2.5 APPENDIX 1: WATER QUALITY DATA COLLECTED DURING JULY 2013

STN			Date	Time	Depth	Temp	Sal	pH	Turb	DO	DO Sat	SS	NO2-N	NH3-N	NOx-N	DIN	PO4-P	SiO4-Si	TP	TOC	Kjeldahl N
					m	ºC	ppt			mg/l	%	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l
Sea			13/07/2013	09:51:00	0.0	19.2	35.0	8.1	3	7.8	105	2	4	49	53	102	<4	300	700	12.5	1
1	29.39206S	31.33490E	13/07/2013	10:00:00	0.5	17.6	0.3	7.5	31	5.7	59										
1	29.39206S	31.33490E	13/07/2013	10:00:00	0.0	17.6	0.3	7.5	33	5.8	58	24	9	18	313	331	14		290		
2	29.38849S	31.33514E	13/07/2013	10:50:00	0.0	17.5	0.2	7.5	33	5.4	57	23.4	7	<5	317	317	10	4500	240		
3	N2 Bridge		13/07/2013	13:00:00	0.0	17.4	0.2	7.6	31.8	8.4	87.5	21.4	4.0	<5	448	448	9		110	14.5	<1

3 MACROPHYTES SPECIALIST REPORT

MACROPHYTES OF THE MVOTI ESTUARY: Janine Adams and Meredith Cowie
Department of Botany, Nelson Mandela Metropolitan University
PO Box 77000, Port Elizabeth, 6031

3.1 INTRODUCTION

The National Biodiversity Assessment of 2011 scored the overall health of Mvoti Estuary as a 'D' (highly degraded) Ecological Category (van Niekerk & Turpie, 2012). The estuary has experienced a moderate reduction (30 %) in flow. The estuary has a high biodiversity importance (80.5), but is not considered of high conservation importance (58.6) (Turpie & Clark, 2007). Mvoti Estuary requires full protection, with an undeveloped margin of 75 %, as it important for supplying nutrient and sediments to the offshore environment (Turpie et al., 2012). Although no proclaimed conservation areas occur within the Mvoti catchment, the estuary falls within a natural heritage site (SANHS 166) that is on privately owned property (Barnes 1998, Sukdeo, 2010).

The Mvoti Estuary is important for the prolific bird life it supports including Red Data species, and numerous migrant species (Begg 1978; Swemmer, 2011). The extensive mudflats are relatively bare sandbars are ideal habitats for birds, with terns particularly abundant in the system. The backwater of the deeper areas of the estuary also provides an important refugia for fish (Swemmer, 2011). Recreationally the large sandbank at the mouth of the system is popular for fishing and boat launching (Begg, 1978; Swemmer, 2011).

Mvoti Estuary has been described as 'grossly polluted', 'botanically unimportant' and 'severely degraded' by Begg (1978) and Heydorn (1985/1986) respectively. Harrison et al. (2000) described Mvoti Estuary on a scale of poor, moderate or good to have poor water quality and moderate aesthetic value. Malharbe (2006) refers to Mvoti as a 'working river' as it is highly utilized and highly developed. Swemmer (2011) conducted an ecological integrity study on the Mvoti Estuary in 2004/2005 and noted the following threats, aside from poor water quality: water abstraction from upstream industries; sugar cane farming on the banks of the estuary accelerating ground erosion and leakage of chemical and nutrients into the system; invasion of alien plant species; and anthropogenic pollution from the Kwa-Dukuza industrial activities upstream (SAPPI SAICCOR factory, Gledhow Sugar Mill and the Stanger-Kwadukuza Waste Water Treatment) and to a small extent recreational activities in the estuary.

According to Begg (1984) Mvoti Estuary has a large floodplain that was sparsely vegetated. The floodplain was dominated by reeds and sedges, mainly *Phragmites* spp. and *Scirpus littoralis (*now *Schoenoplectus scirpoides)*, which occurred along the channels and mudflats (Begg, 1978; Barnes, 1998). A small stand of coastal or lagoon hibiscus (*Hibiscus tiliaceus)* and freshwater mangrove (*Barringtonia racemosa*) has been described south of the estuary mouth (Begg, 1978; Adams, 1996). Moderate habitat loss due to sugarcane cultivation has occurred in the estuary. Sand mining and artificial breaching has also occurred in the estuary (Demetriades, 2007; van Niekerk & Turpie, 2012).

The estuary was visited in July 2013 to document the distribution and species composition of the macrophyte habitats of Mvoti Estuary. A vegetation map for present conditions was produced from the field surveys. The distribution and area covered by different macrophyte habitats was

compared with the earliest aerial photograph available for 1937. These data provided input to the assessment of the present ecological status of the estuary.

3.2 MATERIALS AND METHODS

3.2.1 Field surveys

Mvoti Estuary was surveyed on 17 July 2013 to identify the dominant macrophytes and note their distribution along the length of the estuary. The distribution of the macrophyte habitats was mapped using ArcPad 10 on a Trimble GPS. A species list was compiled and specimens of unidentified plants were collected for identification at the Ria Olivier Herbarium at Nelson Mandela Metropolitan University.

3.2.2 Changes over time in macrophyte habitats

The present and past distribution of habitats within the estuary was mapped using ESRI™ ArcMap 10.1 (2012). Orthorectified aerial images were obtained from the National Geo-spatial Information (previous Chief Directorate: Surveys and Mapping). The best recent images were from 2009. The ESRI™ World Imagery basemap of 2013 was also used to ensure that the habitat map produced was current. Past area of habitats was mapped using the oldest available aerial images (1937) that had been rectified. More recent aerial images were also assessed for changes over time although the area was not mapped. The present area covered by each macrophyte habitat was compared with its past cover to provide an indication of the percentage change in the estuary over time.

For the purposes of this study the geographical boundaries of Mvoti Estuary were:

- Downstream boundary: Estuary mouth (29°23' 30.775 " S, 31°20' 5.47439" E)
- Upstream boundary: 5 km from the mouth until the N2 road bridge. This was not the full extent of the 5 m contour (Figure 3.1).
- Lateral boundaries: 5 m contour above Mean Sea Level (MSL) along each bank.

Figure 3.1 EFZ (indicated by the red outline) of Mvoti Estuary, KZN

3.2.3 Present Ecological Status

The health of the macrophytes was assessed in terms of species richness, abundance and community composition. Change in species richness was measured as the loss in the average species richness expected during a sampling event, excluding species thought to not have occurred under Reference conditions. Species lists compiled for the EFR studies were also considered (Adams, 1997). Abundance was measured as the change in area cover of macrophyte habitats. The following was used to measure change: % similarity = 100 x present area cover /

reference area cover. Change in community composition was assessed using a similarity index which is based on estimates of the area cover of each macrophyte habitat in the reference and present state. (Czekanowski's similarity index: ∑(min(ref,pres) /(∑ref + ∑pres)/2).

3.3 RESULTS AND DISCUSSION

3.3.1 Species composition and macrophyte habitats

Mvoti Estuary has a wide riparian area that supports four of the nine macrophyte habitats as described in Table 3.1. Reeds and sedges, particularly *Phragmites australis*, dominated the floodplain. Swamp forest, represented by freshwater mangrove (*Barringtonia racemosa)* and coastal or lagoon hibiscus (*Hibiscus tiliaceus),* occupied the second largest area. A stand of *B. racemosa* occurred south of the mouth (Figure 3.2) next to a hill covered with invaded coastal forest above which was the Jex Estate. Leaf litter was abundant and there were a few crab holes present in the stand. Extensive sand/mudflats, that attract bird populations, were present at the mouth of the Mvoti Estuary. A large sand bank directed the mouth to flow out in a southerly direction and was utilised for fishing (
Plate 11). Hygrophilous grasses, mainly *E*. *pyramidalis*, fringed the water channel before the reeds and sedges habitat (
Plate 11). Although not mapped dune vegetation (*Commelina africana, Gazania rigens, I. pes-capre* and *S. plumieri)* was present on the sand and mudflats (
Plate 1). Water hyacinth (*Eichhornia crassipes*), blue Egyptian water lily (*Nymphaea nouchali* var. *caerulea)* and filamentous algae were present in freshwater pools located north of the mouth (
Plate 1).

Coastal dune forest occurred on a slope to the north of the estuary, close to the reeds and sedges and freshwater pools (Plate 1e). Species present were Black Milkwood (*Mimusops caffra*), Coastal Silveroak (*Brachylaena discolour)*, Dune Myrtle (*Eugenia capensis*), Wild banana (*Strelitzia nicolai)*, and White Milkwood (*Sideroxylon inerme*). A similar species composition was present on the slope below the Jex Estate on the south bank at the mouth. Other species present in this invaded patch of coastal forest were tick berry bush (*Chrysanthemoides monilifera),* Natal plum *(Carissa macrocarpa)* and the invasive coastal beefwood (*Casurina equisetifolia*) and prickly pear trees (*Opuntia ficus-indica*). The lone *Hyphaene natalensis* palm was present near the parking area south of the estuary.

Little natural floodplain remains at Mvoti Estuary largely due to sugarcane cultivation. Aside from the N2 road bridges no other development occurs within the floodplain. A number of invasive species were present in the estuary, most occurring as bush clumps within the monospecific *Phragmites* spp. stands in the lower reaches. Abundant species were Brazilian Pepper tree (*Schinus terebinthifolius)*, Castor Oil tree (*R. communis*) Peanut butter bush (*Senna didymobotrya),* Spanish Gold (*Sesbania punicea)* and Lantana (*Lantana camara)*. Invasive shrubs and climbers, such as blue weed (*Ageratum conyzoides)* were also present. There was evidence of wetland draining to increase the area suitable for cultivation. A disturbed area being drained on the south bank consisted of *P. australis*, Bulrush (*Typha capensis), A. conzyoides, Persicaria decipiens* and *Ipomoea purpurea.* Invasive blackjacks (*Bidens bipinnata*) and geelbessie (*Othonna natalensis*) was present in the undergrowth of the reed habitat.

3.3.2 Changes over time in the macrophyte habitats

According to Adams (1996) *Phragmites mauritianus* was the most dominant floodplain species and *S. scirpoides* was abundant in the lower mouth reaches. Swemmer (2011) described reed swamp

and perennial weed species fringing the backwaters of Mvoti Estuary. Barnes (1998) describing a visit of George Frederick Angas to Mvoti Estuary in 1847 stated that the floodplain consisted of open grassy hills with a few bush clumps dominated by *Strelitzia* or *Euphorbia*. A substantial stretch of dune forest occurred on the south bank in the lower reaches of Mvoti Estuary (Barne, 1998). Tree species present were *Acokanthera oblongifolia, Brachylaena discolor, Canthium inerme, Carissa macrocarpa, Chrysanthemoides monilifera, Ekebergia capensis, Eugenia capensis, Euclea natalensis, Mimusops caffra, Psydrax obovata* and *Searsia chirindensis. Psychotria capensis, Dracaena hookeriana* and *Peddiea africana* occurred in the undergrowth. Adams (1996) in the botanical assessment for the EFR study for Mvoti Estuary described coastal dune forest, with the same characteristic species, on the north bank towards Blythedale Beach. Dune vegetation occurred as patches on the sand berm at the mouth of Mvoti Estuary (Adams, 1996). Typical species included Beach morning glory (*Ipomea pes-capre)* and Seeplekkie (*Scaevola plumieri)*.

Table 3.1 Present species composition and area of macrophyte habitats in the Mvoti Estuary

Habitat type	Indicator/dominant species	Distribution	Area
Open surface water area	Serves as a possible habitat for phytoplankton.		16
Intertidal sand and mudflats	Intertidal zone consists of sand/mud banks that are regularly flooded by freshwater inflows. This habitat provides a possible area for microphytobenthos to inhabit.		6
Swamp forest	*B. racemosa* and *H. tiliaceus*	A healthy stand of *B. racemosa*, with numerous seedlings present, occurred on the south bank at the mouth of Mvoti Estuary (**Plate** 2.d, e). No species occurred in the undergrowth of the stand. *H. tiliaceus* trees occurred behind the reeds and sedges surrounding the sand/mudbanks at the mouth of Mvoti Estuary. The lagoon hibiscus habitat was heavily invaded with *Ipomoea* creepers and *Setaria sphacelata* var. *sphacelata* grass.	2
Reeds and sedges	*P. australis,* *P. mauritianus* and *S. scirpoides*	A dense monospecific stand of *P. australis* and *P. mauritianus* covered over a third of the floodplain of Mvoti Estuary. Reeds and sedges were dominant in the lower reaches of the estuary and occurred behind the fringe of hygrophilous grasses surrounding the water channel. A stand of *S. scirpoides* occurred on the sand and mudflats at the mouth of the estuary, particularly near the pools of freshwater to the north (**Plate** 2.b.). Dune vegetation and weed species (e.g. *L. camara, Lactuca serriola* and *Plantago major*) were present in the undergrowth of the reeds and sedges situated at the mouth of Mvoti Estuary. Bush clumps, consisting mostly of invasive trees *(S. terebinthifolius, S. punicea* and *M. azedarach*), were present in the reed habitat situated on the south bank between the sugarcane cultivation and the water channel. *A. donax* and a bamboo species was interspersed in the reeds and sedges surrounding the sand and mud flats at the mouth of the estuary (Plate 2.c.)	87

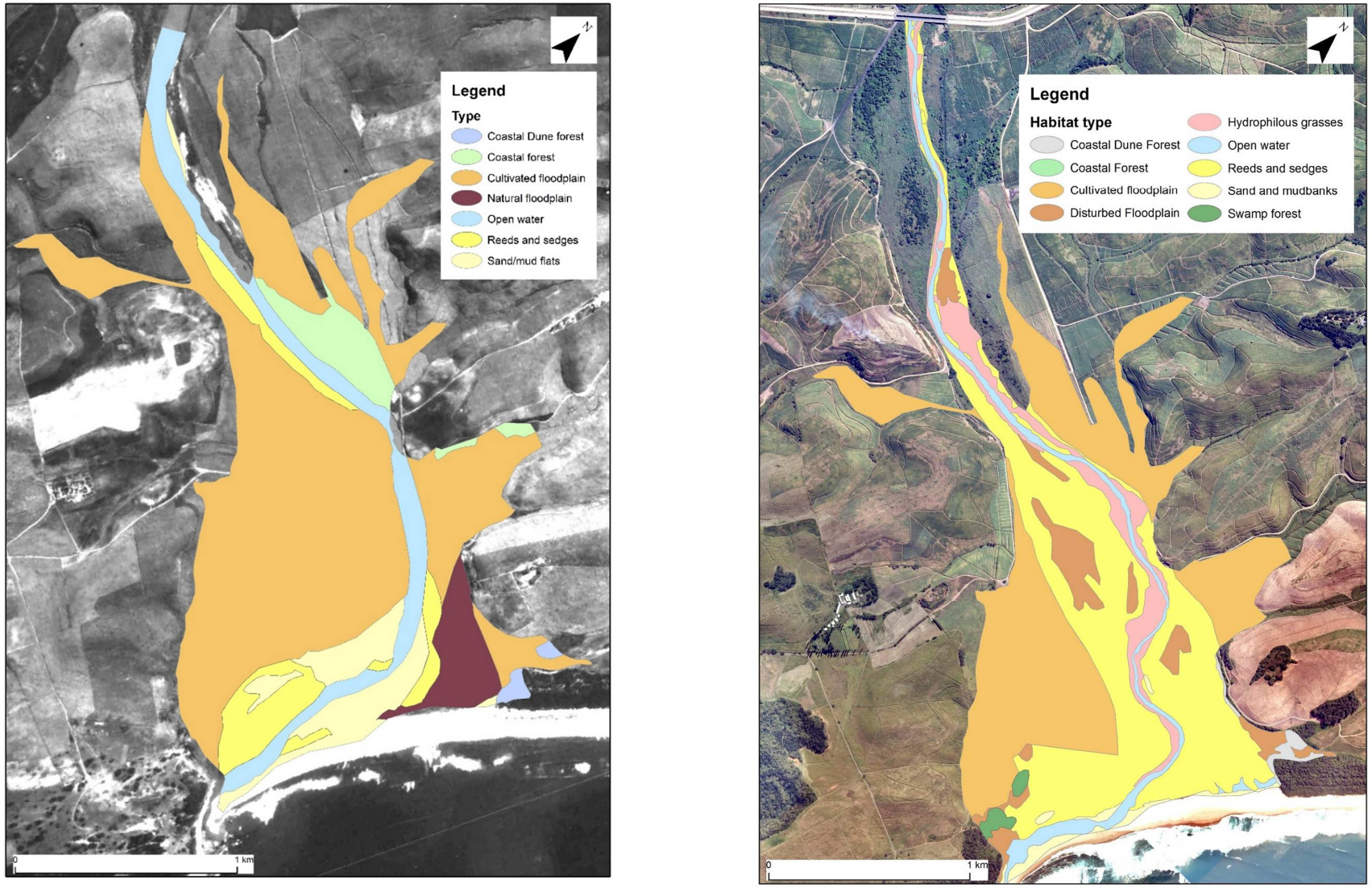

Figure 3.2 Distribution of macrophyte habitats at Mvoti Estuary in 1937 (left) and 2013 (right)

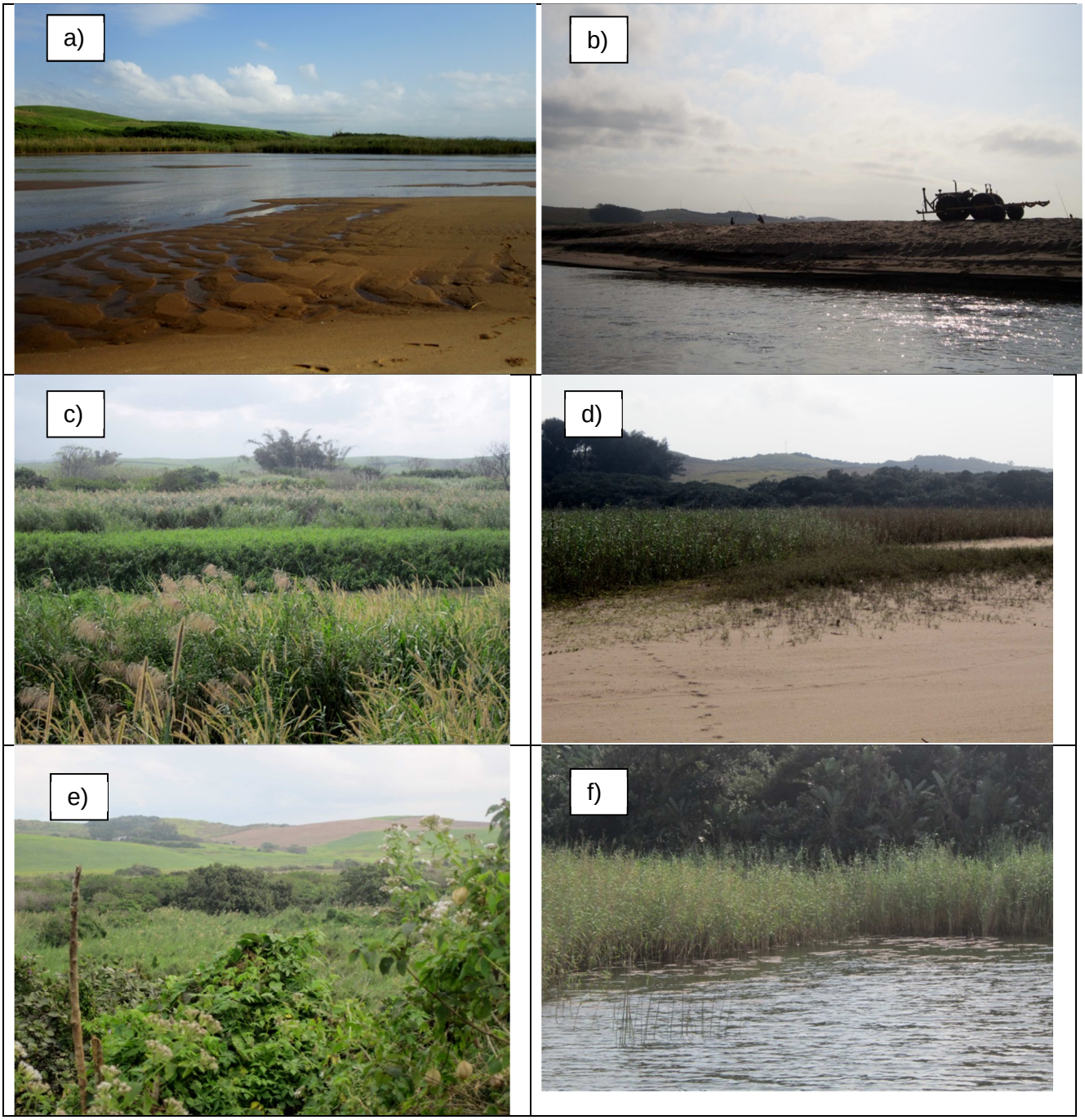

Plate 1: (a). Extensive sandflats at the mouth of Mvoti Estuary. (b). Sandbar at the mouth of Mvoti Estuary. (c). The banks of the middle reaches are fringed with grasses and then reeds. Patches of coastal forest, such as *P. reclinata* remain in the background. (d). Pioneer dune species at the mouth with reeds in the middle and swamp forest in the background. (e). Bushclumps of invasive species amid the reed and sedge covered floodplain of Mvoti Estuary. (f). Water lilies floating on the surface of freshwater pools located to the north of the estuary mouth.

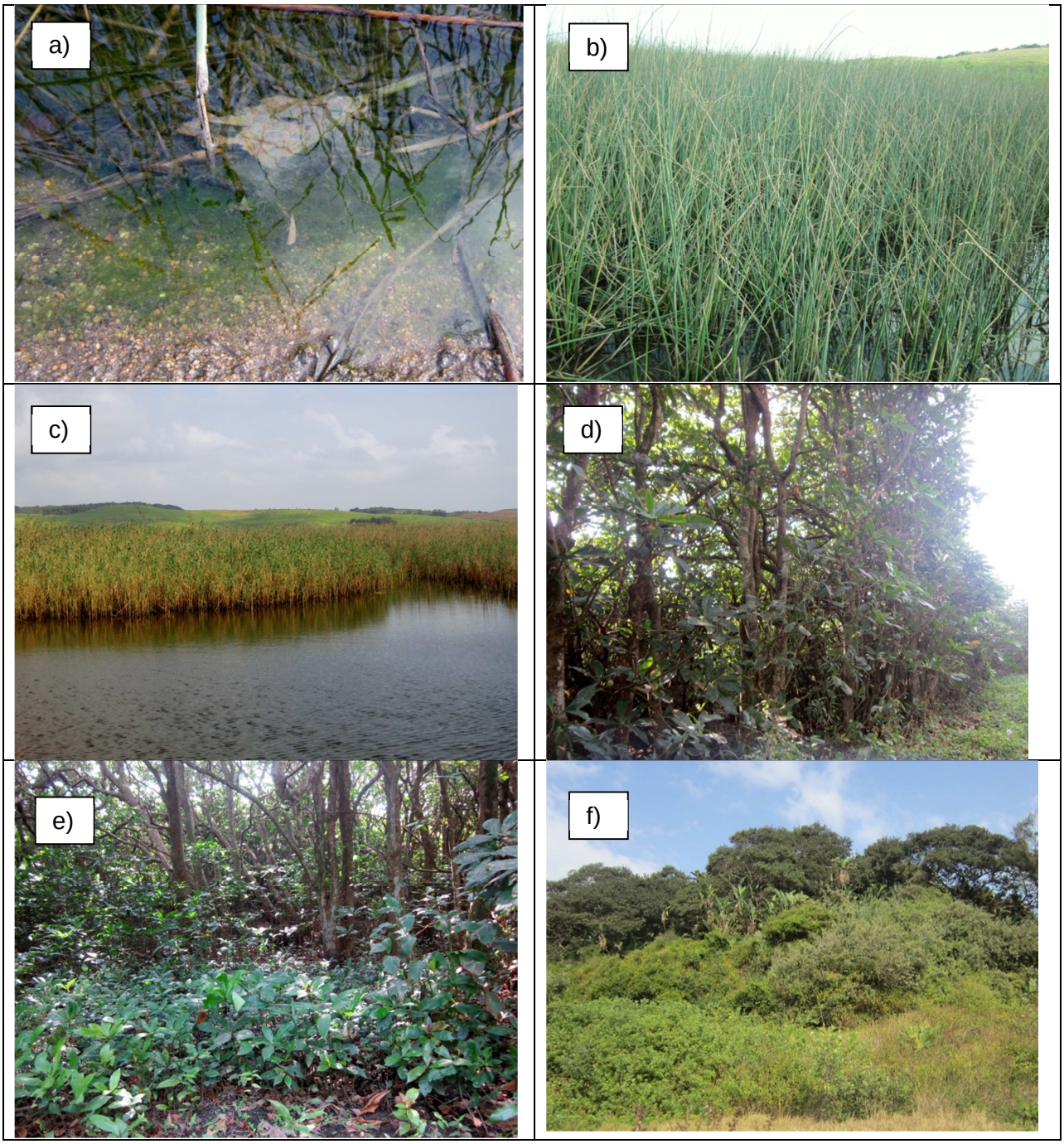

Plate 2: (a). Macroalgal growth within the freshwater pools located to the north of the Mvoti Estuary mouth. (b). *S. scirpoides* stand surrounding the freshwater pools on the north bank of the estuary close to the mouth. (c). Reeds dominating the floodplain of Mvoti Estuary with sugarcane cultivation visible in the background. (d). A stand of *B. racemosa* on the south bank near the mouth of the estuary. (e). Juvenile individuals of *B. racemosa* occurring within the stand (f). Invaded coastal forest on the southern bank of the mouth. Prickly pear present in the foreground and *Casuarina* trees in the background.

The distribution of macrophyte habitats at Mvoti Estuary in 2013 was similar to the historical accounts that date back to 1970. The historical distribution of swamp forest was contradictory, as *B. racemosa* was not described in 1996. The stand described by Begg (1978) on the south bank of Mvoti Estuary was still present in 2013. Almost the entire (71.9 %) floodplain of Mvoti Estuary was already under sugarcane cultivation in 1937. In 2013 this area had declined to 45 % enabling the expansion of reed habitat (Figure 3.3a.). Reed and sedge habitat has almost quadrupled since 1937 where it only fringed the water channel. The dune vegetation present at the sandbar at the mouth was not visible from aerial photography and thus was not mapped. Coastal forest could not be mapped from the 1937 aerial photograph, but it is assumed that it would have naturally occurred in the estuary. The channel of Mvoti Estuary has changed over time (Figure 3.3). The river channel has narrowed upstream and abandoned a large area immediately north of the bend in the system. This area has become overgrown by hygrophilous grasses (Figure 3.4.). Sand and mudflats have also been overgrown with reeds.

Table 3.2 Comparison of macrophyte habitats area (ha) at Mvoti Estuary in 1937 and 2013

Macrophyte habitat	Area	
	1937	2013
Open water	27	16
Cultivation	184	116
Sand and mudbanks	22	6
Reeds and sedges	23	87
Swamp forest	0	2
Natural floodplain	29	0
Hygrophilous grasses	0	51
Alien vegetation	0	7
TOTAL	**285**	**285**

3.3.3 Present Ecological State

23 native macrophyte species in 15 families were recorded in 2013, whereas 42 native species in 22 families were recorded in 1996 (Appendix 2). The lower species richness in 2013 is attributed to the inclusion of more coastal forest species in 1996 as well as seasonality and sampling error. In total, over the two sampling trips, 50 native species in 27 families have been identified in Mvoti Estuary. The majority of species from both sampling trips were graminoids (Poaceae) and herbaceous plants (Asteraceae). Although fewer graminoids were recorded in 2013, particularly from the families Cyperaceae and Juncaceae. The following species were identified in 2013, but were not recorded in 1996: *B. racemosa, C. macrocarpa*, *C. africana*, Coral tree (*Erythrina lysistemon*), *P. australis* and *Typha capensis.*

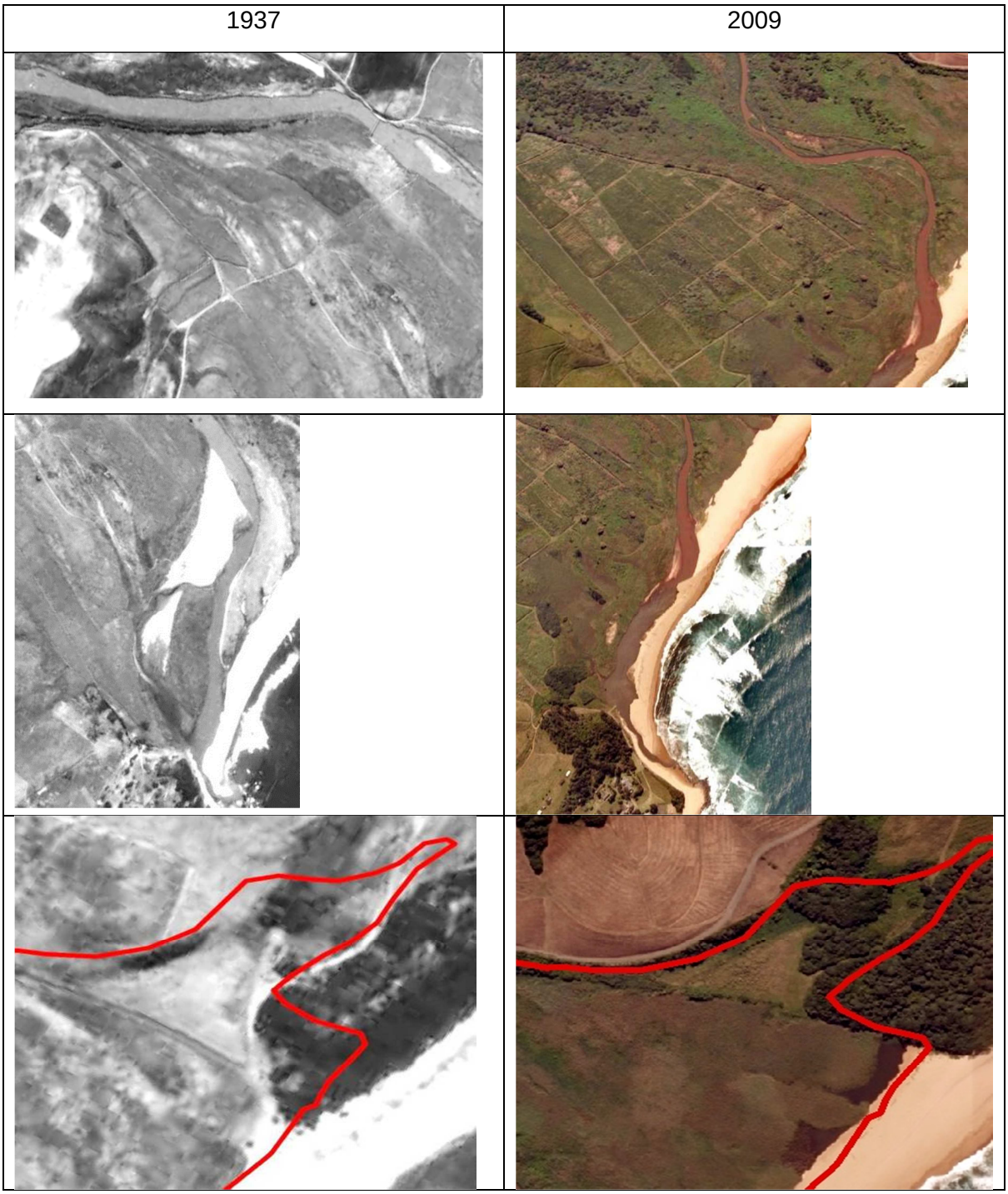

Figure 3.3 **(a). Sugarcane cultivation occurred down to the open water in 1937, but now a section of disturbed reeds and sedges occurs before the channel. (b). The extensive sand/mud banks present at the mouth of Mvoti Estuary. (c). Decrease in coastal dune forest to the north of the mouth and reeds and sedges present in the floodplain surrounding the freshwater pools. The 5 m contour is represented by the red line.**

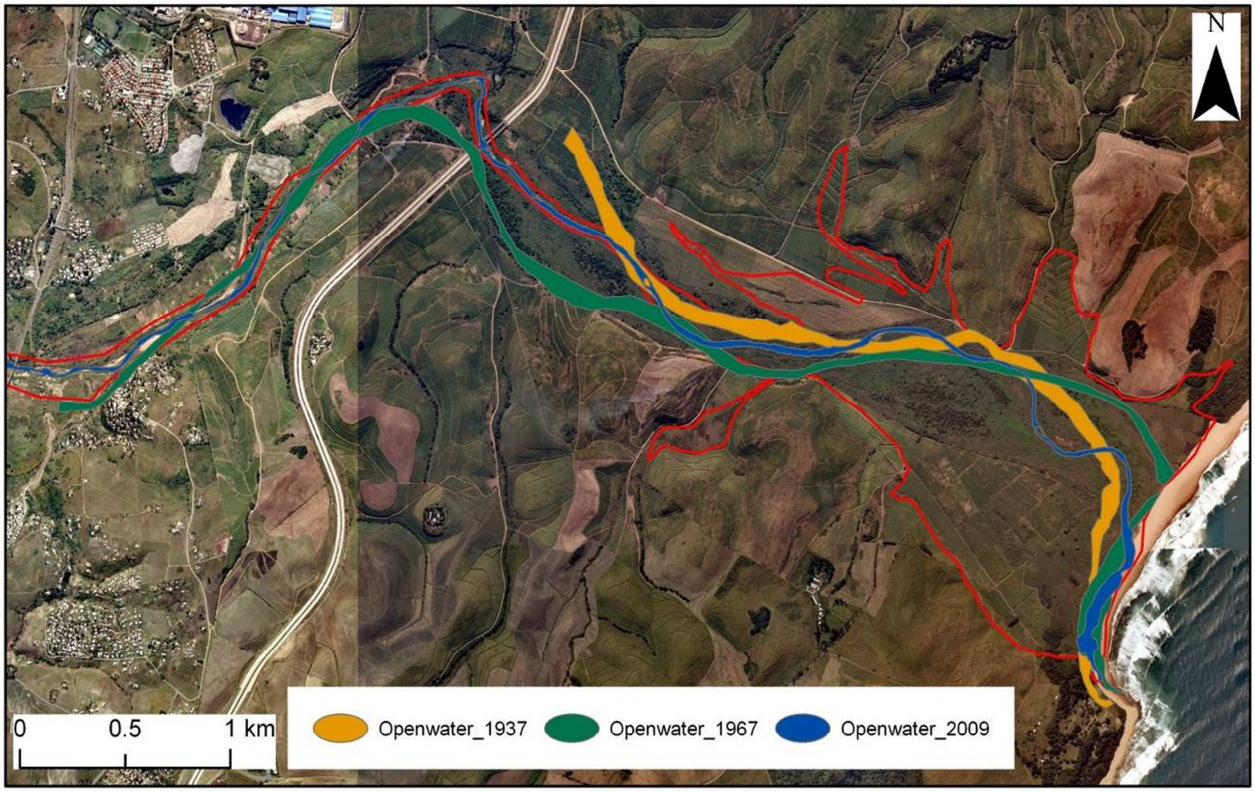

Figure 3.4 Channel changes in the Mvoti Estuary over time. The red line indicates the 5 m contour

In total (1996 and 2013) 21 different exotic species have been recorded at Mvoti Estuary. Of the 41 species identified in 2013 43.9 % were exotic species. 12 of these species were declared invaders as listed by CARA (2011) and NEMBA (2014) (Appendix 2). The number of exotic species recorded at Mvoti Estuary has increased from 12 in the 1996 survey to 18 in 2013. Invasive species were prevalent as undergrowth in the previously cultivated reed covered floodplain as well as along the disturbed middle and upper reaches of the estuary where they have displaced natural macrophytes.

The floodplain of Mvoti Estuary occupies 285 ha that under natural conditions would have been covered by approximately 230 ha of macrophyte habitat, mostly reeds and sedges. In 2013 this area has been reduced to 92 ha almost entirely due to sugarcane cultivation. Reeds and swamp forest habitat has increased in area since the 1937 aerial photograph. Under natural conditions it is likely that the area covered by these macrophyte habitats would have been greater. Swamp forest was probably present under natural conditions, but due to image quality could not be mapped from the 1937 aerial photograph. In terms of macrophyte abundance the 2013 conditions have a 40 % similarity to natural conditions.

The data in Table 3.3 were used to inform the changes in the macrophyte habitats over time. Alien plants were added as a subgroup as they occupy a large area and thus have substantially affected the natural estuarine vegetation. Hygrophilous grasses fringed the water channel in 2013. Based on the historical accounts, it is likely these species have been introduced to the estuary so as to stabilise the banks. The loss of natural floodplain, the extent of invasive species and the presence of hygrophilous grasses has resulted in a low similarity in community composition compared to natural conditions.

Table 3.3 Area (ha) covered by macrophyte habitats and calculation of the similarity in community composition

Macrophyte habitat	Natural area cover	2013 area cover	Minimum
Floodplain	190	0	0
Reeds & sedges	40	87	40
Swamp forest	5	2	2
Alien plants	0	7	0
Hygrophilous grasses	0	51	0
Cultivated floodplain	0	115	0
% similarity			32 %

The low macrophyte health score for Mvoti Estuary is due largely to sugarcane cultivation within the floodplain, hence the high non-flow related impact score (Table 3.4).

3.4 CONCLUSION

The low macrophyte health score for Mvoti Estuary is due to sugarcane cultivation within the floodplain, hence the high non-flow related impact score. A decrease in flooding and loss of the meandering nature of the estuary creates a more stable environment which promotes the growth of reeds, sedges and grasses. Compared to reference conditions there has been a loss in open water surface area, sand and mudflat area. An increase in low flow conditions would encourage the establishment of invasive aquatics such as water hyacinth as they thrive under calm water nutrient rich conditions.

Table 3.4 Similarity scores of macrophytes in the Present condition relative to the Reference condition

Variable	Summary of change	Score	Conf
1. Species richness	Large monospecific stands of reeds and sedges cause low diversity. Invasive species potentially displaced some species. Species have been lost because of disturbance of the floodplain.	60	High
2. Abundance	Extensive sugarcane cultivation in the floodplain has reduced macrophyte habitat. There has been an increase in reeds, sedges, hygrophilous grasses and floating invasive aquatics as a result of nutrient input. The system is less dynamic, emergent macrophytes now colonise stabilised sand and mudbanks which are removed by large floods.	52	High
3. Community composition	Natural floodplain is now cultivated with sugar cane. Sand and mud flats have been colonized by reeds, sedges and grasses..	32	High
Biotic component health score		**32**	
% of impact non-flow related		60	
Adjusted score		44.8	

3.5 REFERENCES

Adams, J.B. 1996. Vegetation Survey of the Mvoti River Estuary. Prepared for the Council for Scientific and Industrial Research at the Department of Botany, University of Port Elizabeth, Port Elizabeth.

Demetriades, N.T. 2007. An Inventory of Sandmining Operations in KwaZulu-Natal Estuaries: Thukela to Mtamvuna. Investigational report for Coastwatch, WESS KZN.

Heydorn, A.E.F. 1986. An assessment of the state of the estuaries of the Cape and Natal in 1985/1986. South African National Scientific Programmes Report No. 130.

Malherbe, C.W. 2006. The current ecological state of the Lower Mvoti River, KwaZulu-Natal. Master of Scientae in Aquatic Health in the Faculty of Science at the University of Johannesburg.

Sukdeo, P. 2010. A study of the natural and anthropogenic impacts on the sediment and water quality of the middle and lower Mvoti River System, KwaZulu Natal, South Africa. Master of Scientae in the School of Environmental Science, Faculty of Science and Agriculture, University of KwaZulu-Natal, Durban.

Swemmer, R. 2011. Ecological Integrity Assessment of the Mvoti Estuary, KwaZulu-Natal, South Africa. Master of Scientae in Aquatic Health in the Faculty of Science at the University of Johannesburg.

Turpie, J and B clark. 2007. Development of a conservation plan for temperate South African estuaries on the basis of biodiversity importance, ecosystem health and economic costs and benefits. C.A.P.E. Regional Estuarine Management Programme, Final Report.

Turpie, J.K., Wilson, G. & van niekerk, L. 2012. National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa. Anchor Environmental Consultants Report No AEC2012/01, Cape Town. Report produced for the Council for Scientific and Industrial Research and the South African National Biodiversity Institute.

Appendix 2: Native species composition for Mvoti Estuary recorded in 1996 (Adams, 1996) and 2013. W: Wetland vegetation associated with the mouth area, D: dune vegetation and CD: coastal dune forest vegetation.

Species	Common name	1996			Present (July 2013)
		W	D	CD	
Trees					
Asteraceae					
Brachylaena discolor DC.	Coast silver oak			x	Coastal forest vegetation found on the slopes on both banks.
Celastraceae					
Mystroxylon aethiopicum (Thunb.) Loes.	Kooboo berry			x	
Gymnosporia heterophylla (Eckl. & Zeyh.) Loes.	Common spike-thorn			x	
Euphorbiaceae					
Bridelia micrantha (Hochst.) Baill.	Brown stinkwood	x			
Fabaceae					
Erythrina lysistemon Hutch.	Coral tree				Found in reeds and sedges in the middle reaches of the estuary.
Lecythidaceae					
Barringtonia racemosa (L.) Roxb.	Freshwater mangrove				Stand on the south bank at the mouth of the estuary.
Malvaceae					
Hibiscus tiliaceus L.	Lagoon hibiscus			x	Situated next to the *B. racemosa* near the mouth.
Myrtaceae					
Eugenia capensis (Eckl. & Zeyh.) Sond.	Dune myrtle			x	
Sapotaceae					
Mimusops caffra E.Mey. ex A.DC.	Coastal red milkwood			x	
Sideroxylon inerme subsp*. inerme*	White milkwood			x	
Shrubs and climbers					
Acanthaceae					
Barleria obtusa Nees.	Klapperbossie			x	Disturbed land near the swamp forest, being drained for cultivation.
Asteraceae					
Felicia muricata (Thunb.) Nees subsp. *muricata*	Blue dune daisy		x		
Gazania rigens var. *uniflora*	Dune gazania		x		Growing on the dunes at the mouth.
Senecio tamoides DC.	Canary Creeper		x		Disturbed land near the swamp forest, being drained for cultivation.
Apocynaceae					
Carissa macrocarpa (Eckl.) A.DC.	Natal Plum				Coastal forest vegetation on the north bank.
Apiaceae					
Conium chaerophylloides (Thunb.) Sond.		x			
Asparagaceae					
Asparagus densiflorus (Kunth) Jessop				x	
Colclicaceae					
Gloriosa superba L.	Flame lily			x	
Commelinaceae					
Commelina africana L. var. *africana*	Wandering jew				Growing on the dunes at the mouth.
Convolvulaceae					
Ipomoea pres-capre (L.) R.Br. subsp.	Goat's foot		x		Growing on the dunes at the mouth.

Species	Common name	1996			Present (July 2013)
		W	D	CD	
Brasiliensis					
Fabaceae					
Canavalia ensiformis (L.) DC.	Jack bean	x			Growing on the sandbanks at the mouth of the estuary.
Vigna vexillata (L.) A.Rich. var. *vexillata*	Wild sweetpea	x			
Goodenaceae					
Scaevola plumieri (L.) Vahl	Seeplakkie		x		Growing on the dunes at the mouth.
Malvaceae					
Sida rhombifolia L. subsp. *rhombifolia*	Koekbossie	x			Growing on the dunes at the mouth.
Nymphaeaceae					
Nymphaea nouchali Burm.f. var. *caerulea* (Savigny) Verdc.	Blue Egyptian water lily				Present on the freshwater pools north of the mouth.
Polyganaceae					
Persicaria senegalensis (Meisn.) Soják forma senegalensis		x			
Oxygonum dregeanum subsp. *dregeanum*	Vleisblommetjie	x			
Persicaria decipiens (R.Br.) K.L.Wilson		x			Disturbed land near the swamp forest, being drained for cultivation.
Pteridophyta					
Microsorum scolopendria (Burm.f.) Copel.				x	
Solanaceae					
Solanum lichtensteinii Willd	Bitterapple	x			
Urticaceae					
Raportea peduncularis (Wedd.) Chew subsp. *peduncularis*		x			Disturbed land near the swamp forest, being drained for cultivation.
Vitaceae					
Rhocicissus digitata (L.f.) Gilg & M.Brandt	Baboon grape			x	
Graminoids					
Cyperaceae					
Cyperus brevis Boeckeler		x			
Cyperus albostriatus Schrad.		x			
Cyperus longus L. var. *longus*		x			
Kyllinga melanosperma Nees		x			
Schoenoplectus scirpoides (Schrad.) Browning		x			Stands in the freshwater pools north of the mouth.
Juncaceae					
Juncus kraussii Hochst. subsp. *kraussii*	Sharp rush	x			
Juncus effuses L.		x			
Poaceae					
Cynodon dactylon (L.) Pers.		x			
Dactylocterium australe Steud.	Durban grass	x			
Digitaria eriantha Steud.	Finger grass	x			
Eleusine coracana (L.) Gaertn. subsp. *africana* (Kenn.-O'Byrne) Hilu & de Wet	Goose grass	x			
Phragmites australis (Cav.) Steud.					Monospecific stands covering most of the floodplain, particularly in the lower reaches.
Phragmites mauritianus Kunth	Dekriet	x			Monospecific stands covering most of the floodplain, particularly in

Species	Common name	1996			Present (July 2013)
		W	D	CD	
					the lower reaches.
Setaria sphacelata (Schumach.) Stapf & C.E.Hubb. ex M.B.Moss var. *sphacelata*	Common bristle grass	x			Present in disturbed areas such e.g. swamp forest at the south bank of the mouth and between stands of *Phragmites* spp. and sugarcane cultivation.
Sporobolus africanus (Poir.) Robyns & Tournay		x			Fringing the water channel in the middle and upper reaches.
Stenotaphrum secundatum (Walter) Kuntze	Buffelsgras	x			Fringing the water channel in the middle and upper reaches.
Typhaceae					
Typha capensis (Rohrb.) N.E.Br.	Bulrush				Disturbed land near the swamp forest, being drained for cultivation.

Appendix 3: Exotic species composition of Mvoti Estuary including the 1996 assessment (Adams, 1996) and in July 2013.

Species	Family	NEMBA and CARA categories	Common Name	1996	2013
Ageratum conyzoides L.	Asteraceae	1b	Blueweed	Wetland vegetation associated with the mouth area.	Growing amongst the reeds and sedges, near the sugarcane cultivations in the lower reaches.
Arundo donax L.	Poaceae	1	Giant/Spanish reed		Growing amongst the reeds and sedges in the lower reaches.
Bidens bipinnata L.	Asteraceae		Blackjack	Wetland vegetation associated with the mouth area.	Disturbed coastal forest area at the mouth of the estuary, near a path to recently planted sugarcane cultivations.
Casuarina equisetifolia L.	Casuarinaceae	2	Horsetail tree	Mouth of the estuary.	Present on both slopes in the coastal forest vegetation.
Coix lacryma-jobi L.	Poaceae		Job's tears		Present in the disturbed reeds and sedges habitat north of the estuary.
Conyza bonariensis (L.) Cronquist	Asteraceae		Gallsick bush (weed)	Dune forest vegetation	Disturbed land on the south bank.
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	1	Water hyacinth		Found on the sand and mudflats at the mouth of the estuary as well as in the freshwater pools north of the estuary.
Ipomoea purpurea (L.) Roth	Convolvulaceae	3		Wetland vegetation associated with the mouth area.	Draped on H. tiliaceus on the south bank at the mouth and around the coastal dune forest to the north of the estuary.
Lactuca serriola L.	Asteraceae		Prickly lettuce		Undergrowth of reeds and sedges on the sand and mudflats at the mouth.
Lantana camara L.	Verbenaceae			Wetland vegetation associated with the mouth area and dine forest vegetation	Growing next to the reeds and sedges on the sand and mudflats at the mouth.
Malva parviflora L. var. *parviflora*	Malvaceae			Wetland vegetation associated with the mouth area.	
Melia azedarach L.	Meliaceae	1b, 3 in urban areas.	Syringa berry		Present in bush clumps in the reed and sedge covered floodplain.
Opuntia ficus-indica (L.) Mill.	Cactaceae	1b	Sweet Prickly pear		Disturbed coastal forest on the south bank below the Jex Estate.

Species	Family	NEMBA and CARA categories	Common Name	1996	2013
Othonna natalensis Sch.Bip.	Asteraceae		Geelbossie (weed)	Dune vegetation.	
Paspalum notatum Flüggé	Poaceae		Bahia grass	Wetland vegetation associated with the mouth area.	Fringing the water channel.
Plantago major L.	Plantaginaceae		Broadleaf Plantago	Dune vegetation.	Present amongst the dune vegetation.
Rumex crispus L.	Polyognaceae		Curly dock		Dune vegetation- undergrowth of reeds and sedges.
Schinus terebinthifolius Raddi	Anacardiaceae	1b in EC, KZN, Limpopo and Mpumalanga. 3 in FS, G, NW, NC and WC.	Brazilian Pepper Tree		Present in bush clumps in the reed and sedge covered floodplain, particularly in the middle reaches.
Senna didymobotrya (Fresen.) Irwin & Barneby	Fabaceae	3 1b in EC, KZN, Limpopo and Mpumalanga	Peanut Butter Bush		Fringing the water channel by the N2 road bridge.
Sesbania punicea (Cav.) Benth.	Fabaceae	1b	Brazilian glorybean		Present in bush clumps in the reed and sedge covered floodplain.
Solanum campylacanthum Hochst. ex A.Rich. subsp. *panduriforme*	Solanaceae		Bitterapple	Wetland vegetation associated with the mouth area.	
Verbena bonariensis L.	Verbenaceae	1b	Blouwater bossies (Naturalized weed)	Wetland vegetation associated with the mouth area.	

4 INVERTEBRATES SPECIALIST REPORT

Citation:

This report should be cited as: **Forbes N.T. & Forbes A.T. 2014**: Invertebrates of the Mvoti Estuary. MER Report 31/2014

N.T. Forbes & A.T Forbes

Version 1.1

September 2014

Prepared by:

MARINE & ESTUARINE RESEARCH

Head Office
Office Suite 3a
27 Moreland Drive
La Lucia Ridge

P.O. Box 417
Hyper-By-The- Sea
4053

Satellite Office:
The Business Centre
Suite 134
Umhlanga Ridge

ph: (031) 572 2705
Fax: (086) 609 0162
cell: (082) 451 8078
email: info@mer.co.za

4.1 INTRODUCTION

A standardised approach to estuary ecosystem health monitoring, analysis and reporting is provided by the *Methods for the Determination of the Ecological Reserve for Estuaries* (2012) established as part of the Water Resource Protection and Assessment Policy of the Department of Water and Sanitation. Standardisation of monitoring, analysis and reporting based on best practice provides consistency at a range of scales (local, regional and national), allows for the comparison of assessments and ensures scientific validity in reporting information provided to the community. This report details the sampling and analysis of the benthic macro-invertebrate community of the Mvoti Estuary

4.2 TERMS OF REFERENCE

CSIR has appointed MER to conduct an assessment of the benthic macroinvertebrate community of the Mvoti estuary. This assessment is required to provide an up to date picture of the current status of the invertebrates within the system during the winter low flow period of August 2013 and summer high flow period during January 2014. In addition to an assessment of the monitoring the estuary to satisfy the conditions of the Water Use Licence granted to allow extractive use of the water upstream of the estuary, this survey was also tasked with the assessment of the system's response to the partial or full abstraction of the ecological reserve component of the flow.

4.3 STUDY AREA

The Mvoti Estuary (Figure 4.1) is a Permanently Open estuary and only of only five between uThukela and Mtamvuna.

4.4 SAMPLING SITES

Four sites were sampled during 2013 - 2014, (Table 4.1). These sites corresponded to areas sampled during previous studies (CRUZ, 2000). Benthic samples for biological and sediment analyses were collected at all sites in August 2013 and January 2014

Table 4.1 Site names, distance from the mouth, geographical locations and estuarine zones where physico-chemical water parameters were measured and biological sampling carried out

Site Reference	Location	Latitude	Longitude
MV1	Mouth/downstream site	29°23'28.42"S	31°20'3.73"E
MV2		29°23'15.82"S	31°20'7.33"E
MV3		29°23'10.63"S	31°20'9.86"E
MV4	Upstream site		

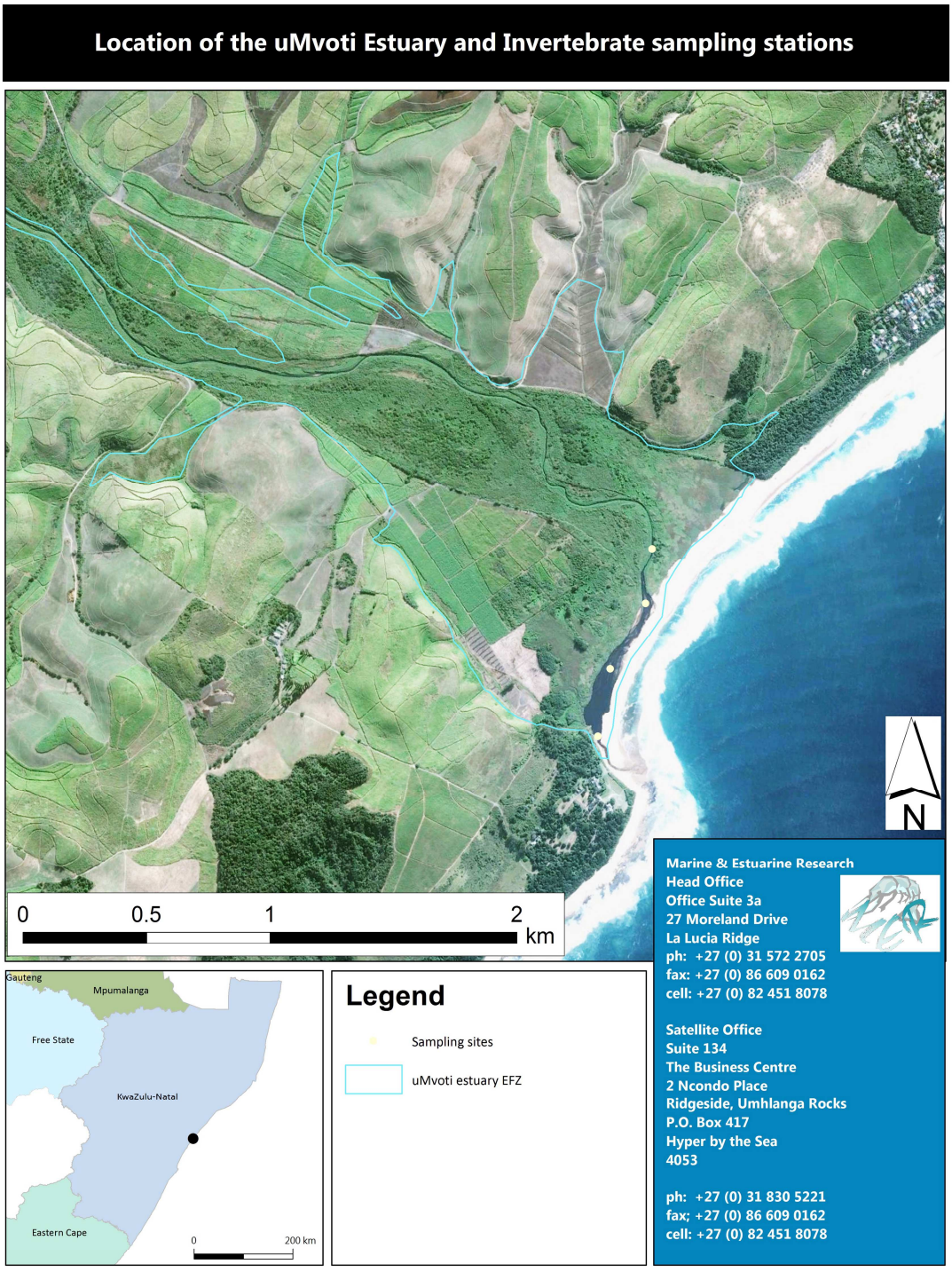

Figure 4.1 Map of the Mvoti estuary showing its position within KwaZulu-Natal and the invertebrate sampling sites

4.5 METHODS

The methods used during the surveys at all sites were the same as those used in previous surveys to allow the annual data sets to be compared to historical data.

Benthic macroinvertebrates

Benthic macroinvertebrates comprise a broad range of organisms that can vary spatially in an estuary as a function of their adaptations and the conditions within the local area. They are usually not very mobile and spend part or all of their lives in close association with the substratum of estuaries, which makes them good indicates of the conditions prevailing in an estuary over the long term. Due to the physico-chemical nature and processes taking place in estuaries, benthic organisms are spatially zoned along axial gradients, linking species distribution to the relative inputs of marine and freshwater. This means that in KZN this group of organisms exhibits strong seasonal patterns in response to changes in rainfall and river flow.

Benthic sampling was carried out at the four sites using a van Veen grab. The sediments and macrobenthic invertebrates were sampled using a Zabalocki-type Eckman bottom grab. Five grab samples were collected within a radius of c. 5 m at each of the four sampling sites. Each of the samples was placed into a separate 20ℓ-25ℓ bucket. A sediment sample was removed from each of the sample buckets and placed in a cooler. If sediments at a station were of a fine grain size (i.e. pass through a 0.5 mm mesh) the entire sample was washed through the collection net. Where coarse sediments were sampled, the entire sample was agitated to encourage benthic organisms to float/swim in the suspension and whilst being continuously stirred, the supernatant was poured through the 0.5 mm sieve net. This was repeated five times as per the standard methods for removal of benthic fauna. The remaining sediment and organic matter was then sieved through a 1 mm mesh and examined for larger animals. Animals and other biological material retained by the net were bottled and fixed in 4% formaldehyde with the dye Phloxine B (which selectively stains animal tissue) added to aid identification in the laboratory.

First degree sorting of macrobenthic invertebrates was done in the field where each sample was stirred into a supernatant, which was then passed through a 0.5 mm sieve. This washing was repeated five times, and any remaining material was then passed through a 1 mm sieve in order to retain larger organisms that may not have become suspended in the supernatant. The sample was then fixed in the field using a formalin/phloxine mixture to preserve and stain the organisms.
Second degree sorting of the samples occurred in the laboratory where the invertebrates will be identified and counted using an Olympus SZ2-1LST light microscope.

Identifications were carried out using the following general guides, viz:

- A Guide to Marine Life on South African Shores (Day 1974)
- Living Shores of Southern Africa (Branch & Branch 1981)
- Two Oceans – A Guide to the Marine Life of Southern Africa (Branch, Griffiths, Branch & Beckley 1994)

The following more specialised texts were also be used, viz:

- Day (1967a, b) for polychaete worms
- Griffiths (1976) for amphipod crustaceans
- Kensley (1978) for isopod crustaceans
- Kensley (1972) for shrimps and prawns
- Appleton (1996) and Kilburn & Rippey (1982) for molluscs

4.6 RESULTS

4.6.1 General observations

4.6.1.1 Sludge deposits

It was noted that from the mouth to the uppermost sampling site there was a dark grey to black sludge present in the estuary (Figure 4.2, Figure 4.3). In most areas this was deposited on the substrate or was suspended in the water column immediately above the substrate. The nature and origin of the sludge could not be verified.

Figure 4.2 Black sludge observed in the Mvoti Estuary on 29 August 2013

Figure 4.3 Black sludge observed in the Mvoti Estuary on 29 August 2013. Note the footprint where one of the team disturbed the viscous jellylike material

4.6.2 Sediments

The estuary and lower river course are sediment saturated, shallow and river dominated. From descriptive narratives there does not appear to have been further accumulation of sediments since the 1940s and the raised bed of the estuary still limits tidal effects to a maximum of about 400 m upstream of the mouth. Sustained outflows, often largely effluent, maintain a relatively coarse, sandy sediment.

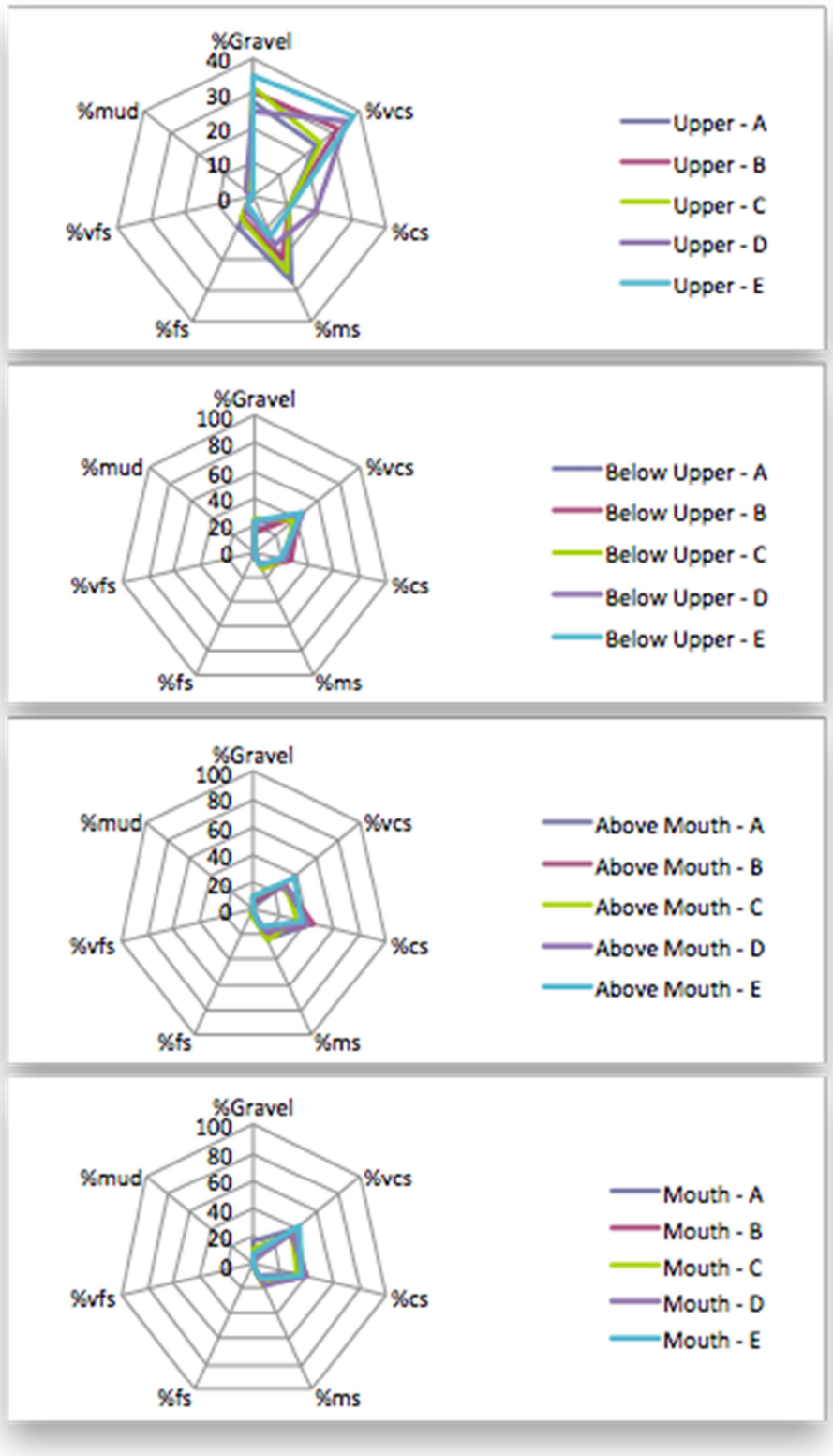

Figure 4.4 Sediment particle size composition at the Mvoti estuary invertebrate sampling sites during August 2013

4.6.3 Benthic Macroinvertebrates

Benthic sampling of intermittently open and river mouth type estuaries in KZN covering virtually every such system (MER, unpublished) in KZN from the Mahlongwa at the southern end of the eThekwini municipal area to the Nhlabane north of Richards Bay indicates that over an extended period a maximum of 30-40 benthic macroinvertebrate species may be encountered in any one system. These include resident species as well as others having a marine phase in the life cycle. In terms of abundance the major groups are the polychaete worms, whose life cycles and dispersal abilities are virtually unknown, and the peracarid groups of crustaceans. Larger anomuran crustaceans and bivalves are uncommon. Chironomid fly larvae are the only insects that occur in any numbers but are typically associated with low salinities. This latter group may also occur with oligochaete worms.

Development of an estuarine type zooplankton would depend to a large degree on water retention in the estuary, which is not a feature of general conditions in the Mvoti.

Five taxa were recorded in total (Table 4.2), consisting of four at the two upper sites and three at the two lower sites in August 2013. The very short list included a total of 19 leeches, eight polychaetes *Ceratonereis keiskama,* one tubificid oligochaete and one bivalve *Brachidontes virgiliae.* Oligochaetes were common at the upper site, decreasing downstream but the benthos was totally dominated by chironomid midge larvae which were between five and 80 times more abundant than the next most common taxon at any one site. The community crashed further in February 2014 when only three taxa were recorded consisting of a single tentatively identified polychaete, a single tubificid oligochaete and the rest oligochaetes. The previously dominant chironomid larvae were not recorded.

Placing the generalisations of invertebrates in KZN systems In the context of the Mvoti estuary it is highly significant that only two taxa occurred in any numbers, *viz.* chironomid fly larvae and oligochaete worms, neither of which could be identified to species level.

Table 4.2 Benthic macroinvertebrates found within the Mvoti estuary during 2013 – 2014

	August 2013				February 2014			
	1	2	3	4	1	2	3	4
ANNELIDA								
Polychaeta								
Ceratonereis keiskama		89						
Cirratulidae					9			
Hirudinea	18		133	9				
Oligochaeta	98	222	977	3863	9	1465	1758	213
Tubificidae			9				9	
MOLLUSCA								
Bivalvia								
Brachidontes virgiliae				9				
INSECTA								
Diptera								
Chironomidae incl pupae	5728	20513	11455	11011				
Mean total individuals.m^2	**5843**	**20824**	**12574**	**14892**	**18**	**1465**	**1767**	**213**
No of taxa at each site	3	3	4	4	2	1	2	1

4.7 DISCUSSION AND CONCLUSIONS

The predominance of very low salinities, bordering on fresh can obviously be attributed to the river flow in the first instance and secondly to the raised bed level in the estuary which would minimise tidal influence except possibly during extreme spring tides. This would have an effect on species sensitive to extended low salinities. The sediments were generally medium to coarse sand which would not necessarily exclude all estuarine macrobenthos. The temperature and turbidity levels recorded would equally not have excluded the macrofauna. The macrobenthic fauna nevertheless bordered on uniquely depauperate being more reminiscent of a sewage conduit than an even partially functional estuary. The fact that oxygen levels recorded in August were effectively zero at all sites sampled is in accordance with the presence of tubificid and other oligochaetes as well as chironomid larvae, all of which are known to be associated with low oxygen aquatic habitats. Whether toxins of some form are present in the water is unknown but this possibility would have to be considered following the absence of the previously abundant chironomid larvae in February. From an estuarine macrobenthic invertebrate faunal point of view in KZN the Mvoti is irrelevant.

4.8 REFERENCES

Appleton C. C. 1996. Freshwater molluscs of southern Africa. University of Natal Press.

Begg G.W. 1978. The Estuaries of Natal Natal Town and Regional Planning Report 41:1-657

Begg G.W. 1984. The Estuaries of Natal. Part 2. Supplement to NTRP Report Vol 41. 55:1-631

Branch G.M. & Branch, M. 1981. The Living Shores of Southern Africa. C. Struik, Cape Town.

Branch G.M., Griffiths C.L., Branch M.L. & Beckley L.E. 1994. Two Oceans. A Guide to the Marine Life of Southern Africa. David Phillip, Cape Town & Johannesburg.

Day J.H. 1967a. A Monograph on the Polychaeta of Southern Africa. Part 1. Errantia. British Museum of Natural History.

Day J.H. 1967b. A Monograph on the Polychaeta of Southern Africa. Part 2. Sedentaria. British Museum of Natural History. Part 2. Sedentaria. British Museum of Natural History.

Day J.H. 1974. A Guide to Marine Life on South African Shores. A.A. Balkema, Cape Town.

Griffiths C. L. 1976. Guide to the Benthic Marine Amphipods of Southern Africa. South African Museum, Cape Town.

Heemstra P. & Heemstra E. 2004. Coastal Fishes of Southern Africa. National Inquiry Service Centre and the South African Institute for Aquatic Biodiversity.

Kensley B. 1972. Shrimps and Prawns of Southern Africa. South African Museum, Cape Town.

Kensley B. 1978. Guide to the Marine Isopods of Southern Africa. South African Museum, Cape Town.

Kilburn R. & Rippey E. 1982. Sea Shells of Southern Africa. South China Printing Co.

5 FISH SPECIALIST REPORT

Steven Weerts: Coastal Systems Research Group (DURBAN). Natural Resources and the Environment CSIR.

5.1 INTRODUCTION

The Mvoti estuary (29.384326°S, 31.338601°E) is the northernmost estuary in the Water Management Area (WMA) 11 on the coast of KwaZulu-Natal (KZN), South Africa. Approximately 60 km northeast of Durban it lies in a subtropical biogeographic zone. The estuary is classified as a river mouth by Whitfield (2000). As such it is only one of four river mouths on the subtropical coast of South Africa, others being the Mfolozi, Thukela and Mzimvubu. While similar to these systems in having a small tidal prism, the Mvoti differs in that it has a much smaller catchment and is characterised by clearer (non-turbid) waters under normal flows conditions. The system also has an elevated bed which, even over much of its lower reach, is raised above sea level and extremely shallow.

The Mvoti estuary has been relatively well studied compared to many other KZN systems, a fact unfortunately related to its poor water quality and degraded state. The poor condition of the system has been reflected in various reports and scientific publications. This situation is not restricted to recent times but dates back to at least the mid-1960s (Brand *et al*. 1967). Begg (1978) noted the system as being severely degraded, mainly as a result of organic pollution from sugar and paper mills and severe rates of siltation. Poor water quality was confirmed by field surveys conducted in 1982, but surprising was not reflected in very low water oxygen tensions (Begg 1984). Low oxygen levels, related to organic loading in the system have been regarded as limiting to aquatic biota in the estuary in subsequent work (MacKay *et al*. 2000, O'Brien *et al*. 2009). Sources of pollution and impact are various, but have mostly been attributed to nutrients from the catchment, agriculture (sugar cane farming in particular), industrial and domestic sewage. In a national scale assessments of the status of estuaries in South Africa, Harrison et al. (2000) rated the Mvoti's water quality and fish fauna as being poor, and the National Biodiversity Assessment of 2011 classified the Mvoti estuary as being highly degraded and in a D Ecological Category (van Niekerk and Turpie, 2012).

This report makes an assessment of the present ecological state of the Mvoti estuary's fish fauna, and gives predictions of the systems fish community response to selected flow scenarios. This work is based on data available from historic fish surveys and the results of a field survey conducted in August 2013. It takes cognisance of, and relies upon the findings of other specialist assessments conducted for the WMA11 Mvoti estuary RDM study.

5.2 MATERIALS AND METHODS

5.2.1 Data sources

Data on fishes of the Mvoti Estuary were sourced from previous studies reported upon in the scientific and grey literature. These included surveys listed below:

Researcher/Organisation	Survey date(s)	Sampling methods	Reference
Begg	1982 (Jan, May, Aug)	Beam trawl	Begg (1984)
CSIR	1986 (Aug)	Seine net, gill net, beam trawl	Ramm et al. (1986)
CSIR	1989 (Feb)	Various	Harrison et al. (1989)
CSIR	1989 (Aug)	Seine net, gill net, beam trawl, otter trawl	Harrison (1990)
CSIR	1990 (Jan)	Seine net, gill net, beam trawl, otter trawl	Harrison (1990)
CSIR	1999 (Feb)	Seine nets, gill net	Harrison et al. (2000)
CRUZ	1999 (Nov)	Seine nets (2), electroshocker	MacKay et al. (2000)
CRUZ	2000 (Aug)	Seine nets (2), electroshocker	MacKay et al. (2000)
UJ	2004 (Sep)	Seine nets (3), gill net, cast net, fyke net, electroshocker	O'Brien et al. (2009)
UJ	2005 (Mar)	Seine nets (3), gill net, cast net, fyke net, electoshocker	O'Brien et al. (2009)
UJ	2005 (Aug)	Seine nets (3), gill net, cast net, fyke net, electroshocker	O'Brien et al. (2009)
UJ	2006 (Mar)	Seine nets (3), gill net, cast net, fyke net, electroshocker	O'Brien et al. (2009)
UJ	2008 (Oct)	Seine nets (3), gill net, cast net, fyke net, electroshocker	O'Brien et al. (2009)
CSIR (this study)	2013 (Aug)	Seine net, gill net	This report

CRUZ = Coastal Research Unit of Zululand, UJ = University of Johannesburg

5.2.2 Field survey

Mvoti Estuary was surveyed for fishes on 28 August 2013. Sampling gears used were a 30 m x 1.7 m x 15 mm bar mesh seine net fitted with a 5 mm bar mesh purse and fleets of gill nets (each 10 m in length and comprising equal lengths of 45 mm, 75 mm and 100 mm stretch mesh monofilament panels, 1.7 m deep. Sampling was restricted to the lower reaches of the estuary, as these could be accessed by boat (albeit pushed rather than rowed or under power of outboard engine for reasons of shallow depth) and also provided the only area of the estuary clear of floating or emergent vegetation and with sandbanks that allowed the seine net to be deployed and hauled ashore. Sampling was conducted during daylight hours.

As far as possible, fishes sampled were identified and measured (to the nearest 10 mm SL) in the field, and returned live to the water. A limited number of specimens (predominantly small mullet that could not be confidently identified in the field) were preserved and returned to the laboratory for identification.

5.2.3 Data analysis

Direct comparisons of fish fauna over the different periods for which data were available could not be made. Sampling gears varied across the different surveys and information on sampling effort was not available in most cases. For this reason fish abundances from different surveys were standardised to percentages. This allowed relative abundances of different species to be compared within and across the different surveys. Frequency of occurrence across all surveys could also be calculated and provided a good indication of the likelihood of each species occurring

in the estuary. Alien species, when they occurred were omitted from abundance comparisons, but their frequencies of occurrence were included.

For the purposes of this study the Mvoti estuary was considered as being the water body from the system's mouth to the N2 road bridge, approximately 5 km (channel length) upstream. Some sites sampled in the historic surveys of the Mvoti lie above this bridge but have been found to support estuarine and estuarine dependent marine fishes. Data from these sites were included in the analysis.

5.2.4 Present Ecological Status

The Present Ecological Status of the fish community of the Mvoti estuary was assessed based on an assessment of fishes sampled in the documented surveys, their relative abundances and frequencies of occurrence. As indicated above, comparison of results from different surveys was difficult, due to differences in sampling gears and sampling effort. Fish distribution can be patchy in estuaries and this makes comparison of abundances of individual species (especially shoaling forms) across surveys difficult. In such cases relative abundances of different fish guilds can be informative.

Fishes with a variety of life histories use South African estuaries and several estuarine association guilds have been applied to categorise our estuarine ichthyofauna. Most widely used has been that of Whitfield (1994), although more recent refinements have applied (e.g. Harrison and Whitfield 2008) based on functional use categories more globally applicable (e.g. Elliot *et al*. 2007). For the purposes of this assessment Whitfield's categorisation (Table 5.1) was used as a basis to classify fishes as:

- Estuarine resident: Species that complete their life cycles in South African estuaries (Whitfield's categories Ia and Ib).
- Estuarine dependent marine: Species which breed at sea with the juveniles dependent on South African estuaries (Whitfield's categories IIa, IIb and Vb).
- Marine: Species which use South African estuaries opportunistically, but are not dependent upon these systems to complete their life cycles (Whitfield's categories IIc and III).
- Freshwater: Species which can (and mostly do) complete their life cycles in fresh water (Whitfield's category IV).
- Catadromous: Anguillid eels, which use estuaries only as transit routes between the marine and fresh water environments (Whitfield's category Vb).

Table 5.1 Classification of South African fish fauna according to their dependence on estuaries (Whitfield 1994)

Category	Description
I	Truly estuarine species, which breed in southern African estuaries; subdivided as follows:
Ia	Resident species which have not been recorded breeding in the fresh water or marine environment
Ib	Resident species which have marine or fresh water breeding populations
II	Euryhaline marine species which usually breed at sea with the juveniles showing varying degrees of dependence on southern African estuaries; subdivided as follows:
IIa	Juveniles dependent of estuaries as nursery areas
IIb	Juveniles occur mainly in estuaries, but are also found at sea
IIc	Juveniles occur in estuaries but are more abundant at sea
III	Marine species which occur in estuaries in small numbers but are not dependent on these systems
IV	Euryhaline freshwater species that can penetrate estuaries depending on salinity tolerance. Includes some species which may breed in both fresh water and estuarine systems.
V	Catadromous species which use estuaries as transit routes between the marine and fresh

Category	Description
	water environments. Includes the following subcategories:
Va	Obligate catadromous species
Vb	Facultative catadromous species

There are of course other ways of categorising, or grouping, components of estuarine fish assemblages. Feeding guilds are another common approach and in this respect most South African species can be assigned to categories as being:

- Detritivores: Species that feed predominantly on detritus, deriving nutrition from bacteria on decaying vegetation and microphytobenthos.
- Zooplanktivores: Species that feed on zooplankton, mostly small crustaceans.
- Zoobenthivores: Species that feed on benthic invertebrates living on, or in the sediments.
- Piscivores: Species that prey upon other fishes.

These categories are also not exhaustive and in most cases estuarine fishes rely upon a variety of food sources and many species feed across these groups, either opportunistically taking advantage of food and prey items easily available, or because of shifts in diet with ontogenetic development (growth). In the majority of species ontogenetic changes involve shifts in diet from zooplankton to zoobenthos. These are extremely common and occur in size ranges of fishes that occupy estuaries.

5.3 RESULTS AND DISCUSSION

5.3.1 Fish habitats

Begg (1984) describer the Mvoti estuary as a shallow, ever-flowing system quite unlike any of the other 62 KZN estuaries which he studied. The system is strongly dominated by a river mouth phase, and is fresh water dominated with little tidal intrusion of saline waters. Flows are unidirectional downstream over the majority of the estuary, although tidal influence is reflected in slowing of outflows and backing-up of fresh water some distance upstream of the estuary mouth.

The shallow nature of the system has been widely attributed to excessive sedimentation (Begg 1978, 1984, O'Brien *et al*. 2009) but this is overstated. Cooper (1994) found that there was no major long-term accumulation of sediments in the estuary, but that the system's morphology followed a cyclical pattern driven by extreme flood events which widened and shortened the channel, and post-flood recovery periods of channel confinement, stabilisation and re-vegetation (Cooper 1994). This has important implications for fish habitat and fishes in the estuary, and therefore also for the setting of a Present Ecological Status based on deviation from a Reference Condition. The shallowness, lack of tidal intrusion and limited habitat diversity in the system limits the natural value of this estuary for estuarine fishes. Estuarine and estuarine dependent marine fishes have historically made use of the Mvoti estuary, but compared to many other systems in KZN, both numbers of species and abundance of these fishes in the estuary is likely to be low and would have also been so under reference conditions. This is accounted for in the analysis that follows.

Fish habitat in estuaries includes predominantly open water and vegetated habitats. Open water habitats can be categorised as being either subtidal or intertidal, and further divided based on various other criteria such as substrate type (mud or sand) and currents (flowing- or still waters). Vegetated habitats may include a variety of emergent and submerged forms. In the Mvoti estuary no submerged macrophytes occur and emergent vegetation is dominated by reeds (*Phragmites*

spp.). Atypical of normal (healthy) estuaries in South Africa is the presence of several floating macrophytes, mainly as rafts of antelope grass (*Echinocloa pyramidalis*) encroaching into the channel from the banks, or free floating mats of water hyacinth (*Eichhornia crassipes*).

The relationship between habitats, river flows and water quality in the Mvoti estuary is important for fishes in the system. After major flood events the channel is relatively wide and characterised by braiding. This creates a matrix of intertidal and subtidal sandflat habitat subject to a variety of current regimes which allow fishes access to still waters in the lee of channel islands and meanders. These are important for juvenile fishes, most notably estuarine dependent marine species, as refuge from the persistently outflowing waters. They are also areas where deposition occurs and supports some benthic (bacterial and invertebrate) productivity. These areas therefore play a significant role in the energetics of developing juvenile fishes.

Under stable flows, vegetation encroaches into the estuary and confines the channel resulting in loss of its braided nature and open water complexity. This is exacerbated by flow reductions and prolonged periods of low flow, as well as elevated nutrient levels which stimulate vegetation growth. Increasing floating vegetation in the form of invasive alien species worsens the situation. Under such conditions areas of open still waters are lost and the main channel becomes increasingly canalised. Open water habitat loses are offset by increases in vegetated habitats, but the forms present and the prevalent salinity regimes support freshwater species rather than estuarine dependent marine fishes. Under these conditions nursery function of the estuary, which is already naturally limited, is further reduced.

Paradoxically, under very low flow conditions and mouth closure, the estuarine function of the Mvoti estuary is likely to increase. Although tidal variation is completely eliminated under mouth closure, a relatively large area and volume of still water is created that suits many estuarine and estuarine dependent marine species. Salinities are likely to be fresh, or near fresh, but most estuarine and estuarine dependent fishes in the system tolerate fresh water. While recruitment into the system is reduced, those fishes in the system will benefit from these conditions which are more productive in supporting higher phytoplankton and therefore zooplankton biomass, as well as increased benthic biomass as detritus settles and forms the basis for a benthic food chain. Selected estuarine resident species are likely to proliferate under such conditions. Elevated nutrient levels under this scenario will however, stimulate plant growth and reduce open water habitat, and ultimately increase the potential for eutrophic conditions to develop.

5.3.2 Fish species composition

Fishes in the Mvoti estuary have been sampled on several occasions in the last 20 years and a fairly wide range of species (48) has been recorded (Appendix 4). Two of these, the guppy *Poecilia reticulata* and the common carp *Cyprinus carpio*, are alien. The former is most likely a result of releases from fresh water aquarium hobbyists and the latter is probably an escapee from a farm dam. Indigenous species include representatives from all functional estuarine use groups and the main trophic categories. In general however, and compared with most other KZN open estuaries, a low number of species occurs in the Mvoti at any one time. Notable also is the fact that very few of these species occur with any regular frequency of occurrence. Only 11 species have been sampled in over 50% of the surveys conducted since the early 1980s. These relatively few species that occur with any degree of consistency include predominantly estuarine dependent marine and freshwater species. The estuarine round herring. *Gilchristella aestuaria* is the noted exception, the only estuarine resident species that has occurred in over 40% of the documented fish surveys. The fish fauna is highly dominated by detritivores, particularly young juvenile mullet and Mozambique

tilapia *Oreochromis mossambicus*. Zooplanktivores occur in the form of *G. aestuaria* and glassies *Ambassis* species, generally in low abundances as in the case with zoobenthivores. Piscivores are even more uncommon.

Overall, estuarine dependent marine and freshwater fishes dominate the fish assemblage in terms of frequency of occurrence and relative abundance. Although estuarine residents occur with a high frequency of occurrence, they do so as different species and in low abundance. Their populations in the Mvoti are neither stable, nor persistent. A notable feature of the estuary's sampled ichthyofauna is the presence of catadromous Anguillid eels. These fishes are seldom caught in South Africa estuaries. They spend little time in estuaries themselves but pass through these systems as larvae and juveniles on their way to fresh water habitats in higher river catchments, and as adults on their way to sea to spawn. The relatively high frequency of occurrence of eels in the Mvoti indicates that the river is important for this group of fishes. The permanently open estuary and consistent flow of fresh water into the sea are therefore important as a migration conduit.

To a large extent then, the low species diversity on the estuary is natural and reflective of the system's reference condition. While the fish fauna is poor relative to most other KZN estuaries, it is fairly unique in the relative importance of different life history categories. The species array in the estuary is more similar to that typical of temporary open/closed estuaries than permanently open systems. This is a result of very low salinity intrusion in the Mvoti and its predominantly fresh water state. However, temporary open/closed estuaries typically have a higher proportion of estuarine residents than that in the Mvoti estuary. These differences are largely natural, and are the result of the naturally poor nursery habitat in the estuary because of its perched nature and ever-flowing fresh water outflow. This fresh water dominance is indicated in the presence of several *Barbus* species. These fishes do not typically occur in estuaries, but rather in river waters. In the Mvoti these fishes occur even in the lower reaches of the estuary.

5.3.3 Changes over time in the fish habitats and community

Changes in the Mvoti estuary fish community over time are difficult to investigate using the data available. There has been no concerted, prolonged sampling effort using similar sampling gears and effort. Highest numbers of species were reported in November 1999 and August 2000 by MacKay *et al*. (2000). These surveys were intensive, conducted over the full range of potential estuarine habitats extending to above the N2 bridge and used a variety of gears suited to estuarine and river habitats. Ascribing relative health to the fish community over this period is likely to be unjustified. However, probable changes in the fish community of the estuary can be inferred from an understanding of changes in fish habitat over time. Changes in fish habitat can be based on changes in hydrology, water quality and aquatic microalgae, macrophytes and invertebrates as reported upon in other specialist reports conducted as part of the wider Estuarine Freshwater Requirements (EFR) study (see Appendices A, B, C, D this report).

Natural habitat fluctuations in response to flood events and post-flood recovery have already been discussed. Macrophytes play an important role in this, in encroaching from the banks of the estuary and confining the channel during periods of normal flow. This is accelerated by poor water quality, in particular elevated nutrient levels that stimulate plant growth and, at high concentrations, contribute to the spread of alien invasive floating vegetation.

Several key changes in the hydrology of the system under present day compared to reference conditions are important. Reductions in high flows have reduced the frequency and severity of flood events which scour and open the channel of the lower river reaches and estuary. Reductions

in low flows have resulted in accelerated constriction of the channel in between floods. This has resulted in an overall loss in the meandering nature of the channel and loss of still water habitat in the loss of meanders and channel islands. Some sedimentation has occurred resulting in loss of subtidal habitat area. While reduced flows have caused a slight increase in mouth closure events this is unlikely to have been a major impact on the species that predominantly occur in the estuary (and may even benefit them to some degree). Loss of habitat due to channel confinement is, however, more of an issue. This is exacerbated by increased vegetation which has benefitted from the more stable conditions of reduced floods and base flows. Water quality has played a major role in further aggravating this impact. High levels of nutrients have stimulated plant growth. Reed encroachment from the banks, rafting beds of antelope grass and floating water hyacinth have resulted in large losses in natural sandy bank habitat as well as open subtidal water. Open water habitat has decreased from an estimated 27 ha under natural conditions to 16 ha. Reeds and sedges and hygrophilous grasses have increased in coverage (40 - 87 ha, 0 - 51 ha respectively) (Chapter 3).

Fish species composition (both in terms of numbers and types of species) is unlikely to have been significantly affected by these habitat changes, being limited rather by the overriding natural form of the estuary as a shallow, ever-flowing river mouth with very limited salinity penetration. However the relative abundances in which species occur have undoubtedly impacted by these habitat changes. Estuarine and estuarine dependent marine fish abundances have declined due to losses in open still water habitat, and freshwater fish abundances have increased due to the much higher prevalence of vegetated habitats.

Water quality is likely to be even more of an issue in terms of direct impacts to fishes in the estuary. Toxic effects are possible, given reports of elevated levels of organo-chlorinated compounds in the system's sediments and fish tissues (IOL News, 2005). Low oxygen concentrations are a more persistent issue in the lower river and estuary. This has been noted in most surveys of the estuary. During the August 2013 survey conducted for the purposes of this study oxygen concentrations in the flowing waters of the estuary were all < 2 mg/l. This is not a natural phenomenon and is the result of high nutrient and organic loading to the system. It has an undeniable impact on the estuary's biota, especially fishes which are at the top of the aquatic food chain. A feature of the fish fauna in the estuary is the small size of fishes. Very few fishes, especially estuarine dependent marine species, reach their full size or age potentials in the estuary. This is almost certainly a result of poor water quality and is indicative of a degraded estuarine nursery function.

5.3.4 Present Ecological State

Changes in hydrology, water quality and habitats in the Mvoti estuary have resulted reduced fish health in the system. Habitat losses, particularly in open water habitat (subtidal and intertidal) have reduced habitat available for estuarine and estuarine dependent species. Loss of the meandering nature of the main channel has also resulted in loss of habitat heterogeneity in terms of depth and flow variability and of slow or still water area in particular. Mullet are probably the group of fishes that are most affected by these changes and there is consequently a significant reduction in their abundance in the estuary. *Myxus capensis*, *Mugil cephalus* and *Valamugil cunnesius* are species most likely to have been affected. Freshwater species are likely to have been least affected and in fact have probably benefited from increased vegetated habitats and have increased in relative abundance. They include at least two alien species. Water quality has become a serious issue with low oxygen concentrations particularly problematic. Many of the estuarine dependent marine fishes

that do recruit into the estuary leave the system as younger fishes and at smaller size classes than they otherwise would have, or they perish in the system because of poor water quality.

Habitat losses and poor water quality such as that experienced by the Mvoti estuary would have resulted in major impacts to fish assemblages in other KZN estuaries. The fact that the Mvoti is a system that was naturally characterised by a fish community less diverse and abundant than most other KZN estuaries has, to some extent, buffered the relative losses experienced in the system's fish community health. The compliment of species that occurs in the estuary presently is quite probably similar that that would have occurred under natural conditions. Some loss of species richness has occurred in the present state, primarily due to poor water quality rather than hydrology or habitat changes. Fish abundances are reduced, particularly estuarine and estuarine dependent marine species, due to habitat losses as well as water quality degradation. Estuarine, estuarine dependent and freshwater components of the ichthyofauna have responded differently to present day conditions and this has resulted in a significantly different fish community than that typical of reference conditions. Estimated similarity scores in various community attributes, between present and reference conditions, are provided below in Table 5.2.

Table 5.2 Similarity scores of fishes in the present condition relative to the reference condition, and PES of the fish assemblage

Variable	Summary of change	Score	Conf
1. Species richness	Loss of water areas and intertidal habitat results in loss of some species.	80	M
2. Abundance	Loss of water area and intertidal habitat results in reduced abundance of estuarine and marine fishes.	55	H
3. Community composition	Reduced estuarine and marine component, especially mullet. Many of these species also do not mature in the estuary but leave prior to full utilisation of nursery habitat (reduced size).	65	H
Biotic component health score		**55**	
% of impact non-flow related		70	

5.3.5 Response of fishes to further water resource development scenarios

Responses of fishes in the Mvoti estuary to different water resource development scenarios are informed by anticipated changes in hydrology, water quality and aquatic microalgae, macrophytes and invertebrates as reported upon in other specialist reports conducted as part of the wider EFR study (see Appendices A, B, C, D this report). These are presented in summary format in Table 5.3 below. Likely health scores of the fish assemblages under these different scenarios are provided in Table 5.4.

Under Scenario A slightly increased base flows over the winter and early spring period result in reduced mouth closure (State 1) compared to present day, but differences in hydrology, and frequency of different estuarine abiotic states are marginal. Changes in the fish fauna are likely to be manifest in slight modified community composition. Scenario B however, involves marked flow reductions that result in a significant increase the tidal, intermittently closed state of the estuary (State 2) and the expense of the fresh water state (State 4). Increased mouth closure is likely to have little impact on a fish assemblage that is naturally limited. Higher water levels under State 2 and greater estuarine volumes potentially benefit estuarine and estuarine dependent species, but this is offset by impacts of poorer water quality (lower dissolved oxygen concentrations). Freshwater species will be lost from the lower reaches of the estuary, which is a change from both present and reference conditions. This results in slightly lower species abundance in the estuary and changes to the species composition. Scenario C is unlikely to be any different from Scenario A and is therefore expected to have a fish community very similar to present day conditions.

Changes in the fish fauna are likely to be manifest in slight modified community composition only. Scenario D see very marked flow reductions and, while State 1 (mouth closed state) is unlikely to occur, the estuary occurs in a tidal, intermittently closed state for most of the year. This is a significant change from present and reference conditions. Frequency of occurrence and durations of tidal (State 3) and fresh water (State 4) states are markedly reduced. This results in very different salinity conditions, but also significant water quality degradation. The whole fish assemblage will be impacted and reductions in species richness and abundance will occur, as well as changes in species composition.

Table 5.3 Summary of change in fish component under different scenarios

Scenario	Summary of Changes
A	Slight increase in base flows over the dry period results in a marginal reduction in mouth closure compared to present day. Differences in hydrology, and frequency of abiotic states are marginal. Changes in the fish fauna are likely to be manifest in slight modified community composition.
B	Higher water levels under State 2 (tidal, intermittently closed) and greater estuarine volumes potentially benefit this estuarine and estuarine dependent species, but this is offset by impacts of poorer water quality. Freshwater species will be lost from the lower reaches of the estuary. This results in a slightly lower species abundance in the estuary and changes to the species composition.
C	Changes in hydrology, and frequency of abiotic states are marginal. Changes in the fish fauna are likely to be manifest in slight modified community composition.
D	The estuary will occur in a tidal, intermittently closed state for most of the year. Frequency of occurrence and durations of tidal (State 3) and fresh water (State 4) states are markedly reduced. This results in very different salinity conditions, but also significant water quality degradation. The whole fish assemblage will be impacted and reductions in species richness and abundance will occur, as well as changes in species composition.

Table 5.4 EHI scores for fish component under different scenarios

Variable		Scenario Group				
	Present	A	B	C	D	Conf
1. Species richness	80	80	70	80	60	M
2 Abundance	55	55	55	55	50	M
3. Community composition	65	60	55	60	50	M
Biotic component score	**55**	**55**	**55**	**55**	**50**	**M**

5.4 ACKNOWLEDGEMENTS

Mr Ruwendren Pillay and Mr Alan Blair are acknowledged and thanks for fieldwork conducted for the 2013 fish survey of the Mvoti estuary.

5.5 REFERENCES

Begg, G.W. 1978. The estuaries of Natal. Natal Town and Regional Planning Report 41: 657 pp.

Begg, G.W. 1984. The estuaries of Natal. Part 2. Natal Town and Regional Planning Report 55: 631 pp.

Brand, P.A.J., Kemp, P.H., Pretorius, S.J. and Schoonbee, H.J. 1967. Water Quality and Abatement of Pollution in Natal Rivers. Part II. Survey of the Three Rivers Region. National Institute for Water Research, CSIR and the Town and Regional Planning Commission Report.

Cooper, J.A.G. 1994. Sedimentary processes in the river-dominated Mvoti estuary, South Africa. Geomorphology 9(4): 271-300.

Elliott. M., Whitfield, A.K., Potter, I.C., Blaber, S.J.M., Cyrus, D.P., Nordlie, F.G. and Harrison, T.D. 2007. The guild approach to categorizing estuarine fish assemblages: a global review. Fish and Fisheries 8, 241–268.

Harrison, T.D. 1990. Preliminary determination of the fish community structure in differing estuarine systems of Natal. NECRU Report 90/101. CSIR. 24 pp.

Harrison, T.D. and Whitfield, A.K. 2008. Geographical and typological changes in fish guilds of South African estuaries. Journal of Fish Biology, 73(10), 2542-2570.

Harrison, T.D., Cooper, J.A.G. and Ramm, A.E.L. 1989. The estuarine ichthyofauna of the Mvoti River system. NECRU Report 89/101. CSIR. 8 pp.

Harrison, T.D., Cooper, J.A.G., Ramm, A.E.L. 2000. Geomorphology, ichthyofauna, water quality and aesthetics of South African estuaries. Division of Water, Environment and Forestry Technology, Environmentek, CSIR, South Africa, prepared for the Department of Environmental Affairs and Tourism. Report ENV-DC 2000-01.

IOL News. 2005. Chemical poisons found in KZN river. 10 February 2005. http://www.iol.co.za/news/south-africa/chemical-poisons-found-in-kzn-river-1.233618#.VFYT-vmUcqI.

MacKay, C.F., Weerts, S.P. and Cyrus, D.P. 2000. Ecological evaluation of the lower Mvoti River and Estuary. CRUZ Environmental Report No. 4, Empangeni. 110 pp.

Maree, R.C., Whitfield, A.K. and Quinn, N.M. 2003. Prioritisation of South African estuaries based on their potential importance to estuarine-associated fish species. WRC report No. TT 203/03.

O'Brien, G.C., Swemmer, R. and Wepener, V. 2009. Ecological integrity assessment of the fish assemblages of the Matigulu/Nyoni and Umvoti estuaries, KwaZulu-Natal, South Africa, African Journal of Aquatic Science 34: 293-302.

Ramm, A.E.L., Cerff, E.C. and Harrison, T.D. 1986. The Mvoti Estuary. Natal Estuaries Status Report No. 56. CSIR. 13 pp.

Van Niekerk, L. and Turpie, J.K. (eds) 2012. South African National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component. CSIR Report Number CSIR/NRE/ECOS/ER/2011/0045/B. Council for Scientific and Industrial Research, Stellenbosch.

Whitfield, A.K. 1994. An estuary-association classification for the fishes of southern Africa. South African Journal of Science 90: 411-417.

Whitfield, A.K. 2000. Available scientific information on individual South African estuarine systems. Water Research Commission Report 577/3/00, pp 1 – 217.

Appendix 4: Historic records, and 2013 survey results, of fishes sampled in Mvoti Estuary (% abundance), frequency (%) of occurrence and average abundance (%) indicated. Alien species indicated by *. Highlights indicate species that occur most frequently in the system, at the highest relative abundance.

Reference	Begg (1984)	Ramm et al. (1986)	Harrison et al. (1989)	Harrison et al. (1990)	Harrison et al. (1990)	Harrison et al. (2000)	MacKay et al. (2000)	MacKay et al. (2000)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	This study	Frequency of occurrence	Average abundance
Survey date	1982 (Jan, May, Aug)	1986 (Aug)	1989 (Feb)	1989 (Aug)	1990 (Jan)	1999 (Feb)	1999 (Nov)	2000 (Aug)	2004 (Sep)	2005 (Mar)	2005 (Aug)	2006 (Mar)	2008 (Oct)	2013 (Aug)		
Mugil cephalus	25.0	4.2	6.4	9.3	4.6	9.3	25.2	46.9	5.0	3.6	1.8	24.3	1.7	71.4	100	17.1
Oreochromis mossambicus	25.9	2.1	0.2	4.1	2.9	10.6	19.4	8.8	28.1	16.7	21.6	3.5	8.2	13.7	100	11.8
Myxus capensis	3.6	0.2		3.1		9.9	5.2	4.0	29.5	0.7	6.0	47.0	18.2	7.9	86	9.7
Mullet fry		67.4	85.0	46.0	73.9	5.3	6.9	7.1	18.5	54.7	11.5		9.5		79	27.6
Gilchristella aestuaria	3.6	9.1		3.4	3.3		2.2	1.1	1.4	9.2	0.9	0.9	0.4		79	2.5
Clarias gariepinus	1.8	0.2	0.1			2.6	0.3	0.6	0.4	0.2	0.5	0.9	1.7		79	0.7
Terapon jarbua	21.4	1.5	2.5	0.7	3.3	6.6	1.9	0.1		7.0	5.5				71	3.6
Barbus paludinosus			0.1				0.4	2.4	1.1	0.5	1.8	0.9	13.4	0.9	64	1.5
Valamugil cunnesius		3.9		16.6	2.2	12.6	16.4	19.6			4.6		15.6		57	6.5
Pseudocrenilabrus philander							0.2	0.3	2.8	0.7	1.4	0.9	3.5	2.2	57	0.9
Barbus trimaculatus								1.5	6.4	2.7	2.3	2.6	26.8	1.8	50	3.2
Awaous aeneofuscus						0.7	0.1	0.4	1.1	0.2	0.5	0.9			50	0.3
Ambassis ambassis							11.5	0.1	3.2	1.6		6.1			36	1.6
Ambassis natalensis					0.1		1.5	0.6			6.4	7.0			36	1.1
Liza dumerilii			2.6	1.1	3.3		5.2	0.4							36	0.9
Pomadasys commersonnii	2.7		0.1	3.0	0.1			0.1							36	0.4
Glossogobius callidus				2.9	0.2		0.6	0.1						0.4	36	0.3
Acanthopagrus vagus			0.2	0.4	0.6	0.7		1.0							36	0.2
*Poecilia reticulata**							X	X	X		X				29	X
Rhabdosargus holubi							2.1	0.4	1.1			0.9			29	0.3
Liza tricuspidens								1.1		0.2	28.9				21	2.2

Reference	Begg (1984)	Ramm et al. (1986)	Harrison et al. (1989)	Harrison et al. (1990)	Harrison et al. (1990)	Harrison et al. (2000)	MacKay et al. (2000)	MacKay et al. (2000)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	This study	Frequency of occurrence	Average abundance
Survey date	**1982 (Jan, May, Aug)**	**1986 (Aug)**	**1989 (Feb)**	**1989 (Aug)**	**1990 (Jan)**	**1999 (Feb)**	**1999 (Nov)**	**2000 (Aug)**	**2004 (Sep)**	**2005 (Mar)**	**2005 (Aug)**	**2006 (Mar)**	**2008 (Oct)**	**2013 (Aug)**		
Oligolepis acutipennis	8.0	8.5	0.6												21	1.2
Barbus viviparus	4.5							0.1						1.3	21	0.4
Liza macrolepis				4.6	1.0		0.1								21	0.4
Oligolepis keiensis			1.5	2.9	1.2										21	0.4
Glossogobius giuris	0.9	2.5									1.4				21	0.3
Caranx spp.					0.1					1.6	2.8				21	0.3
Labeobarbus natalensis	2.7								0.4		0.5				21	0.2
Pegusa nasuta		0.4	0.9	0.4											21	0.1
Megalops cyprinoides										0.2	0.5		0.4		21	0.1
Anguilla sp.								0.1				3.5			14	0.3
Stenogobius kenyae							0.2	2.5							14	0.2
Anguilla mossambica									0.4		1.4				14	0.1
Leiognathus equula				0.5	0.7										14	0.1
Hippichthys spicifer							0.1					0.9			14	0.1
Caranx sexfasciatus					0.2	0.7									14	0.1
Monodactylus argenteus							0.1		0.7						14	0.1
Liza alata				0.4	0.1										14	0.0
*Cyprinus carpio**					X										7	X
Liza spp.						27.8									7	2.0
Valamugil spp.						11.9									7	0.9
Valamugil robustus						1.3									7	0.1
Lichia amia					1.0										7	0.1
Caranx sem					0.9										7	0.1
Redigobius dewaali														0.4	7	<0.05
Anguilla bengalensis													0.4		7	<0.05
Rhabdosargus sarba							0.4								7	<0.05

Reference	Begg (1984)	Ramm et al. (1986)	Harrison et al. (1989)	Harrison et al. (1990)	Harrison et al. (1990)	Harrison et al. (2000)	MacKay et al. (2000)	MacKay et al. (2000)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	O'Brien et al. (2009)	This study	Frequency of occurrence	Average abundance
Survey date	1982 (Jan, May, Aug)	1986 (Aug)	1989 (Feb)	1989 (Aug)	1990 (Jan)	1999 (Feb)	1999 (Nov)	2000 (Aug)	2004 (Sep)	2005 (Mar)	2005 (Aug)	2006 (Mar)	2008 (Oct)	2013 (Aug)		
Elops machnata				0.3											7	<0.05
Microphis brachyurus										0.2					7	<0.05
Eleotris spp.					0.2										7	<0.05
Eleotris fusca								0.1							7	<0.05
Ambassis gymnochephalus								0.1							7	<0.05
Sparidae sp.								0.1							7	<0.05
Periophthalmus koelreuteri af'							0.1								7	<0.05
Argyrosomus japonicus				0.1											7	<0.05
Oligolepis sp.					0.1										7	<0.05
Pomadasys spp.					0.1										7	<0.05
Estuarine resident	12	18	2	9	5		16	5	5	11	7	15	<0.5	1	93	8
Estuarine dep' marine	53	78	98	87	91	86	63	81	55	68	61	72	45	79	100	73
Marine straggler					1										7	<0.05
Freshwater	36	5		4	3	14	21	15	41	21	33	10	54	20	100	20
Catadromous								<0.5	<0.5		1	3	<0.5		36	<0.05
Detritivore	54.5	77.8	94.1	85.3	88.1	88.7	78.2	88.0	81.1	75.9	74.3	74.8	53.2	93.0	100	79.1
Zooplanktivore	3.6	9.1		3.4	3.4		15.5	1.9	5.3	11.0	7.3	14.8	0.4		79	5.4
Zoobenthivore	40.2	12.9	5.8	10.9	6.3	7.9	6.1	9.5	13.2	11.0	14.7	9.6	44.2	7.0	100	14.2
Piscivore	1.8	0.2	0.1	0.4	2.1	3.3	0.3	0.6	0.4	2.0	3.7	0.9	2.2		93	1.3

6 AVIAN SPECIALIST REPORT

David G. Allan: Curator of Birds
Durban Natural Science Museum
Email: David.Allan@durban.gov.za
Tel. 031-3224214; 082-3610261

Figure 6.1 General view of Mvoti Estuary taken from the mouth area looking north

6.1 INTRODUCTION

The aim of this specialist report is to inform the avian (waterbird) section of the Mvoti Estuary component of an investigation into the classification of water resources and determination of the comprehensive reserve and resource quality objectives in the Mvoti to Umzimkulu Water Management Area. The content of the report is based on both a synthesis of existing knowledge and on information from recent field surveys.

Among the first to present details of a waterbird count at the Mvoti Estuary were Ryan *et al.* (1986) who made a count there in 1980/81. They noted that although waterbird numbers were not particularly high at the estuary, species richness was, as was the density of waterbirds relative to the length of shoreline.

The Mvoti Estuary is classified as a sub-regional Important Bird Area (IBA) under the global IBA initiative (Barnes 1998; see also: http://www.birdlife.org.za/conservation/important-bird-areas).

Large numbers of terns, up to 10 000 individual birds, have been recorded regularly roosting at the estuary on expansive and exposed islands in the main water channel. Nine tern species have been recorded roosting, of which three are particularly important: Common Tern, Arctic Tern and Sandwich Tern, with smaller numbers of both Caspian Tern (a Red Data species; Barnes 2000) and Little Tern also having been regularly recorded. Another key waterbird species is the Collared Pratincole (Figure 6.2), a Red Data species, which has been found breeding on the exposed sandbanks in the river. With the historical loss of breeding in the Isipingo area near Durban, the breeding site at the Mvoti Estuary was the most southerly of only three remaining breeding localities in KwaZulu-Natal. 'Hundreds' were present in the 1960s but subsequent numbers were lower, i.e. 24 chicks fledged in the 1989-1990 season. Other noteworthy Red Data waterbirds recorded at the estuary include African Marsh Harrier, Woolly-necked Stork and Chestnut-banded Plover. Mvoti Estuary has also boasted the regular presence of a large number of vagrant waterbirds over the years, e.g. Sooty and Bridled terns, making it a popular spot for bird-watching and bird-watchers.

Figure 6.2 Collared Pratincole (photo High Chittenden)

A recent report on the IBA status of the Mvoti Estuary (Theron 2012), however, reported that the waterbird avifauna of the site has deteriorated since about the mid-2000s and recommended that the site be de-listed as an IBA. Since that time, large numbers of terns no longer roost at the estuary and nor do Collared Pratincoles nest there. The report attributed these negative developments to habitat destruction, e.g. through sugar-cane planting, sand-winning, water abstraction, water pollution, eutrophication, the spread of alien vegetation, encroachment by reedbeds, disturbance and changes to the physical configuration of the estuary. Loss of the exposed sandbanks in the main channel to encroaching vegetation was identified as a major contributor to the loss of the roosting terns and breeding pratincoles. The report stated that there seemed little chance of any reversal of this deterioration.

6.2 STUDY AREA

Begg (1978, 1984) provides detailed, if dated, background information on the ecology of the Mvoti Estuary. The estuary is situated at the mouth of the Mvoti River at 29°23' 32.58" S; 31°20' 08.20" E on the coast of KwaZulu-Natal, just downstream of the town of KwaDukuza (Stanger). The Mvoti River is some 180-215 km long and its catchment area measures some 2551-2736 km^2. The extent of the estuary is estimated at 18.4 ha, with an axial length of 1.75 km and a shoreline length of 3.8 km. The mouth of the Mzimkulu estuary is usually open but occasionally closes and it is often then subject to artificial breaching. Siltation of the estuary and associated encroachment by vegetation, both alien and indigenous, is a major problem and is likely linked to erosion in the catchment, alterations in flow, eutrophication and cultivation of the floodplain upstream of, and surrounding parts of, the estuary.

There is a major SAPPI forestry mill just upstream of the estuary, as well as an apparently fairly major waste-water treatment works.

Figure 6.3 Comparison of the Mvoti Estuary between 1937 (left, courtesy of L. van Niekerk) and 2014 (right). The reduction in exposed sandbank areas in the main river channel is clearly evident

Figure 6.4 A view of the main channel of the Mvoti River taken from the main sandbar at the mouth looking inland in October 2014, showing the congestion of the estuarine habitat with aquatic vegetation

Figure 6.5 A similar view also taken from the main sandbar at the mouth of the estuary in October 2014 again showing the congestion of the estuary with aquatic vegetation

Figure 6.6 A view of extensive sugar cane and a drainage ditch in the Mvoti River floodplain close to the mouth.

6.3 METHODS

The waterbird data synthesised in this report comes from three main sources:

1. A count done by Ryan *et al.* (1986) during their 1980-81 counts made along the entire coastline and coastal wetlands of KZN.

2. Thirty-two counts done as part of the Co-ordinated Waterbird Counts (CWAC; Taylor *et al.* 1999; see: http://cwac.adu.org.za/) of the Animal Demography Unit, University of Cape Town, spanning the period July 1993 – August 2013.
3. Two complete waterbird counts made as part of this study, on 14 January and 18 October 2014.

The results of these counts are synthesised in Appendix 5.

6.4 RESULTS

A total of no less than 104 waterbird species have been recorded at Mvoti Estuary during the various waterbird counts made there (Appendix 5).

The four graphs presented below are based on the data presented in Appendix 5 and synthesis these count data in terms of trends in waterbird species richness and numbers at Mvoti Estuary. Figure 6.7 shows the overall decrease in the total number of waterbird species recorded at Mvoti Estuary over time. Figure 6.8 similarly shows the decrease in the total number of individual waterbirds counted at Mvoti Estuary. Figure 8 also shows the total number of individual waterbirds counted but with the data for terns excluded. An equally strong decrease is reflected in this graph. Figure 6.9 shows the decrease in the number of roosting terns at Mvoti Estuary.

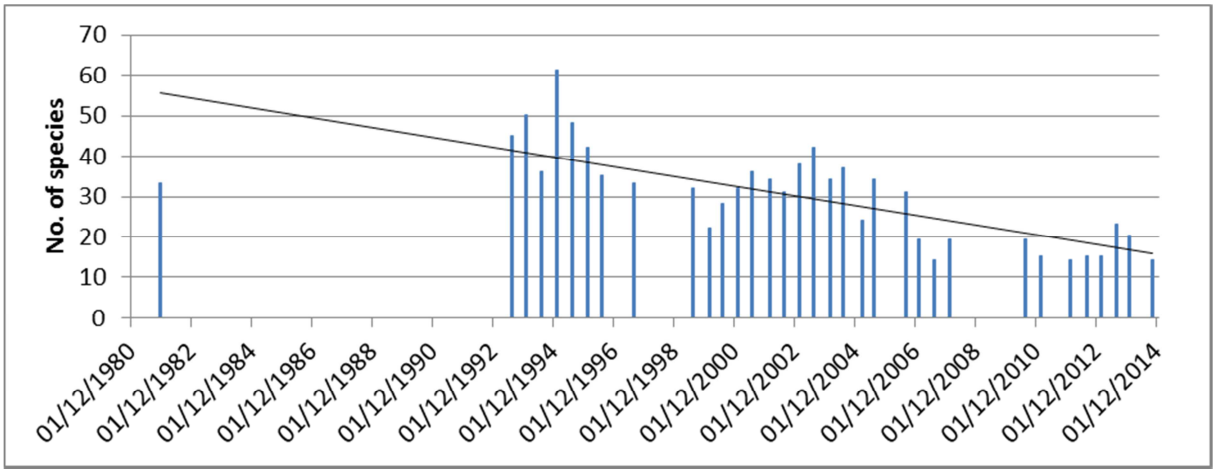

Figure 6.7 The overall decrease in the total number of water birds species recorded at Mvoti Estuary over time

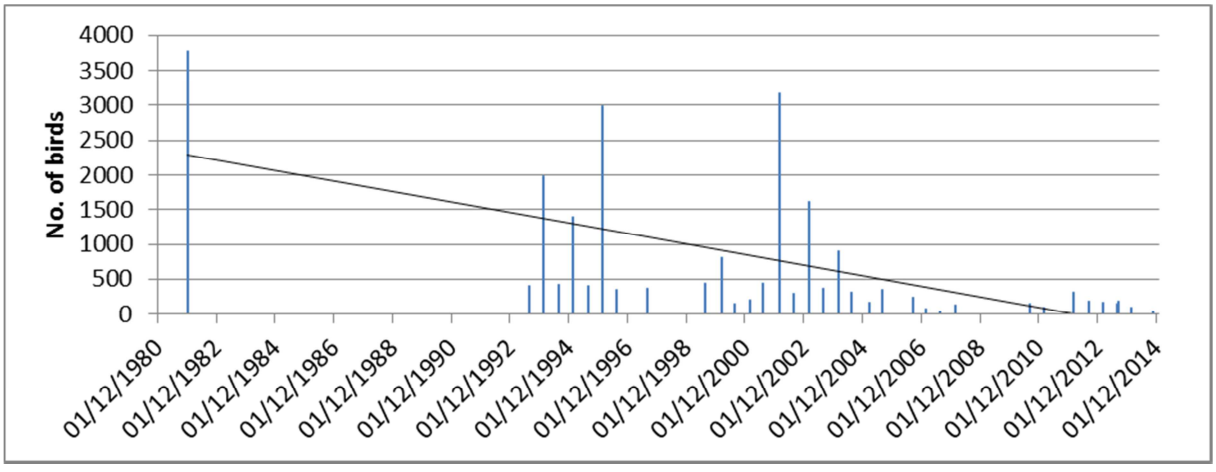

Figure 6.8 The decrease in the total number of individual waterbirds counted at Mvoti Estuary over time

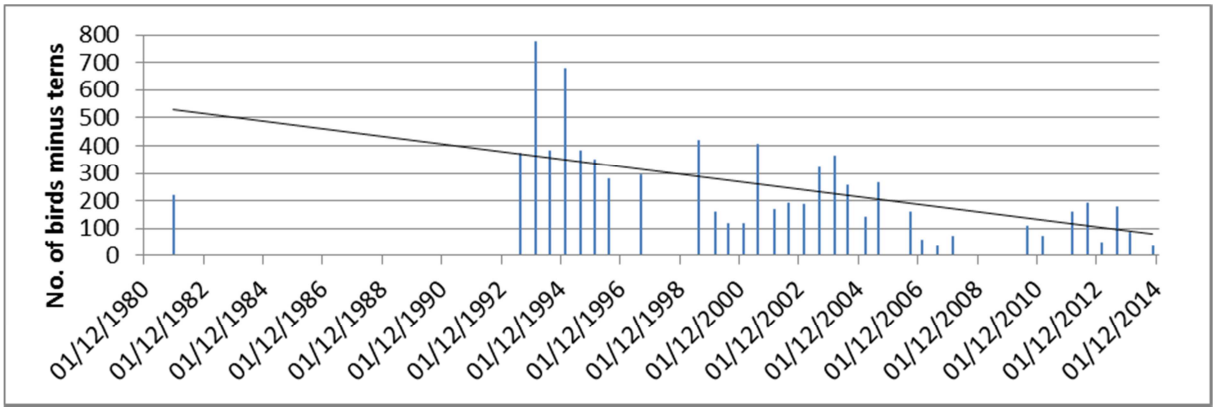

Figure 6.9 The total number of individual waterbirds counted with the data for terns excluded

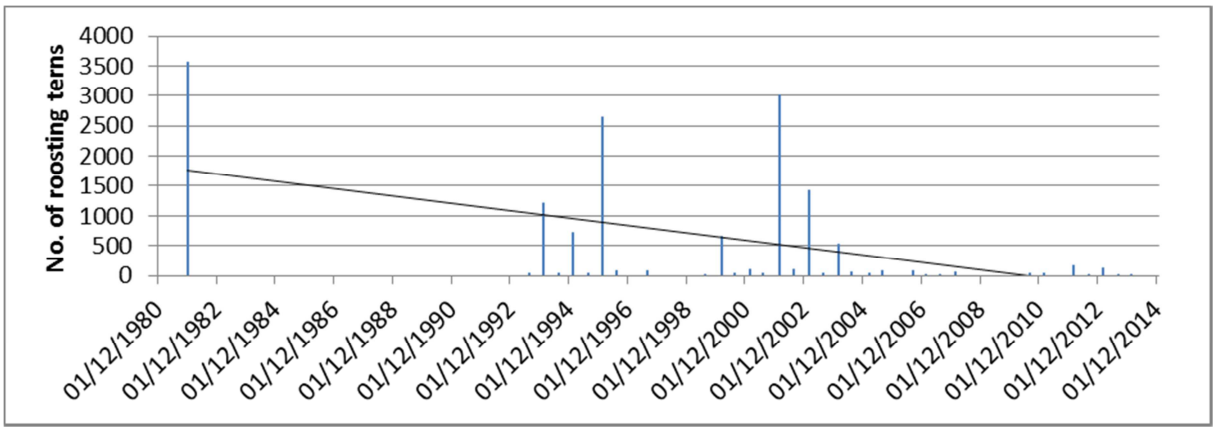

Figure 6.10 The decrease in the number of roosting terns at Mvoti Estuary

6.5 DISCUSSION

The waterbird information synthesised in this report clearly show a dramatic decrease in both species richness and the abundance of waterbirds at Mvoti Estuary between the 1980s and today. Most notable have been the desertion of the site by large numbers of roosting terns (mainly Palaearctic migrant terns) and by breeding Collared Pratincoles. The site has deteriorated from being one of significant avifaunal importance, as evidenced by its listing as an Important Bird Area, and great popularity with bird-watchers, to a site no longer worthy of IBA status and now rarely visited by bird-watchers. The primary reasons for this diminution in avifaunal value stem from a chronic deterioration in the aquatic habitats present at the estuary. The primary damage to the estuarine functioning is associated with extensive sugar-cane planting in the catchment and floodplain (including floodplain drainage), siltation, sand-winning, water abstraction and other flow-related factors, water pollution including eutrophication, the spread of both alien and indigenous (reedbeds) aquatic vegetation, human disturbance and changes to the physical configuration of the estuary. Loss of the exposed sandbanks in the main channel to encroaching vegetation was identified as a major contributor to the loss of the roosting terns and breeding pratincoles. At this stage, there seems little chance of any reversal of this deterioration.

6.6 REFERENCES

Barnes, K.N. (ed.) 1998. The Important Bird Areas of southern Africa. BirdLife South Africa: Johannesburg.

Barnes, K.N. (ed.) 2000. The Eskom Red Data Book of birds of South Africa, Lesotho and Swaziland. BirdLife South Africa: Johannesburg.

Begg, G. 1978. The estuaries of Natal. *Natal Town and Regional Planning Report* 41: 1-657.

Begg, G. 1984. The estuaries of Natal (Part II). *Natal Town and Regional Planning Report* 55: 1-631.

Ryan, P.G., Cooper, J., Hockey, P.A.R & Berruti, A. 1986. Waders (Charadrii) and other water birds on the coast and adjacent wetlands of Natal, 1980-81. *Lammergeyer* 36: 1- 33.

Taylor, P.B., Navarro, R.A., Wren-Sargent, M., Harrison, J.A. & Kieswetter, S.L. 1999. TOTAL CWAC Report: Coordinated Waterbird Counts in South Africa, 1992-97. Avian Demography Unit, Cape Town.

Theron, N. 2012. IBA assessment for Umvoti Estuary. BirdLife South Africa: Johannesburg. unpubl. report. 26 pp.

Appendix 5. Details of waterbird counts made at Mvoti Estuary during 1980/81 (1 count; Ryan *et al.* 1986), 1993-2013 (32 counts; CWAC project) and 2014 (2 counts; this study).

Common name	Scientific name	Ryan *et al.* 1986	CWAC				This study	
No. of counts		1 count	32 counts				2 counts	
Period		1980/81	1993-2013				14-Jan-14	18-Oct-14
			N	Min	Av	Max		
Grebe, Little	*Tachybaptus ruficollis*		7	1	6	18		
Pelican, Pink-backed	*Pelecanus rufescens*		2	1	4	6		
Pelican, Great White	*Pelecanus onocrotalus*		3	0	16	24		
Gannet, Cape	*Morus capensis*		3	0	1	2		
Cormorant, White-breasted	*Phalacrocorax carbo*		26	1	7	29		
Cormorant, Cape	*Phalacrocorax capensis*		4	1	3	5		
Cormorant, Reed	*Phalacrocorax africanus*		20	0	9	26	3	
Darter, African	*Anhinga rufa*		10	0	7	17		
Heron, Grey	*Ardea cinerea*	2	14	0	6	21		
Heron, Black-headed	*Ardea melanocephala*		22	1	3	6		
Heron, Goliath	*Ardea goliath*	1	15	0	1	2		
Heron, Purple	*Ardea purpurea*	1	6	0	2	4		
Egret, Great	*Egretta alba*		8	0	2	4		
Egret, Little	*Egretta garzetta*	3	23	0	5	28		
Egret, Yellow-billed	*Egretta intermedia*		2	1	1	1		
Egret, Cattle	*Bubulcus ibis*		22	0	14	88		
Heron, Squacco	*Ardeola ralloides*		3	1	1	2		
Heron, Green-backed	*Butorides striata*		1	0	0	0		
Heron, Black	*Egretta ardesiaca*		1	2	2	2		
Night-Heron, Black-crowned	*Nycticorax nycticorax*		2	0	3	5		
Hamerkop	*Scopus umbretta*	1	17	0	3	18		
Stork, Yellow-billed	*Mycteria ibis*		1	1	1	1		
Stork, Woolly-necked	*Ciconia episcopus*		24	0	5	20		1
Ibis, African Sacred	*Threskiornis aethiopicus*		13	0	7	23		
Ibis, Hadeda	*Bostrychia hagedash*		20	0	6	15	4	
Spoonbill, African	*Platalea alba*		7	1	7	16		
Goose, Spur-winged	*Plectropterus gambensis*	2	21	0	33	125	13	3
Goose, Egyptian	*Alopochen aegyptiacus*		20	0	13	60	35	2
Duck, Comb	*Sarkidiornis melanotos*		1	12	12	12		
Shoveler, Cape	*Anas smithii*		6	1	5	14		
Duck, African Black	*Anas sparsa*		1	2	2	2		
Duck, Yellow-billed	*Anas undulata*	11	22	0	14	43		
Teal, Red-billed	*Anas erythrorhyncha*	2	9	1	9	34		
Teal, Cape	*Anas capensis*		10	1	11	27		
Teal, Hottentot	*Anas hottentota*		10	0	9	53		
Duck, White-faced	*Dendrocygna viduata*		2	2	4	6		
Pochard, Southern	*Netta erythrophthalma*		1	17	17	17		
Vulture, Palm-nut	*Gypohierax angolensis*		1	1	1	1	1	
Fish-Eagle, African	*Haliaeetus vocifer*		22	0	1	3	2	2
Marsh-Harrier, African	*Circus ranivorus*		7	0	1	3		
Osprey	*Pandion haliaetus*		5	1	1	2	2	
Rail, African	*Rallus caerulescens*		1	1	1	1		

Common name	Scientific name	Ryan *et al.* 1986	CWAC				This study	
No. of counts		**1 count**	**32 counts**				**2 counts**	
Period		**1980/81**	**1993-2013**				**14-Jan-14**	**18-Oct-14**
			N	**Min**	**Av**	**Max**		
Crake, African	*Crecopsis egregia*		2	2	4	5		
Crake, Baillon's	*Porzana pusilla*		1	1	1	1		
Crake, Black	*Amaurornis flavirostris*		6	0	1	2		
Flufftail, Red-chested	*Sarothrura rufa*		1	1	1	1		
Swamphen, African Purple	*Porphyrio madagascariensis*		5	0	1	2		
Gallinule, Allen's	*Porphyrio alleni*		1	1	1	1		
Moorhen, Common	*Gallinula chloropus*		4	0	2	3		
Coot, Red-knobbed	*Fulica cristata*		2	2	3	3		
Finfoot, African	*Podica senegalensis*		1	1	1	1		
Crane, Grey Crowned	*Balearica regulorum*		1	2	2	2		
Jacana, African	*Actophilornis africanus*		3	2	4	5		
Painted-snipe, Greater	*Rostratula benghalensis*		1	1	1	1		
Oystercatcher, African Black	*Haematopus moquini*		6	0	3	7		
Turnstone, Ruddy	*Arenaria interpres*	3	4	1	1	1		1
Plover, Common Ringed	*Charadrius hiaticula*	3	16	2	16	52	2	1
Plover, Lesser Sand	*Charadrius mongolus*		2	0	1	1		
Plover, White-fronted	*Charadrius marginatus*	10	30	1	9	37	1	5
Plover, Chestnut-banded	*Charadrius pallidus*		3	2	3	4		
Plover, Kittlitz's	*Charadrius pecuarius*		22	1	27	118		
Plover, Three-banded	*Charadrius tricollaris*	2	28	0	15	53	2	
Plover, Greater Sand	*Charadrius leschenaultii*		1	1	1	1		
Plover, Grey	*Pluvialis squatarola*		5	1	1	2		
Lapwing, Blacksmith	*Vanellus armatus*		25	0	11	40		1
Lapwing, African Wattled	*Vanellus senegallus*		2	2	3	3		
Snipe, African	*Gallinago nigripennis*		8	1	4	9		
Sandpiper, Curlew	*Calidris ferruginea*	23	15	1	19	90		
Stint, Little	*Calidris minuta*	1	10	1	31	62		
Knot, Red	*Calidris canutus*		1	3	3	3		
Sanderling	*Calidris alba*	6	11	1	10	30		9
Ruff	*Philomachus pugnax*	90	8	0	26	52		
Sandpiper, Common	*Actitis hypoleucos*	11	19	1	6	39	8	2
Sandpiper, Marsh	*Tringa stagnatilis*	2	13	1	2	10		
Greenshank, Common	*Tringa nebularia*	11	21	1	4	9	6	5
Sandpiper, Wood	*Tringa glareola*	5	18	1	7	27	1	1
Godwit, Black-tailed	*Limosa limosa*		1	1	1	1		
Whimbrel, Common	*Numenius phaeopus*		1	3	3	3		
Avocet, Pied	*Recurvirostra avosetta*		4	1	3	6		
Stilt, Black-winged	*Himantopus himantopus*		14	1	10	63		
Thick-knee, Water	*Burhinus vermiculatus*		5	0	5	18		
Pratincole, Collared	*Glareola pratincola*	9	4	2	23	41		
Gull, Kelp	*Larus dominicanus*	7	24	1	7	32		
Gull, Grey-headed	*Larus cirrocephalus*	5	21	1	8	36		
Kingfisher, Pied	*Ceryle rudis*	1	29	1	4	12	1	1
Kingfisher, Giant	*Megaceryle maximus*	1	19	1	2	3		

Common name	Scientific name	Ryan *et al.* 1986	CWAC				This study	
No. of counts		**1 count**	**32 counts**				**2 counts**	
Period		**1980/81**	**1993-2013**				**14-Jan-14**	**18-Oct-14**
			N	**Min**	**Av**	**Max**		
Kingfisher, Malachite	*Alcedo cristata*		18	0	2	7	1	1
Kingfisher, Mangrove	*Halcyon senegaloides*		1	0	0	0		
Martin, Brown-throated	*Riparia paludicola*		7	1	1	1		
Wagtail, African Pied	*Motacilla aguimp*	2	20	0	3	23	1	
Wagtail, Cape	*Motacilla capensis*	3	31	1	14	70	4	
Wagtail, Mountain	*Motacilla clara*		1	1	1	1		
Wagtail, Yellow	*Motacilla flava*		4	1	2	4		
Wader, Unidentified			2	45	54	62		
Duck, Unidentified			1	13	13	13		
Tern, Caspian	*Sterna caspia*		5	1	7	19		
Tern, Common	*Sterna hirundo*	3000	16	5	436	2000	4	
Tern, Sooty	*Sterna fuscata*		1	1	1	1		
Tern, Sandwich	*Sterna sandvicensis*	120	9	1	11	31		
Tern, Lesser Crested	*Sterna bengalensis*	10	4	1	1	2		
Tern, Swift	*Sterna bergii*	80	24	3	30	85	1	
Tern, Little	*Sterna albifrons*	350	15	1	236	1000	1	
Tern, White-winged	*Chlidonias leucopterus*		5	1	11	25		
Tern, Black	*Chlidonias niger*	1						
Tern, Whiskered	*Chlidonias hybrida*		3	1	4	11		
Tern, Bridled	*Sterna anaethetus*		1	1	1	1		
Tern, Unidentified			1	1	1	1		
No. spp.		33	106	106	106	106	20	14
Total inds		3779	1002	176	1370	5035	93	35
Total inds minus terns		218	918	159	632	1859	87	35
Terns		3561	84	17	738	3176	6	0