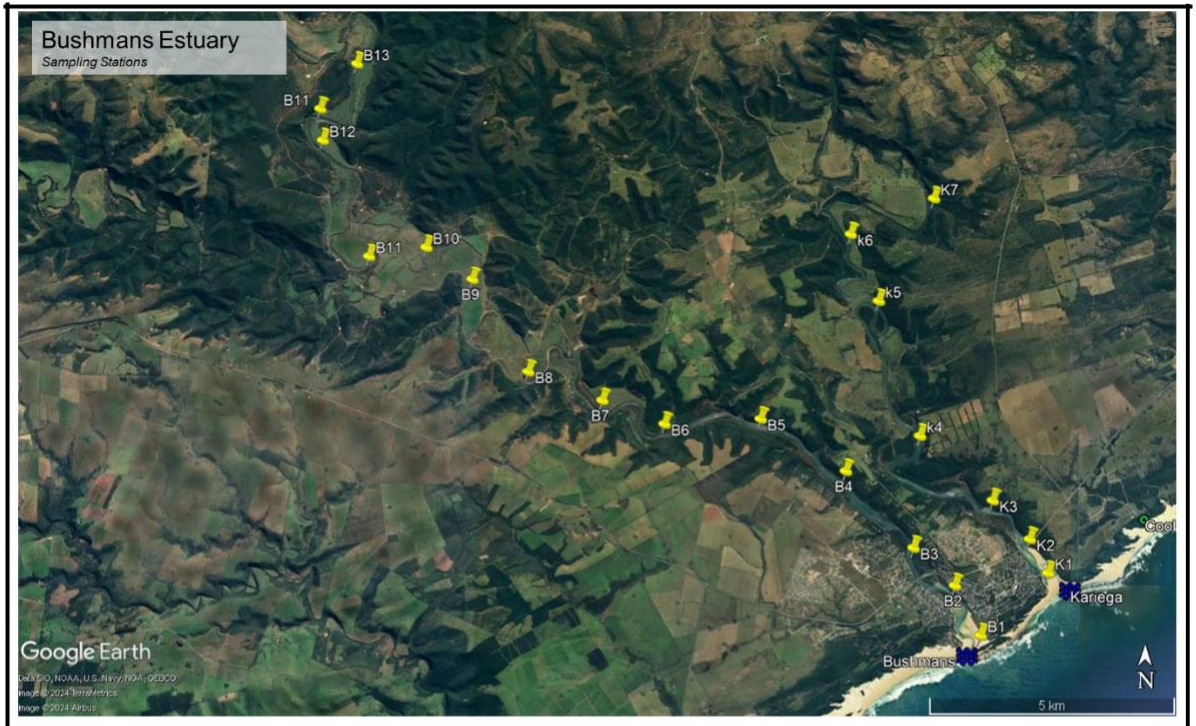

Figure 7-2: Map of Fish survey sites for the Bushmans Estuary field survey - May 2024

Twenty-eight species (4594 individuals) were caught from 13 sites in the Bushmans Estuary. Of the species collected during this survey ten live and breed in estuaries, represented by river goby, prison goby, speckled sandgoby, barehead goby, super klipfish, Cape silverside, estuarine roundherring, Cape halfbeak, longsnout pipefish and estuarine pipefish. The critically endangered estuarine pipefish, which is only known to occur in the Bushmans and Kariega estuaries, was found in the extensive eelgrass beds above the bridge. Together estuarine species comprised 54% of the catch numerically. Thirteen estuary-associated marine species, represented by southern mullet, groovy mullet, diamond mullet, striped mullet, flathead mullet, Cape stumpnose, strepie, blacktail, white steenbras, spotted grunter, Cape sole, blackhand sole and oval moony, together comprised 45% of the catch numerically. Four species of marine stragglers (zebra, blue stingray, oriental flying gurnard and olive grunter) were caught in the lower and middle reaches and one catadromous species (freshwater mullet) in the upper reaches. Numerically, estuarine roundherring (40%) and Cape stumpnose (37%) were the dominant species caught, collectively comprising over 75% of the catch. Other abundant species caught included river goby (7%), southern mullet (4%), super klipfish (2%) and Cape silverside (2%).

7.3 Kariega Estuary

Sample Date	19/05/2024	Reserve Level Assessment	Rapid
Estuary Name	Kariega Estuary	IUA	IUA_P01
No. of sites	Entire Estuary	IUA description	P primary catchment
Estuary Type	Predominantly Open	Prioritised RU	E_RU09
Altitude (m.a.s.l.)	0	Quaternary catchment	P30C
Longitude	26.686399	Latitude	-33.68277083
PES (NBA, 2018)	C	Conditions during sampling	Marine dominated State
Components currently impacting PES	Hydrology, physical habitat, macrophytes and fish.		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 660
- Reference MAR (m^3x10^6): 21.69
- Seasonality of rainfall: All Year
- Marine upwelling zone: Yes
- Important Fish Nursery: High
- Estuary length: 20.9 km

Site impacts:

- Very High - Flow reduction pressure;
- Low - Pollution pressure;
- Medium - Habitat loss/Transformation of banks in lower reaches; and
- Medium - Fishing pressure.

Components sampled:

- Fish

Fish:

See **Figure 6-3** for the location of survey sites.

Figure 7-3: Fish sites for the Kariega Estuary field survey - May 2024

A total of 4678 individuals representing 31 species were caught in six seine net hauls in the Kariega. Numerically catches were dominated by Cape stumpnose (50%), estuarine roundherring (15%), river goby (9%), southern mullet (7%), groovy mullet (5%), oval moony (4%), blackhand sole (1%) and Cape silverside (1%). Of the taxa collected during this survey nine species were estuarine resident species represented by river goby, prison goby, speckled sandgoby, spotted sandgoby, super klipfish, Cape silverside, estuarine roundherring, Cape halfbeak and the critically endangered estuarine pipefish. This group of fishes comprised 27% of the total catch numerically. Sixteen species were estuary-associated marine species and these included southern mullet, groovy mullet, longarm mullet, flathead mullet, Cape stumpnose, strepie, blacktail, white steenbras, spotted grunter, Cape sole, blackhand sole, oval moony, bartail flathead, ladyfish, blackspotted electric ray and marbled electric ray. These fishes comprised 71% of the catch numerically. Four species of marine stragglers (zebra, olive grunter, blackedged blaasop and blacktip kingfish), one catadromous species (freshwater mullet) and one freshwater species (Mozambique tilapia) were caught.

7.4 Keiskamma Estuary

Sample Date	20-21/05/2024	Reserve Level Assessment	Rapid
Estuary Name	Keiskamma Estuary	IUA	IUA_R01
No. of sites	Entire Estuary	IUA description	Keiskamma
Estuary Type	Predominantly Open	Prioritised RU	E_RU10
Altitude (m.a.s.l.)	0	Quaternary catchment	R10M
Longitude	27.491233	Latitude	-33.28148
PES (NBA, 2018)	B/C	Conditions during sampling	Transition state
Components currently impacting PES	Water quality, Physical habitats, Macrophytes, Invertebrates, Fish,		
Ecological Importance	High Importance		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 2 696
- Reference MAR (m^3x10^6): 138.9
- Seasonality of rainfall: All Year/Late/Very Late Summer
- Marine upwelling zone: No
- Important Fish Nursery: High
- Estuary length: 22 km

Site impacts:

- Low - Flow reduction pressure;
- Medium - Pollution pressure;
- Medium - Habitat loss/Transformation of banks in lower reaches;
- High - Fishing pressure;
- High - Grazing/cattle browsing pressure; and
- High - Alien/translocated fish.

Components sampled:

- Fish

Fish:

See **Figure 5-9** for the location of survey sites.

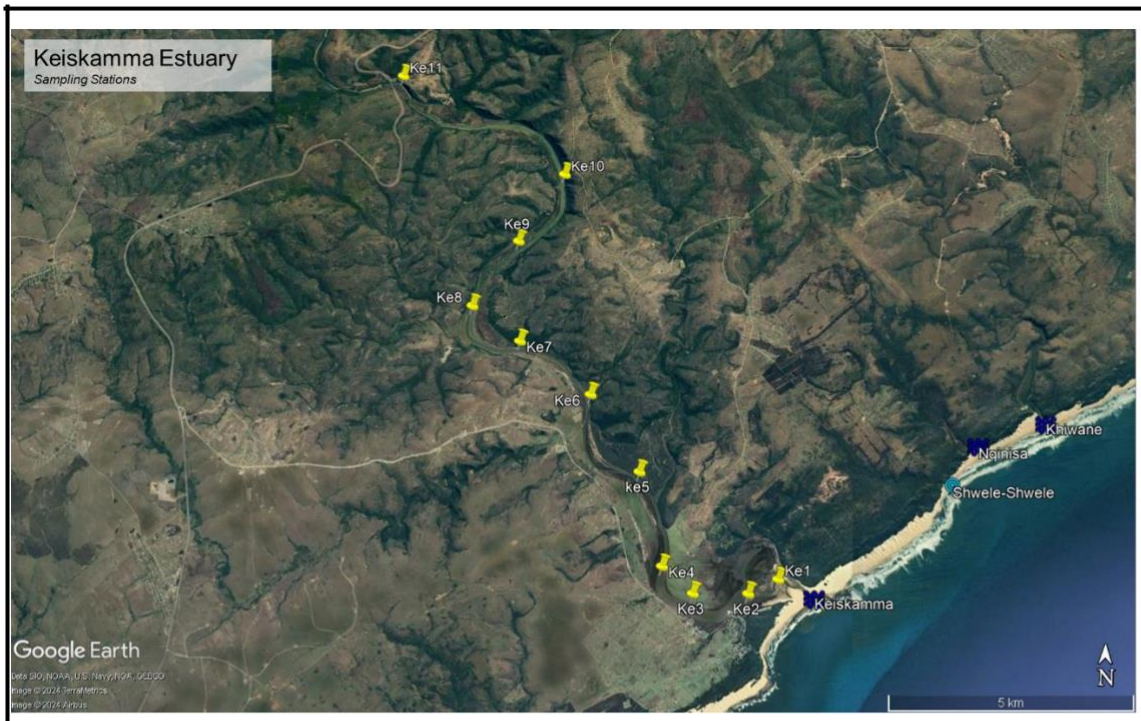

Figure 7-4: Fish sites for the Keiskamma Estuary field survey - May 2024

Ten seine net hauls and six gill nets caught a total of 1598 individuals representing 29 species. Numerically, estuarine roundherring (31%), Cape stumpnose (12%), southern mullet (10%), prison goby (9%), freshwater mullet (7%), groovy mullet (6%), Cape silverside (6%), white seacatfish (3%), river goby (3%), blackhand sole (3%), flathead mullet (2%), spotted grunter (2%), speckled sandgoby (2%) and diamond mullet (1%) dominated the catch. Of the taxa collected during this survey six were estuarine resident species. These were represented by estuarine roundherring, Cape silverside, Cape halfbeak, prison goby, river goby and speckled sandgoby. This group of fishes comprised 50% of the catch numerically. Eighteen estuary-associated marine species were recorded comprising 42% of the catch. These were represented by southern mullet, groovy mullet, flathead mullet, diamond mullet, largescale mullet, Cape stumpnose, estuarine bream, white steenbras, spotted grunter, dusky kob, small kob, garrick, Cape sole, blackhand sole, oval moony, doublespotted queenfish and ladyfish. Two species of marine stragglers (striped threadfin and olive grunter), one catadromous species (freshwater mullet) and one freshwater species (Mozambique tilapia) were caught.

7.5 Kabeljous Estuary

Sample Date	27/05/2024	Reserve Level Assessment	Rapid
Estuary Name	Kabeljous Estuary	IUA	IUA_KL01
No. of sites	Entire Estuary	IUA description	Kromme from Kromme Dam to estuary and Gamtoos
Estuary Type	Large Temporarily Closed	Prioritised RU	E_RU05
Altitude (m.a.s.l.)	0	Quaternary catchment	K90G
Longitude	24.932503	Latitude	-34.00880697
PES (NBA, 2018)	C	Conditions during sampling	Hypersaline state
Components currently impacting PES	Hydrology, physical habitat, water quality, macrophytes and fish.		
Ecological Importance	Important		

Site Description:

- Biogeographical region: Warm Temperate
- Catchment area (km^2): 208
- Reference MAR (m^3x10^6): 11.5
- Seasonality of rainfall: All Year
- Marine upwelling zone: Yes
- Important Fish Nursery: Medium
- Estuary length: 2.7 km

Site impacts:

- Medium - Flow reduction pressure;
- Medium - Pollution pressure;
- Medium - Habitat loss; and
- Low - Fishing pressure.
- High – Alien invasive plants

Components sampled:

- Water quality;
- Microalgae;
- Macrophytes;
- Invertebrates;
- Fish, and

- Birds

Hydrodynamics and Physical Processes:

Mouth closed and water levels relatively high; System hypersaline – DFFE reported mean salinity of ca. 40 two weeks prior; Mouth possibly breached from marine overwashing between 9-19 March (Sentinel 2 Images).

Water Quality and Microalgae:

Water quality and microalgae measurements were taken at the same sites. See **Figure 6-3** for the location of survey sites.

Figure 7-5: Map of Water Quality and Microalgae sites for the Kabeljous Estuary field survey - May 2024

Table 7.1 lists *in situ* water quality measurements that were taken during the field trip. Nutrient samples will be processed by SAEON/NMU laboratory.

The mouth of the estuary was closed on the day of sampling. However, Sentinel 2 imagery suggests that there may have been overwashing from the sea approximately two months prior (ca. 19 March 2024).

Salinity gradients were largely absent from the estuary, with homogeneous hypersaline conditions (salinity > 38) observed from Site 1 to Site 4. The only exceptions were the surface waters of Site 3 and Site 4, where salinity was approximately 35.

Dissolved oxygen concentrations were typical of well-oxygenated conditions (>7 mg/L) from in the lower and middle reaches (Site 1–3), with lower mean concentrations (<5 mg/L) recorded in the upper reaches (Site 4).

Turbidity was low (NTU < 3.5) throughout but increased from the mouth to the upper reaches.

Table 7-1: Kabeljous Estuary *in situ* water quality measurements

(Low - 11.54 am)	Time	Co-ordinates	Distance to mouth (km)	Depth (m)	Salinity	DO (%)	DO (mg/l)	pH	Temp (°C)	NTU
Site 1	08h55	34° 0'20.74"S; 24°56'0.78"E	0.2	0	38.44	89.30	7.12	8.21	14.90	0.10
				0.5	38.44	88.60	7.07	8.22	14.90	0.18
				1	38.48	93.00	7.45	8.27	14.90	1.35
Site 2	09h15	34° 0'10.13"S; 24°55'38.25"E	0.9	0	38.46	92.50	7.24	8.25	15.80	0.73
				0.5	38.46	89.90	7.05	8.25	15.70	0.74
				0.8	38.46	89.50	7.03	8.25	15.70	2.86
Site 3	09h40	33°59'49.10"S; 24°55'38.79"E	1.6	0	35.76	86.30	6.85	8.15	15.90	1.02
				0.5	38.09	89.70	6.89	8.25	16.80	1.38
				1	38.34	95.90	7.40	8.30	16.70	2.20
				1.4	38.39	97.70	7.55	8.32	16.80	3.02
Site 4	10h05	33°59'39.42"S; 24°55'42.90"E	2.25	0	35.59	69.20	5.20	8.13	18.30	2.28
				0.5	37.87	66.60	4.99	8.13	18.60	3.64
				1.1	37.85	74.00	4.75	8.11	18.60	3.60

Macrophytes:

Sampling took place on the 27 May 2024. The mouth was closed and water level high. Macrophytes present were salt marsh (supratidal species represented by *Salicornia* spp*., Triglochin* spp*., Limmonium scabrum, Juncus kraussii, Dipshyma crassifolia* and the saline grasses *Cynodon dactylon, Stenotaphrum secundatum* and *Sporobolus virginicus)*. Many of the salt marsh species form a mosaic on the floodplain and are well represented in the middle to upper reaches, with *Juncus kraussii* forming dense stands on the northern bank in the upper reaches. In the lower reaches salt marsh is narrow due to the steep topography. Reeds and sedges (P*hragmites australis, Schoenoplectus corymbosus, Scirpus nodosus* and other Cyperaceae) occur in the upper reaches adjacent to the water channel. The submerged macrophytes *Zostera capensis* and *Ruppia cirrhosa* were present. Filamentous algae and the macroalga *Caulerpa filiformis* was also present.

Pressures include *Opuntia ficus-indica*, *Opuntia aurantiaca*, *Acacia cyclops*, and *Argemone mexicana* which occur in the catchment and along the tributaries. Agricultural practices in the catchment (small farm dams, spraying of pesticides and fertilizer) potentially leach into the estuary increasing sediment load and nutrient input, and decrease freshwater inflow. Residential development in the lower reaches potentially also result in elevated nutrient input. Numerous footpaths near the mouth trample and fragment salt marsh as people access the estuary from the car park.


27 05 2024 08 29
27 05 2024 08:45
27 05 2024 10 01
27 05 2024 10:17

Macroinvertebrates:

Field observations for this estuary are made from direct measurements (sediment coring and suction pumping) of the macroinvertebrate infauna with channel-fringing shallow subtidal habitats, as well as in situ observations. Estuary is in a temporarily open closed, transitional, state with a closed mouth condition although recent (past six months) occasional connection to the ocean following storm and rainfall events. Recreational-associated habitat modification in the lower reaches (e.g., jetties) are minimal. Lack of a permanent marine connection will hinder the recruitment of estuarine-dependent species, as evidenced by only sand prawn *Kraussillichirus kraussi* rather than mud prawn *Upogebia africana* burrows in the system. Minimal fishing pressures, likely with little impact on top-down pressures on macroinvertebrates. The zooplankton community would be naturally depauperate except during tidal connection. The lower reaches near the mouth support an extensive shallow sand flats with sand prawn burrows at approximately 22 n per m^2, decreasing to 12 n per m^2 in the middle reaches and none in the upper. Other typical sand associated species were observed, such as the sandflat crab *Daniella edwardsii* in the lower reaches, approximately 3 n per m^2. Other infauna such as amphipods were preserved in situ from triplicate sediment grabs and will later be enumerated in the laboratory at Nelson Mandela University. Sediment organic matter (SOM) and grain size samples (granulometry) were also collected throughout the estuary and will later be analysed at Nelson Mandela University. Ad hoc in situ observations showed that these were most dense in the lower reaches, extending over the sand flats, and likely are an important food resource for wading waterbirds and planktivores such as the flamingos and spoonbills. The system is likely in its most productive state following relatively recent marine connection and freshwater input.

Fish:

Seventeen species of fish (1312 individuals) were sampled from six seine hauls in the Kabeljous Estuary (See **Figure 7-2**), with catches dominated by three estuary-associated marine species, southern mullet (29%), Cape sole (26%) and Cape stumpnose (24%). Other marine species caught included blackhand sole, garrick, oval moony, white steenbras, groovy mullet, flathead mullet, striped mullet, spotted grunter and white stumpnose, which collectively comprised 4% of the catch numerically. Six species that live and breed in estuaries represented by speckled sand goby (5%), river goby (5%), prison goby (4%), Cape silverside (4%) and estuarine round herring (1%) were also an important component of the catch.

Figure 7-6: Map of Fish sites for the Kabeljous Estuary field survey - May 2024

Birds:

Waterbirds were sampled at fixed interval sites from the mouth to the middle/upper reaches (Table 7-2), beginning at 08h49 and ending at 09h50. Low tide was at 11h53, but the mouth was closed, therefore of no perceived impact. Weather was sunny and wind free. Therefore, observation conditions ideal except for the solar glare – but since the estuary is small, all birds present could be identified. Expected to observe resident species and occasional over-wintering Palearctic migrants. A total of 196 waterbirds were observed across 23 species. Within the extensive sand banks at the mouth a substantial flock of greater flamingos was observed as well as other planktivorous or benthivorous wader such as spoonbills and black-winged stilts. Sandwich terns, African black oystercatchers and several cormorant species were either foraging or roosting on the estuary fringes or sandbanks, including reed, Cape and white-breasted cormorants. Little and great white egrets were observed foraging on the

estuary's fringes in the lower reaches. In the middle to upper reaches waterfowl such as Cape teals and yellow-billed ducks were observed, as well as pied and Giant kingfishers and waders such as blacksmith lapwings, a single three-banded plover, a single common ringed plover and a single overwintering grey plover.

Table 7-2: Kabeljous Estuary bird counts

Common name	Count
Kelp Gull	28
Sandwich Tern	3
Greater Flamingo	43
Black-Winged Stilt	5
African Black Oystercatcher	6
Grey Heron	1
Cape Cormorant	41
Spoonbill	5
Sacred Ibis	3
Little Egret	12
Reed Cormorant	10
Great White Egret	5
Grey-Headed Gull	3
White-Breasted Cormorant	1
Water Thicknee	3
Cape Wagtail	5
Three-Banded Plover	1
Cape Teal	9
Yellow-Billed Duck	2
Common Ringed Plover	2
Pied Kingfisher	3
Blacksmith Lapwing	4
Grey Plover	1

8. Appendix A: Estuary Survey Programmes

Date	Agenda	Accommodation	Total Distance Travelled
29 Nov *Wed evening*	LVN flied in from CPT NMU pack for fieldtrip and mobilise boats	-	-
30 Nov *Thurs*	Travel to Mbashe	The Haven	524 km / 7.5 hours
1 Dec *Fri*	Sample Xora	The Haven	40 km / 1.5 hours
2 Dec *Sat*	Sample Mbashe	The Haven	-
3 Dec *Sun*	Travel to and sample Kei	Kei Mouth (Neptune's Cove?)	261 km / 4 hours
4 Dec *Mon*	Travel to and sample Tyolomnqa & Keiskamma	Mpekweni Beach Resort	129 km / 2 hours
5 Dec *Tues*	Travel to and sample Keiskamma	Mpekweni Beach Resort	60 km / 1 hour
6 Dec *Weds*	Sort samples, pack & clean boats of salt water, travel back		137 km / 1.5 hours

Date	Agenda	Accommodation	Total Distance Travelled
22 April *Mon eveing*	LVN flied in from CPT NMU pack for fieldtrip and mobilise boats	-	-
23 April *Tues*	Travel to East Kleinemonde Sample Kowie	East Kleinmonde/Port Alfred	2 hours
24 April *Wed*	Sample Bushmans	East Kleinmonde/Port Alfred	30 min
25 April *Thurs*	Sample Kariega Drive back, sort samples and clean boats Fly back to CPT/JHB	PE	30 min

Date	Fish sample plan
13 May *Mon evening*	Mobilise boats & nets and travel to EC
14 May *Tues*	Repair boat trailer axel
15 May *Wed*	Sample Gamtoos
16 May *Thurs*	Travel to Bushmans
17 May *Friday*	Sample Bushmans
18 May *Sat*	Sample Bushmans
19 May *Sun*	Sample Kariega
20 May *Mon*	Travel to Keiskamma
21 May *Tues*	Sample Keiskamma
22 May *Wed*	Sample Keiskamma (replace sampling of Tyolomnqu to cover larger system)
23 May *Thurs*	Travel to Cape Town
24 May *Fri*	Travel to Cape Town