THE ESTUARIES OF NATAL



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THE ESTUARIES OF NATAL

by
George Begg

A resource inventory report to the
Natal Town and Regional Planning Commission
conducted under auspices of the Oceanographic Research Institute, Durban

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FOREWORD

Since earliest times, estuaries have held exceptional attraction because of their scenic beauty, their recreational potential and the good fishing they offer. Natal, with its many estuaries is no exception, and the estuarine environment has been used extensively for residential purposes, the establishment of hotels and flats for holidaymakers and, through the utilization of floodplains, for agricultural purposes as well as for the establishment of industrial complexes. Understandably this multiple use has led to much conflict of interests. What is more important, it has also led to progressive degradation of Natal's overall estuarine environment.

The implications of this situation are serious for various reasons. Degraded estuaries greatly reduce the attractiveness of the Natal coast to holidaymakers, and the extent to which the economy of the coastal regions of Natal hinges on tourism cannot be over-emphasized. Because estuaries fulfill an important role as nursery areas to many marine organisms, the food-producing and fishing potential of Natal's nearshore waters is also endangered by the degradation of estuaries. Finally there is the moral responsibility of not only utilizing our natural resources wisely, but also of protecting that which is aesthetically beautiful for the enjoyment of future generations.

As is so often the case in matters of environmental degradation, the extent of the cumulative damage to Natal's overall estuarine environment was not clearly recognised until it was fairly well advanced. As soon as the Natal Town and Regional Planning Commission realised that the future of Natal's overall estuarine environment was at stake, a research programme was initiated in which all available information on this environment was to be reviewed, summarised and then compiled in the form of a single cohesive report. This report could then be used as a basis for the formulation of an overall management policy for Natal's estuaries founded on the recognition of their sensitivities, i.e. of the interacting factors maintaining them in a natural state of equilibrium. The report also serves as a means of identifying gaps in knowledge and thus future research needs.

The present document is the outcome of the first phase of the estuarine survey programme sponsored by the Commission. The Oceanographic Research Institute, Durban, was given this task and appointed Mr George Begg who worked for a two year period to produce the report. Once the project had come underway, it became clear that the scope of the task had been hopelessly underestimated. It was only through the extreme dedication of Mr Begg and many hours of overtime, that it was possible to meet the deadline. The biggest problem was to condense the massive amount of available information and yet to avoid superficiality. He has succeeded to a remarkable degree — but the reader who is interested in specific aspects should nevertheless refer to the original sources of information indicated in the report.

Furthermore it must be emphasized that the report should be regarded as a statement of progress at the time of its submission. Estuaries are dynamic and change continuously in their natural state, and as the result of human activity. The report must therefore be seen as a baseline document which should not only be updated from time to time, but which should be supplemented by more specialized reports on for example, land use analysis in the catchment (which can lead to changes in river flow patterns and siltation), more detailed analysis of estuarine vegetation types (which represent a sensitive index to ecological change), more information on the all-important physical water exchange mechanisms with the sea, etc..

It should also be mentioned that while this report is restricted to the coastline of Natal, geographic boundaries between Natal and the Transkei or between the Transkei and the Eastern Cape are more political than ecological in nature. An extension of the present survey to other parts of the South African coastline would therefore be highly desirable, but would obviously have to be sponsored by bodies other than the Natal Town and Regional Planning Commission. It is gratifying that this need has been recognised by both the Department of Planning and the Environment and the S.A. Council for Scientific and Industrial Research.

Finally, the question of ameliorative action in certain estuaries is raised in the report. This may seem ambitious, but it has become very clear that the majority of those responsible for industry, agriculture or township development have not wilfully gone about destroying estuaries. Such damage is caused rather through ignorance of the ecological functioning of estuaries, sometimes coupled to short-term expediency. But, on the whole, there is much goodwill towards attempts to undo ecological damage where this is still possible, and carefully planned action can still be effective in the ecological re-instatement of many estuaries. Such opportunities should never be overlooked.

In submitting this report to the Natal Town and Regional Planning Commission we hope that it will not be placed on bookshelves subsequent to its consideration, but that it will mark

the beginning of a cohesive and scientifically based management programme for the estuaries of Natal.

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September 1978

Special Acknowledgment

The author wishes to acknowledge his indebtedness to Prof. A. R. Orme (University of California, U.S.A.) for his permission to reproduce in this report many of the drawings he made of vegetation, geomorphology and the nature of the sediments underlying several of Natal's estuarine systems. In doing so, he hopes that this report will go a long way towards providing the wider recognition Prof. Orme's work so richly deserves.

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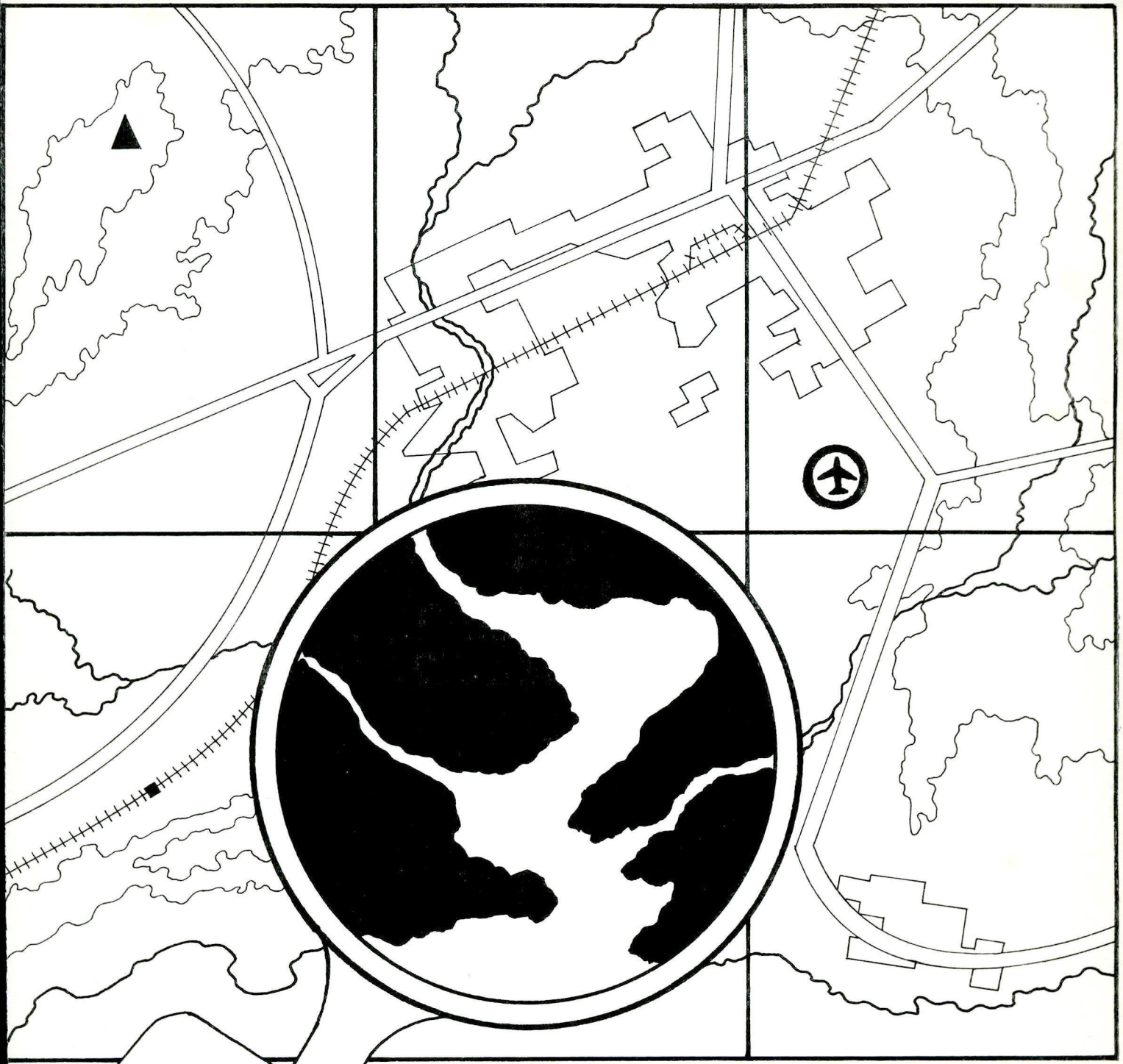


Part One

INTRODUCTION

Part 1 INTRODUCTION

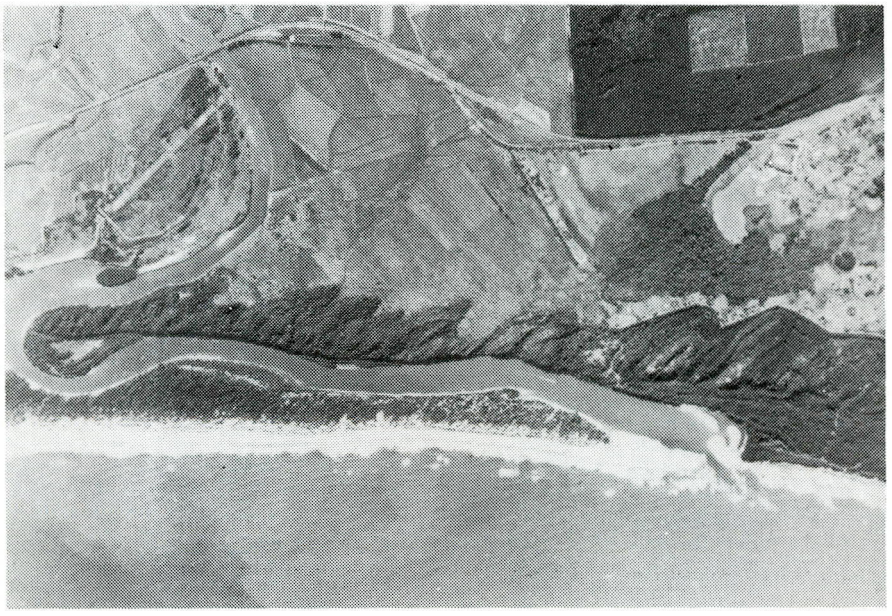
1.1 Definition of an estuary

Application of the word estuary to each of Natal's 73 estuarine systems would be using the term very loosely. Thus, in introducing a study of this nature, it seems logical to begin by defining what is meant by an estuary, particularly as this vulnerable virtually non-renewable resource forms the subject of this study.

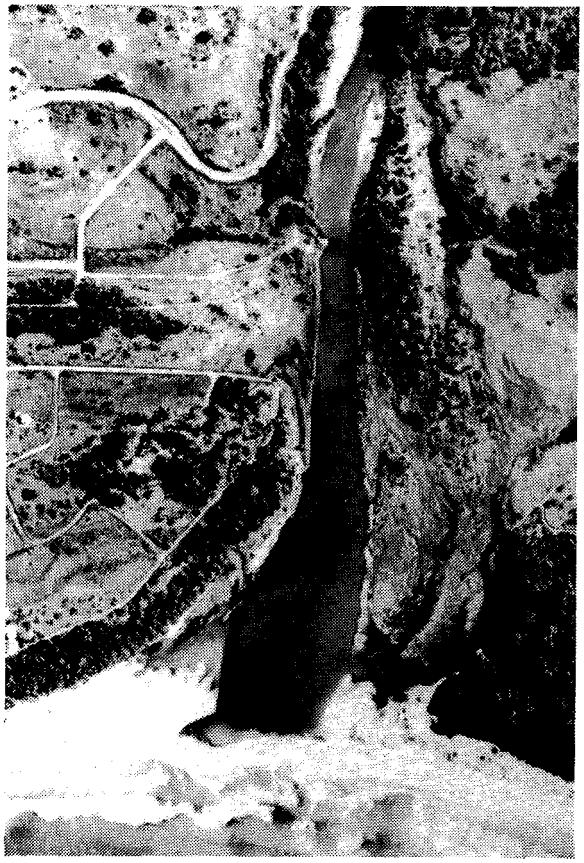
Throughout the pertinent literature there have been many attempts to define an estuary. A general criticism by Ketchum ([237]) was that "each definition seems to include too much or too little of the coast to suit the scientist who is evaluating the definition". However, for the purposes of this report estuary definitions have been purposely confined to the 570 km long coastline of Natal, from a point just south of Ponta do Ouro (in the north) to the Mtamvuna estuary (in the south).

An estuary is that portion of a river system where it enters the sea and where there is, as a consequence, a gradual transition in physical, chemical and biological characteristics from fresh water to sea water ([39]) or alternatively where tidal influence is noticeable ([226]). However, guided by the definition provided by Cameron and Pritchard ([66]), Natal's estuaries can **initially** be separated into two major types these being estuaries and lagoons. The distinction between the two can be made on the following grounds:

Property	Estuary	Lagoon
Access to the sea	A semi-closed system with a free connection to the sea.	Generally a closed system, or one separated from the sea by a low sandbar.
Salinity	A system dominated by sea water in which salinity is measurably diluted by incoming fresh water derived from land drainage.	A system dominated by fresh water in which salinity is measurably increased by incoming sea water. This may be derived from waves overtopping the bar, or (if the mouth is open) by the entry of sea water through tidal mechanisms.
Mixing mechanism	A system which is generally mixed twice daily by the sea tide although river flow may dominate during flood periods.	A system which is generally mixed by river flow or the wind, although tidal on those occasions when the mouth is open.



The Mlalazi estuary — photographed from the air by Prof. Scogings on 14 May 1976. Note the permanently open mouth.



The Mpenjati lagoon — photographed by Prof. Scogings from the air on 12 June 1976. Note that it is closed off from the sea.



An aerial photograph of Richards Bay in 1964 taken by the Air Survey Co. of Africa.

Opinions on the subject differ; for example a lagoon has been defined by Moes ([226]) as a system that has no river entering it. However, the division of Natal's estuarine systems into two is not as simple as that.

To begin with, differences are apparent between estuaries such as the Mlalazi (a good example of an estuary *sensu stricto*) and estuaries such as Richards Bay or Durban Bay. These estuarine systems should be classed as embayments. Within an embayment tidal influences increase and the salinity is not reduced to the same extent by fresh water. However, because they are tranquil environments, protected from ocean currents and wave action, and contain nutrient rich bottom substrates, they fulfil many of the functions of an estuary, in terms of the life such an environment can support.

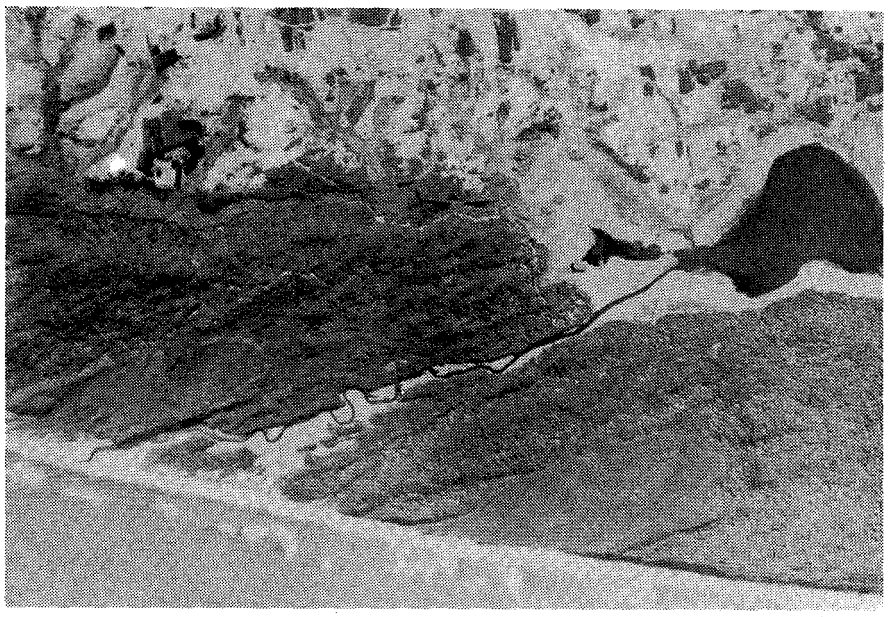
An estuary such as that of the Tugela, although open to the sea, is also not really an estuary in the true sense. As a result of man-induced changes it is no longer principally mixed by the tide, and it is not salt water dominated. Thus it is suggested that the Tugela should be regarded as a river mouth.

It should also be appreciated that certain of Natal's estuaries (such as the Mzimkulu or the Mgeni) may exhibit typically estuarine characteristics for most of the year but, during floods become river mouths. At the same time, an estuary such as the Mvoti may, during a flood, assume both the characteristics of a river mouth and a lagoon. This situation develops when the mainstream becomes isolated from its former course.

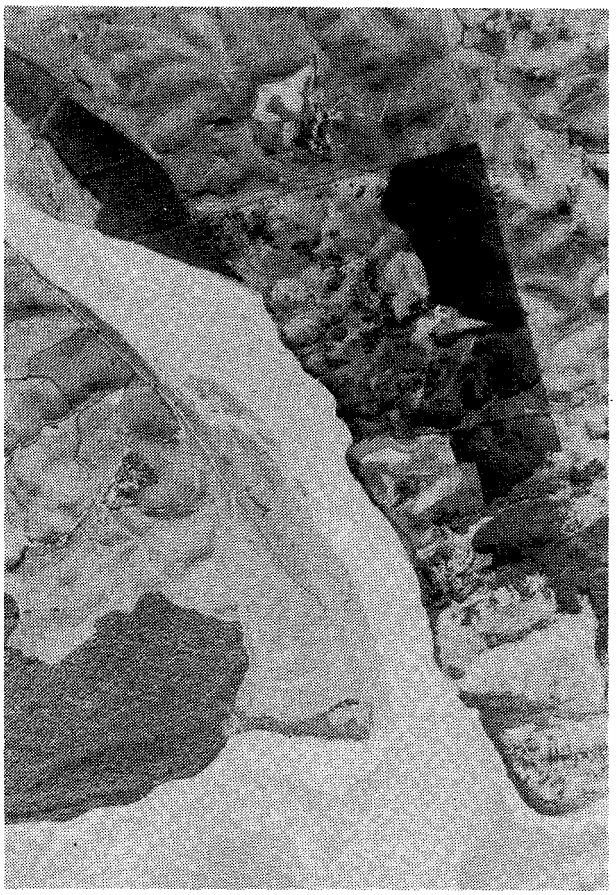
Furthermore, many of Natal's lagoons (such as the Mdloti, or the Mhlanga) undergo periods during which they exhibit classical estuarine characteristics. This occurs for varying lengths of time when the sandbar at the mouth is breached, either naturally or artificially. During floods lagoons also become river mouths for a short period of time. They cease to portray such characteristics after the mouth is closed again.

Another important distinction to make is between typical estuaries (such as the Mlalazi) and estuaries which are connected to coastal lake systems. Examples of such systems are St. Lucia, Kosi and (until recently) the Nhlabane.

In the case of St. Lucia the system may fluctuate in character from being hyper-saline to being totally fresh, according to the climatic cycle prevailing at the time.



The Nhlabane serves as an example of a lake-linked estuarine system. The photograph was taken by Prof. Scogings on 14 May 1976.



An aerial photograph of the Tugela river mouth taken by Prof. Scogings on 14 May 1976. Note the "estuary" extending into the sea, is unconfined by banks.

Schedule 1. Classification of Natal's estuaries.

	ESTUARY	LAGOON	EMBAYMENT	ESTUARY LINKED LAKE SYSTEM	RIVER MOUTH		ESTUARY	LAGOON	EMBAYMENT	ESTUARY LINKED LAKE SYSTEM	RIVER MOUTH
Kosi				●		Sezela		●			
Mgobezeleni				●		Mdesingane		●			
St. Lucia				●		Fafa		●			
Mfolozi	●				○	Mvuzi		●			
Nhlabane				●		Mtwalume		●			
Richards Bay ◁			●			Mnamfu		●			
Mlalazi	●					Kwa Makosi		●			
Siyai		●				Mfazazana		●			
Matigulu	●					Mhlungwa		●			
Nyoni	●					Mhlabatshane		●			
Tugela					●	Mzumbe		●			
Zinkwasi		●				iNtshambili		●			
Nonoti		●				Koshwana		●			
Mdlotane		●				Damba		●			
Mvoti	●					Mhlangamkulu		●			
Seteni		●				Mtentweni		●			
Mhlali		●				Mzimkulu	●				○
Tongati		●				Mbango		●			
Mdloti		●				Boboyi		●			
Mhlanga		●				Zotsha		●			
Mgeni	●				○	Mhlangeni		●			
Durban Bay			●			Vungu		●			
Sipingo		●				Kongweni		●			
Mbokodweni		●				Uvuzana		●			
Manzimtoti		●				Bilanhlolo		●			
Little Manzimtoti		●				Mvutshini		●			
Lovu	●	○				Mbizana		●			
Msimbazi		●				Kaba		●			
uMgababa	○	●				Umhlangankulu		●			
Ngane		●				Mpenjati		●			
Mkomazi	●				○	Kandandhlovu		●			
Mahlongwana		●				Tongazi		●			
Mahlongwa		●				Ku-Boboyi		●			
Mpambanyoni		●				Sandlundlu		●			
Mzimayi		●				Zolwane		●			
Mzinto		●				Mtamvuna	●				
Mkumbane		●				Total out of 73	10	56	2	4	1

◁ = despite being presently divided into two separate systems.
○ = occasional tendencies

Clearly therefore Natal's estuarine systems are dynamic in nature, for which reason one cannot be categorical about their type. Nevertheless, Schedule 1 has been presented in order to assign each of the 73 systems under review to one or other of the categories described above.

1.2 Definition of the extent of the estuarine environment in Natal

In confining our attention to estuaries it is necessary to define the boundaries (or limits) of the estuarine environment. However, estuarine boundaries are difficult to describe geographically because they fluctuate. For example, the seaward boundary of an estuary (as in the Tugela) may at times extend an appreciable distance out to sea, or along the coast. However, for the purpose of this exercise, the dividing line between the sea and an estuary has been taken to be the high tide mark along the coastline.

The landward boundary of an estuary is traditionally that point nearest to the sea where the water of the river no longer shows traces of salinity, or, is no longer subjected to measurable tidal action ([39]). However, as the majority of the systems under review are lagoons (see Schedule 1), the landward boundary of an estuarine system has been taken to be that point at which river water becomes impounded through the direct or indirect action of the sea.

Lagoons smaller than 0,25 ha in extent (such as Adam's Spruit, Winklespruit, the Inkomba lagoon, and many others) have been excluded from this survey. There are in fact 239 independent outlets to various drainage systems along the coast of Natal (Ward, pers. comm.). This report involves the study of 73 of the more significant of these, the total area of which amounts to more than 408 km^2 (see Schedule 2).

Schedule 2. Some of the essential statistics on the rivers and estuaries of Natal.

Estuary	CATCHMENT CHARACTERISTICS			ESTUARINE MORPHOMETRY		Estuary	CATCHMENT CHARACTERISTICS			ESTUARINE MORPHOMETRY	
	Catchment Area km^2	River Length km	M.A.R. m^3x10^6	Area ha.	Shoreline length km		Catchment Area km^2	River Length km	M.A.R. m^3x10^6	Area ha.	Shoreline length km
Kosi	± 500	30	n/r	3 500*	53.5	Sezela	20*	12*	n/r	9	6.4
Mgobezeleni	33*	6	n/r	1.3	1.5	Mdesingane	6	5.2	n/r	.4	1.0
St. Lucia	8 982*	306	295	32 500	347	Fafa	252*	66*	30*	30.1*	6.5
Mfolozi	10 645*	395	729			Mvuzi	8	6.5	n/r	.8	1.5
Nhlabane	104*	12	29	17	6	Mtwalume	551*	85	68*	24.8	6.0
Richards Bay	4 373*	209	616	2 820	60	Mnamfu	15	9	n/r	1.3	1.0
Mlalazi	454*	54*	135*	129*	23.7	Kwa Makosi	10	7	1.5	2.5	1.2
Siyai	18	8	n/r	±8	5.2	Mfazazana	15	10.5	n/r	2.1	1.3
Matigulu	876*	96*	159*	122	16.5	Mhlungwa	31	18	n/r	3.1	1.7
Nyoni	114	±25	21.6	±70	15	Mhlabatshane	41.5*	16	n/r	2.3	1.2
Tugela	28 702*	405*	5 071	55	±2	Mzumbe	617*	84	74.8*	15.8	3.9
Zinkwasi	73*	22*	14.3	19*	10.3	iNtshambili	34	12.5	n/r	1.7	1.5
Nonoti	251*	37.5*	47.8*	18	4.2	Koshwana	12	6.3	n/r	1.2	1.3
Mdlotane	43*	13*	9.9	9.4	5	Damba	26	11	n/r	1.7	1.2
Mvoti	2 651*	197*	297*	18.4	3.8	Mhlangamkulu	12	7	n/r	3.9	2.0
Seteni	16	5	n/r	1.1	1	Mtentweni	53*	20*	3.9	8.0	4.8
Mhlali	294*	46.5*	54.8*	21	6.4	Mzimkulu	6 694*	329*	1 455	74	11.2
Tongati	412*	50*	88.7*	7.6	4.7	Mbango	12	8	n/r	.9	1.3
Mdloti	558*	81*	112*	13.6	6.5	Boboyi	31	14	n/r	1.3	1.2
Mhlanga	135*	28	24.6*	11.4	5.3	Zotsha	71*	20*	12*	7.3	4.7
Mgeni	4 871*	232*	707	48	14.2	Mhlangeni	44	12.5	n/r	3.6	1.7
Durban Bay	210	50	n/r	1 060	27	Vungu	102*	24*	17.5*	1.1	.6
Sipingo	39*	27	3.34	6.8	4.2	Kongweni	18	6	n/r	1.4	1.5
Mbokodweni	243*	59*	9.5	7.2	2.6	Uvuzana	7	2.5	n/r	.6	.7
Manzimtoti	30*	11.6*	1.5*	6.7	2.6	Bilanhlolo	19	12	n/r	2.6	1.2
Little Manzimtoti	12.5*	15	n/r	1.5	1.7	Mvutshini	6	6.5	n/r	.9	.7
Lovu	938*	135	115	10.5	3.8	Mbizana	150*	26	20.2*	12.4	3.9
Msimbazi	36.4*	16*	n/r	13.2	8.4	Kaba	12	9	n/r	2.4	1.5
uMgababa	37*	14.5*	13.5	17.6	8.2	Umhlangankulu	10	6.5	n/r	5.8	2.6
Ngane	16.5*	8	n/r	1.4	.75	Mpenjati	87*	18	16*	11.6	3.8
Mkomazi	4 315	298	1 072	37.8	6.2	Kandandhlovu	11	8	n/r	1.8	1.2
Mahlongwana	17	6	n/r	6.8	3.1	Tongazi	20	8.5	n/r	.8	.7
Mahlongwa	100	23	14.7	5.9	3.3	Ku-Boboyi	4	4	n/r	1.1	1.2
Mpambanyoni	548*	100	38.8*	2.3	.8	Sandlundlu	19	7.5	n/r	4	1.2
Mzimayi	31	20	n/r	.9	.6	Zolwane	7	6.5	n/r	0.5	.5
Mzinto	164*	37	25.2*	7	3.8	Mtamvuna	1 589*	162*	281*	52.7	10.3
Mkumbane	28*	14*	n/r	.3	.2	Grand Total:				40 871	

* Denotes the average of the various figures quoted.

Without becoming involved in estimates made by previous authors or matters such as fluctuations in the extent of estuaries such as St. Lucia which alter this figure, it is important to realize that:

(a) the total area of estuaries in South Africa (although almost certainly an underestimate) has been calculated by Grindley to be less than 600 km² ([176]). **If** this is correct and 408 km² (68%) of this is in Natal, then by South African standards the province is particularly well endowed with estuaries.
(b) Of this area at least 80% is made up by the St. Lucia system.
(c) When compared to countries such as the United States of America (with a coastline of ±10 000 km) where estuaries encompass 107 722 km² ([290]), South Africa (with a coastline of ±3 000 km) is very poorly endowed with estuaries.
(d) The small size of Natal's estuaries (see Schedule 2) make them all the more vulnerable to degradation.

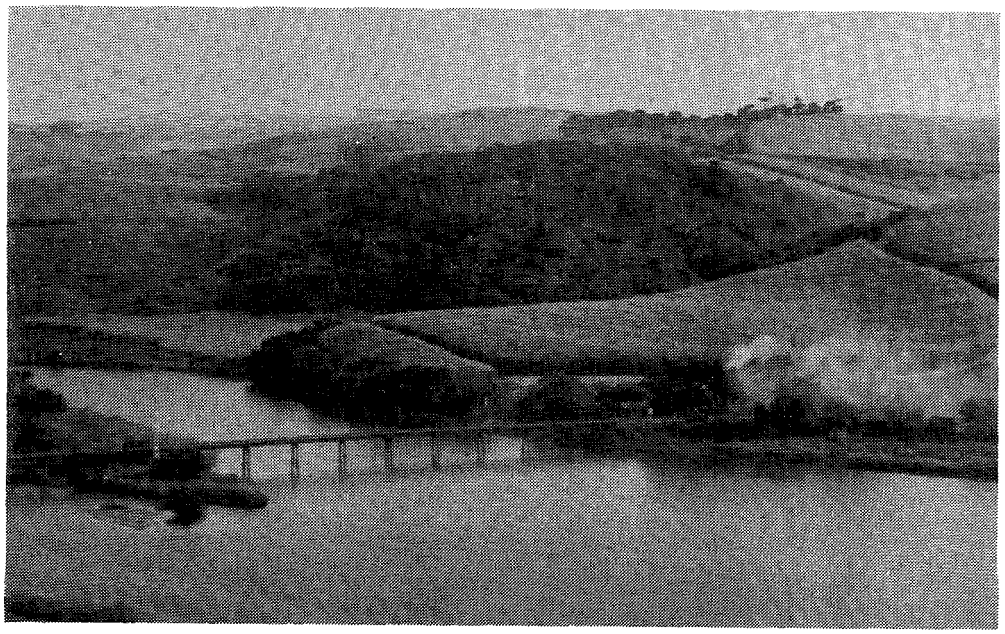
1.3 The past and present condition of the estuarine environment in Natal.

To describe Natal's estuaries as they were in the past is difficult because the earliest ecological surveys of estuaries only date back to 1947. The process of estuarine degradation had by then already set in. Thus to describe the condition of estuaries in the early part of the 20th Century reliance upon unscientific accounts is necessary. Certain deductions can also be made with the aid of early photographs.

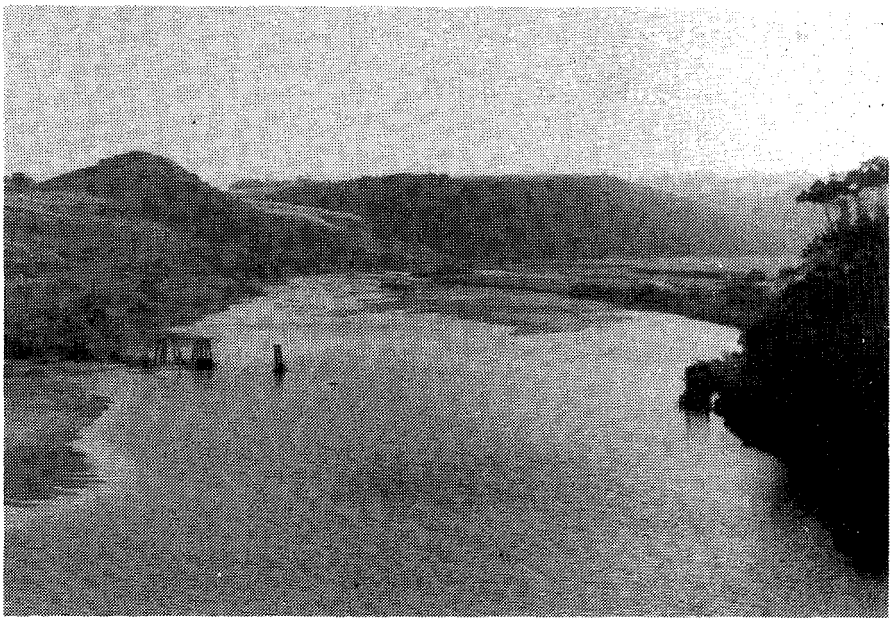
The nursery function of lagoons was appreciated by fishermen in Natal by 1909. The following extract from a Mercury Pictorial (dated 25 March, 1909) reads . . . "it is the lagoons which form the nursery for our local fish fry. The small fish enter these sanctuaries in the spring and summer, when the rivers break out, and stay there in shelter until the next summer, when they are big enough to look after themselves".

A description of the Mtwalume estuary in the 1930's provided by Mr A. R. Thorpe (pers. comm.) has been invaluable in providing some insight into its original condition. The Mtwalume estuary used to extend 4 km inland to a set of rapids where the old national road bridge now stands. A fairly large boat (capable of carrying 17 people) used to be taken up the estuary to this point regularly. The estuary no longer exists. The remnants are now a lagoon, which when open, seldom extends more than 0,7 km inland.

The estuary used to be 6 m deep in certain places and to seaward of the old railway bridge one could not wade across the estuary even at low spring tide. People could dive with safety off the old railway bridge into the estuary. No one knows the depth of the Mtwalume lagoon today, but it is unlikely to be deeper than 1,5 m.



A photograph of the Mtwalume estuary taken in the 1930's by a German photographer, but kindly provided by Mr A. R. Thorpe.

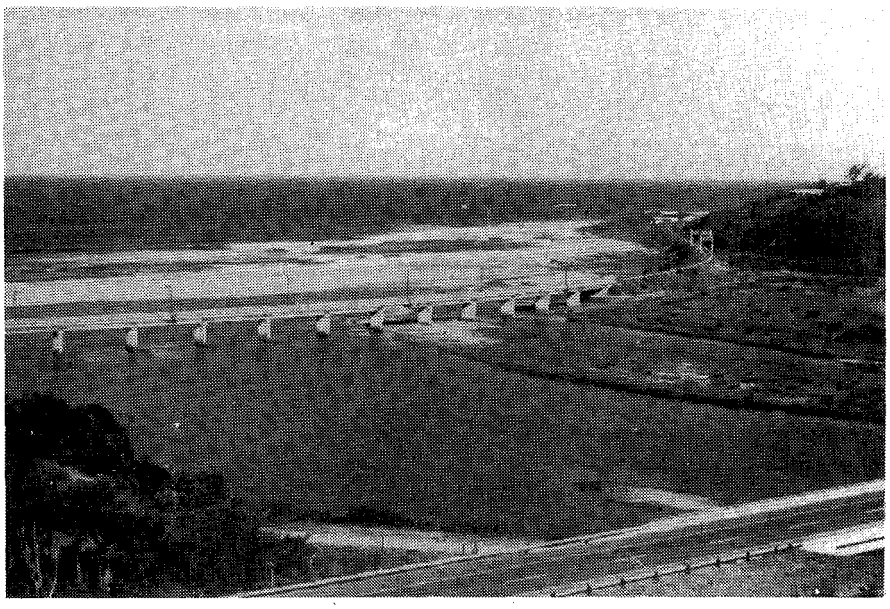


The silted remains of the Mtwalume estuary 18 July 1977. Notice also the remains of the railway bridge.

Floods in 1917 imparted no real change to the estuary, but since the 1940's have brought down silt, trees and debris in ever increasing amounts.

The mouth of the estuary was always in the extreme southern corner of the system. Only since the estuary has become silted up and altered by road and rail bridges, has the mouth wandered about from one position to another.

In the 1930's big jellyfish used to come up the estuary on the spring tides, and the rocks were covered in oysters (*Crassostrea*) and barnacles (*Balanus* sp.). The banks were rich in mud prawns (*Upogebia*) and nearer the sea, where they became sandy, cracker shrimps (*Callianassa*) were abundant. Swimming prawns (Penaeids) were common and used to appear in vast shoals at Easter, when they could be caught with hand or cast-nets. Mullet came into the estuary in such shoals that they could be jigged with a single hook and trout rod from the old railway bridge. Of the 35 varieties of fish that Thorpe recalls



Bridge construction across the Mtwalume estuary (3 June 1978). Notice the embankment of the railway bridge across the floodplain, and the freeway in the foreground.

having caught, the occurrence of brindle bass (*Promicrops*), shad (*Pomatomus*), blacktail (*Diplodus*), and honeycomb rays (*Dasyatis*) is almost unbelievable in the light of the scarcity of such fish in estuaries today.

The Mtwalume lagoon is at present regarded as barren. It hardly supports any marine life at all. Its condition changed in the late 1930's when the Umtwalume Valley Estates expanded their sugar cane farming interests in the catchment area. The construction of embankments across the floodplain to support the new railway line in the 1940's, reduced the tidal exchange and constricted floodwaters to the extent that the silt they carried became deposited in the estuary. What was water became land, which became planted under more sugar cane and used for the new freeway that presently spans the lagoon.

This rather depressing account of the Mtwalume estuary regrettably holds true for the majority of Natal's estuaries, although the process of degradation may have been brought about in different ways. Consequently an attempt has been made to classify Natal's estuaries into three types, according to their present environmental condition (see Schedule 3).

Classification has been based upon whether the system in question appears, **in its present day condition**, to be functional, and contributing in some way to Natal's overall estuarine environment. This is a subjective assessment based on criteria such as the degree to which peripheral plant communities have been disturbed; the diversity of the animal life present; the depth (as an indication of sedimentation rates); and the appearance of the water. In this way Schedule 3 provides the means of forming an initial impression as to which of Natal's estuaries appears still to be functional; which are beginning to lose this function; and which have lost it. The schedule also illustrates how many of Natal's estuaries are in need of attention, some more so than others. It goes without saying that the need to protect the functional systems is becoming more and more important.

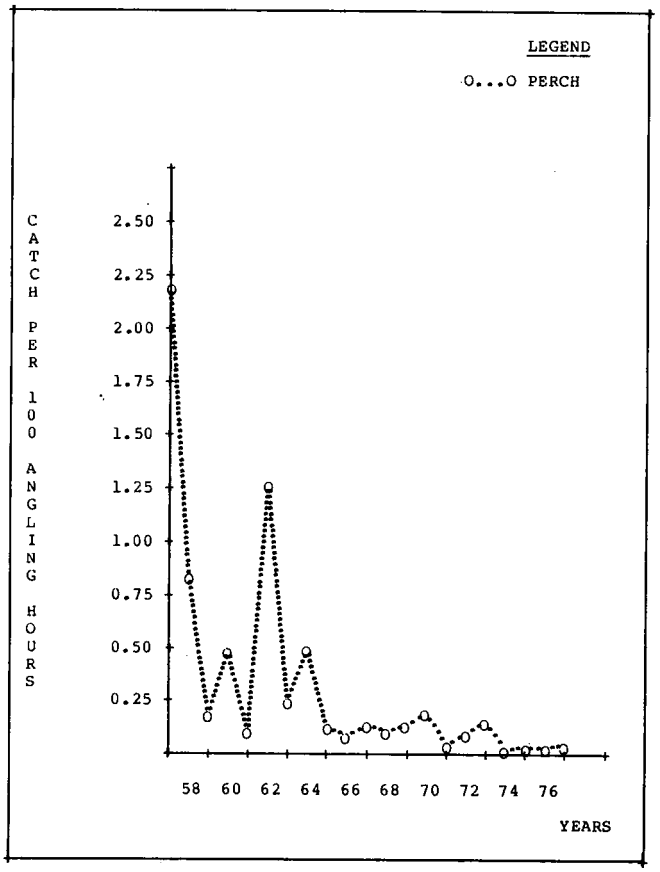


Figure 1. A graph (kindly provided by R. van der Elst) showing the decline of the numbers of perch (*Acanthopagrus berda*) caught by anglers in Natal over the past 22 years. Perch are an estuarine dependent species.

Schedule 3. Present day environmental condition.

ESTUARY	GOOD	FAIR	POOR	ESTUARY	GOOD	FAIR	POOR
Kosi	●			Sezela			●
Mgobezeleni	●			Mdesingane		●	
St. Lucia	●			Fafa	●		
Mfolozi *		●		Mvuzi			●
Nhlabane	●			Mtwalume			●
Richards Bay *		●		Mnamfu		●	
Mlalazi	●			Kwa Makosi		●	
Siyai		●		Mfazazana		●	
Matigulu	●			Mhlungwa			●
Nyoni	●			Mhlabatshane		●	
Tugela			●	Mzumbe			●
Zinkwasi		●		iNtshambili	●		
Nonoti		●		Koshwana			●
Mdlotane	●			Damba	●		
Mvoti *		●		Mhlangamkulu		●	
Seteni			●	Mtentweni		●	
Mhlali		●		Mzimkulu		●	
Tongati			●	Mbango		●	
Mdloti		●		Boboyi		●	
Mhlanga	●			Zotsha	●		
Mgeni *		●		Mhlangeni			●
Durban Bay		●		Vungu	●		
Sipingo		●		Kongweni			●
Mbokodweni			●	Uvuzana		●	
Manzimtoti			●	Bilanhlolo		●	
Little Manzimtoti			●	Mvutshini		●	
Lovu		●		Mbizana *			●
Msimbazi	●			Kaba		●	
uMgababa	●			Umhlangankulu		●	
Ngane			●	Mpenjati		●	
Mkomazi		●		Kandandhlovu		●	
Mahlongwana	●			Tongazi		●	
Mahlongwa	●			Ku-Boboyi			●
Mpambanyoni			●	Sandlundlu		●	
Mzimayi			●	Zolwane	●		
Mzinto		●		Mtamvuna	●		
Mkumbane			●	Total out of 73:	20	33	20

* alternative ratings also applicable (see Section 2.1).

To establish why an estuary has been assigned to one of these categories it is recommended that the reader consults the information available on that particular estuary in Section 2.1.

Turning to more recent scientific accounts of the situation, it is known that where 95 invertebrate species and 58 species of fish were recorded in the Mlalazi estuary in 1963 ([182]) only 27 invertebrates and 15 species of fish were present in 1972 ([158]). Hardly any of the animal life described from the Mgobezeleni estuary in 1963 ([217]) occurs today due to the decimation of mangroves in the estuary through the restriction of the tidal regime by the construction of a bridge ([62]). Comparison of the life present in the Sipingo lagoon in the 1950's ([114]) with that existing today cannot be made without the necessary surveys being done, but the same sort of impoverishment is probable. Where 183 animal species were recorded from Richards Bay in the 1950's ([225]) a harbour now exists, in which no one really knows what is to be found. In Durban Bay 563 species of marine animals occurred in the early 1950's ([120]). 186 of these were different types of fish. Whether they still occur today is unknown.

Added to this, results from a recent analysis of 22 years of fishing competition catch statistics ([313]) have indicated a progressive decline in the overall catch per unit of effort of teleost fish caught by sport fishermen in Natal (see Fig. **1**). In St. Lucia alone fish such as kingfish (*Caranx*), garrick (*Lichia*) and rock salmon (*Lutjanus*) now scarcely feature in angler's catches any longer ([313]). All this confirms that such resources are under stress and that one of the most likely causes is estuarine degradation.

The existence of diverse biological communities in Natal's estuaries some 30 to 40 years ago is living proof that not long ago mankind and nature lived in harmony. Cain ([65]) stressed that "if we are to endure and enjoy our resources to the utmost, we must strike a balance with nature", and Heydorn ([174, 179]) has repeatedly described the futility of trying "to build a sound economy upon a damaged environment."

It was due to considerations of this nature that the Natal Town & Regional Planning Commission decided (in June 1975) to launch the present project. Preparations were completed in March 1976, and work commenced in October of that year. The final report was completed in September 1978.

1.4 The objectives of the study.

The objectives of this study were twofold:

(a) **to gather and review all the pertinent information available on 73 of Natal's estuaries so as to assess the present day state of knowledge of such systems.**

(b) **to construct a framework of the various parameters that maintain a state of equilibrium in the estuarine environment of Natal, with emphasis on land and water relationships within each estuary.**

A review was necessary because information on Natal's estuaries relevant to their ecological, social and economic importance was fragmented and scattered, sometimes as far afield as Cape Town and the United States of America. What was required was to eliminate institutional barriers and to correlate information from unpublished, obscure and well known sources. By accumulating, analysing and interpreting the available information, it has become possible to establish where information gaps (or data voids) occur (see Section 4,1; Schedule 8). The process has also brought estuarine research in Natal into a position whereby it can (with the necessary co-operation) be effectively co-ordinated on an inter-disciplinary basis.

Information gathering also led to the identification of estuarine problems (Section 3.2, Schedules 5 and 6). It is hoped that through the recognition of these, the necessary action will be taken at local and state levels to overcome them.

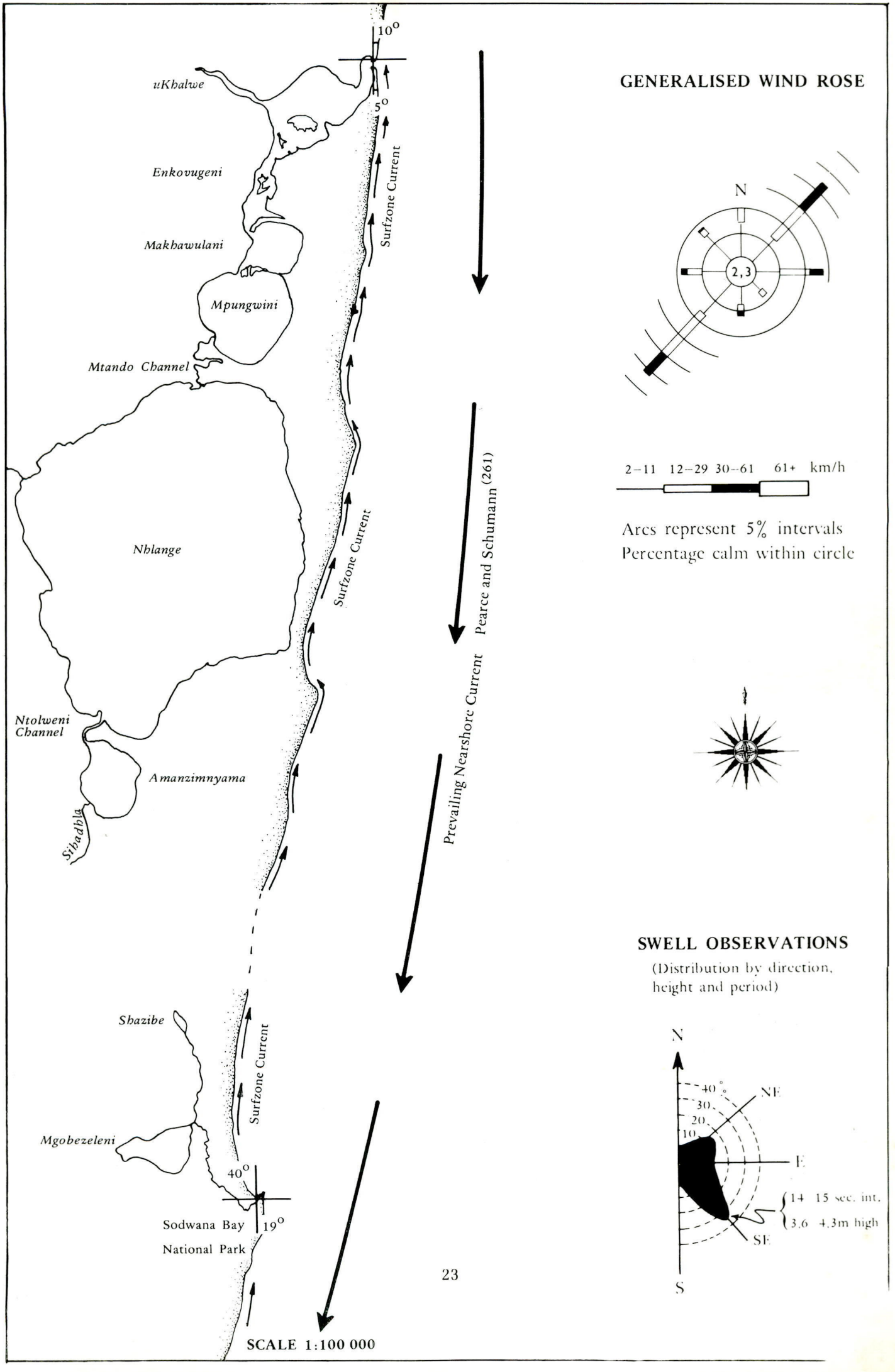
The second objective developed because of the need to identify factors and forces to which Natal's estuaries are sensitive, especially where slight change may cause a significant change in the environment. The framework constructed provides what Clark ([83]) refers to as "a comprehensive ecological background for local government decision making and for the building of a management framework that will lead to the best achievable ecosystem function and the highest carrying capacity". This framework (appearing as Part 3) has been drawn up to show how factors such as road and rail construction, land apportionment, waste disposal and recreational demands affect estuaries. It provides a basis upon which the Natal Town & Regional Planning Commission can in future assess the implications of development in the vicinity of estuarine systems.

THE ESTUARIES OF NATAL



a summary of available information

Part Two


10°
5°
uKhalwe
Enkovugeni
Makhawulani
Mpungwini
Mtando Channel
Nhlange
Ntolweni Channel
Amanzimnyama
Sibadbla
Surfzone Current
Surfzone Current
Surfzone Current
Prevailing Nearshore Current
Pearce and Schumann (261)
Shazibe
Mgobezeleni
40°
Sodwana Bay National Park
19°
SCALE 1:100 000
GENERALISED WIND ROSE
N
2,3
2–11 12–29 30–61 61+ km/h
Arcs represent 5% intervals
Percentage calm within circle
SWELL OBSERVATIONS
(Distribution by direction, height and period)
N
40
30
20
10
NE
E
SE
S
14 15 sec. int.
3,6 4,3m high

2.1.1.1 **KOSI**

Synonyms/Nomenclature of the Kosi System

There is good reason to suggest that the name Kosi is a misnomer. As Tinley points out ([159, 300]) "no physical feature in the entire area is known by that name to the natives", and that it is known to them as Nkovugeni ([300]) (or Enkovukeni) to describe "the up and down action of the water" ([289]) — i.e. its tidal regime.

The name Kosi has three possible origins:

(a) from being adopted by Europeans who associated the area with Chief Makuza who lived in the neighbourhood ([300]);
(b) from being adopted in 1882 by those aboard the ships "Leven" and "Barracouta" who were searching for a river known to them as the "Umkosi" (a distortion of the name for the Mkuze river which flows into St. Lucia) ([289]); or
(c) from having been derived from the Zulu word for an eagle — "Ukosi"([289, 300]).

There is an equal degree of confusion over the naming of the various parts of the Kosi system. Appreciating this fact, most workers ([3, 4, 33, 51, 53, 159, 183,]) have adopted the names shown on the standard 1:50 000 map No. 2632 DD printed by the Government in 1963. Others ([170]) adopt some of these names, and some of the names used by Tinley ([300]). However, the nomenclature of the system as used by Tinley has more authenticity, because over a period of two years he collected such names from local natives in the area. Pike ([263, 264]) and Vahrmeijer ([305]) also follow this nomenclature. In the most recent edition of maps of the Kosi system (1:250 000 Topo Cadastral Sheet No. 2632) it appears that the Government Printer has abandoned the use of certain names on earlier maps and also adopted those used by Tinley, Pike *et al.* It is suggested therefore that for the future, all workers adopt these names accepting that in the interim, confusion will arise.

Fig. 2 has been presented to illustrate the need for the adoption of a generally accepted set of names and to assist workers on the Kosi system to establish to which part of the Kosi system an author is referring.

Thonga meanings ([289, 305])

Zilondo	— ?
uKhalwe	— the distant one
Enkovugeni	— the up and down action of the water
Makhawulani	— ?
Mpungwini	— 'Okhunwini' is said to mean "the place of the fireweed" ([289]), while Ward (pers. comm.) is of the opinion that it is the local name for the cracker shrimp (or sand prawn) *Callianassa kraussi* which is common on the edge of the lake. Blaber (pers. comm.) believes the word refers to the smell of hydrogen sulphide in the sediments.
Mtando channel	— ?
Nhlange	— the reedy place
Ntolweni channel	— ?
Amanzimnyama	— dark water
Sihadhla	— ?

Location

The greater part of the Kosi system is situated within 26°50'S to 27°11'S and 32°38'E to 32°53'E ([300]), and is orientated on an east north-east to south south-west axis.

The system lies on the coastal plain west of the Lebombo Mountains in the north east extremity of the Ingwavuma district (Tongaland ([300]), or Maputaland ([180]). It is destined to become entirely incorporated into KwaZulu.

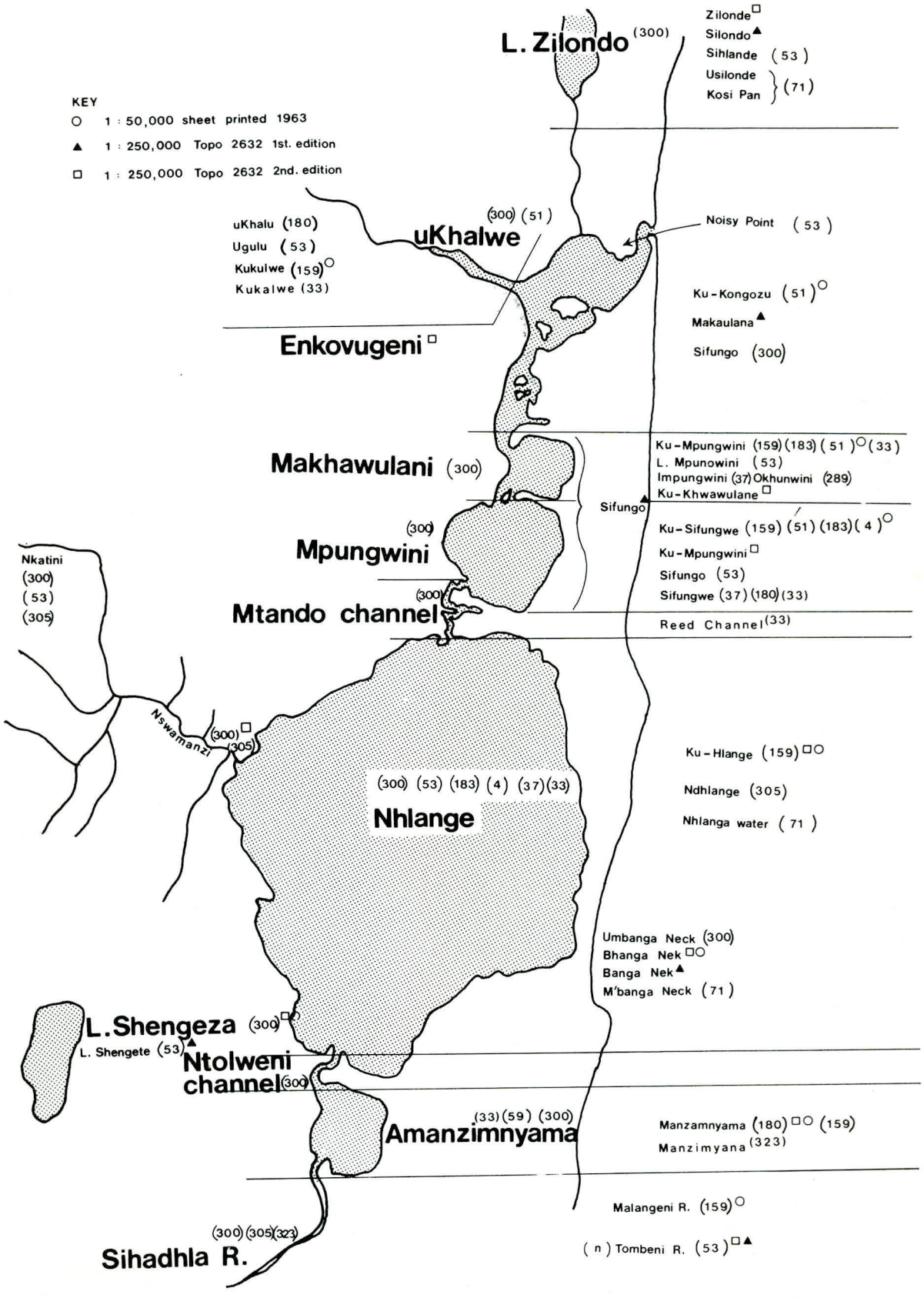
A small portion of the catchment (i.e. that draining into Lake Zilondo) is inside Mozambique.

Accessibility

The Kosi system is some 470 km north east of Durban. The nearest town is Ubombo, situated 134 km from the estuary, although the village of Maputa is 13 km from the Natal Parks Board Camp on the western shores of Lake Nhlange.

The system is relatively inaccessible in that permits are required to visit it, and because the nature of the road between Maputa and the estuary is suitable for four-wheel drive vehicles only.

Fig. **2.** Nomenclature of the Kosi system.





Enkovugeni (21 September 1977).

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. The Kosi drainage system is ill-defined because of the pans, swamps and marshes which surround it. It is best known and described by Tinley ([300]), and is estimated to be ±500 km² in extent.

River length. There are two principal rivers which enter the system (see Fig. 2):

(a) Sihadhla river which rises in the Mtombeni pans, is ±30 km long, and, after receiving contributions from a network of 12 principal tributary streams, enters Lake Amanzimnyama.
(b) Nswamanzi river which is ±15 km long, collects water from nine principal tributaries, and enters Lake Nhlange on its western shore.

Mean annual run-off. Due to the high infiltration rate of water on the sandy coastal plain over which such rivers move, Orme ([257]) suggests that only 5% of the total annual precipitation is borne by rivers/streams in the Kosi area. Attention has been drawn to the fact that small changes in drainage patterns could result in the isolation of Lake Nhlange because of its tenuous connection (the Mtando channel) to the sea ([33]). Thus reports of swamp drainage at the source of the Sihadhla river ([323]) are viewed in a serious light.

Flow. Hill ([183]) refers to "a fairly strong seasonal inflow of fresh water into the head of the estuary . . .", but other than some recordings made by Ward in August/September 1976 (pers. comm.) there is no information available on the hydrology of the Kosi system. In 1976 the Department of Water Affairs installed seven guage plates and two water level recorders, after the recommendations of Bruton ([59]). Records are maintained by staff members of the KwaZulu Department of Nature Conservation stationed at Kosi.

Flood History. The most memorable floods in recent times were in January 1966 (said to be January 1967 in ([4])) when "Cyclone Claude" swept over the Kosi system.

Level fluctuations. During "Cyclone Claude" the mouth was closed, having been so since 17 August 1965 ([51]). Consequently water levels had been gradually rising (0,3 m) over a period of 140 days. During "Cyclone Claude" levels rose 1,6 m ([51]), after the area was subjected to 640 mm (25") of rain in three days. However Boltt and Allanson ([37]) talk of a 2 m rise in lake levels over this period. Increased lake levels led to the mortality of the mangrove communities described under 'flora'.

Tidal effects are noticeable in Nhlange particularly in winter (low water level periods) ([170]). Day ([119]) and Blaber ([33]) point out that the levels in Kosi are lower at low neap tide than at low spring tide because the water which enters the estuary on the high spring tide does not have time

to leave before the next high tide starts rising. Recordings of such movements were made by Ward in August/September of 1976 (pers. comm.). Information on current speeds in various parts of the Kosi system have only recently become available ([33]). These revealed that outflow towards the sea is greater during summer and water movements during the winter are due to tidal effects. In all cases outflow speeds exceeded any inflow speeds.

As water level recorders have now been installed within the system, precise data should be available soon.

Dams. There are no dams existing or proposed in the catchment area.

Siltation. Orme ([256]) considers that since the Holocene transgression, the surface water area of the Kosi system has decreased by 68% (i.e. from 104 km^2 to 34 km^2) due to sedimentation, segmentation and reed swamp encroachment.

Hemens *et al* ([159]) consider that Lake Amanzimnyama has acted in the past in the manner of a sedimentation basin and was formerly much deeper than it is today.

However, the silt free nature of Kosi is one of the most outstanding characteristics of the system which repeatedly reflects itself through the manner in which the flora and fauna of the system respond. Both MacNae ([218]) and Tinley (pers. comm.) emphasize that the rivers which feed Kosi rise in podsolized (leached) acid sands, and as a result, they carry no silt into the Kosi system. The dark colour of the river and lake water is a result of humate staining (from peat sources) and is typical of drainage from swamps and marshes.

Hill ([183]) refers to the shallow entrance of the Kosi system as being "silted up" by sand, but this is due to substantial movement of sand along the coast, and transport into the estuary mouth. The native fish traps of the Kosi system have often been regarded as contributing to the sanding up of the tidal basin ([53, 70]) and thus the channel between the traps has been widened from 10 m to 30 m by the Natal Parks Board as a conservation measure, to permit the free passage of fish ([296]). However, the local natives consider this to be one reason why the channel depth in the tidal basin is decreasing (Jackson, pers. comm.); their reason being that there was previously greater tidal scouring in the formerly narrower channel.



Guide fences of Thonga fish traps at Kosi. Note the destruction of forest cover on the opposite shore.

Land ownership/use.

In catchment and around estuary: Enormous afforestation schemes are reported in the headwaters of the Kosi catchment ([323]), but besides this the area is entirely Bantu influenced, especially on the western and south-eastern sides of the system. 80 000 Bantu were reported to be living in the area in 1968 ([71]). Cultivation is principally aimed at production of sweet potatoes, maize and groundnuts, although mangoes and cashew nuts are also grown ([300]). One of the consequences of such cultivation is the destruction of forest communities (see under 'flora').

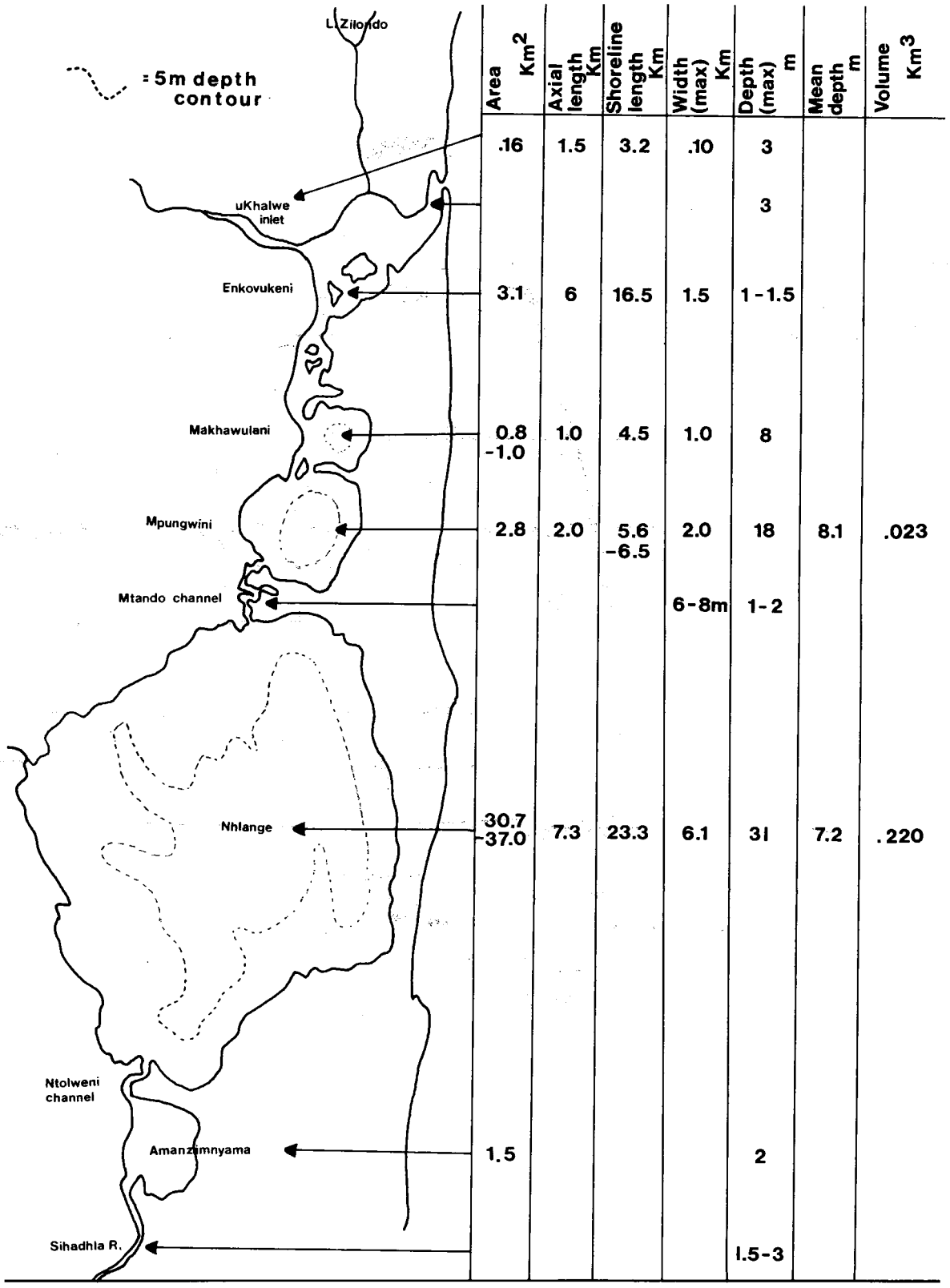


Fig. 3. Morphometry of the Kosi system.

At one stage an attempt was made to grow coconuts commercially in the Kosi catchment (Bruton, pers. comm.) ([323]), and ever since the days of President Kruger (i.e. before the turn of the 20th Century) Kosi Bay has been considered as a viable harbour site ([71]). It was proposed to create a harbour from Lake Nhlange by cutting through the coastal dunes at Banga Neck ([70, 71]) (see Fig . **2**).

Local authority: The area is in a state of transition in that the Department of Bantu Affairs and the Natal Parks Board are handing it over to the KwaZulu Nature Conservation Department.

Estuary uses. Principal use of the estuary is made by anglers and nature lovers. Madlangula camp on the western shores of Lake Nhlange can cater for up to 105 visitors at a time in the season. Attention has been drawn to the effects of bank erosion caused by the bow-waves from boats passing through the Mtando channel ([230]).

Morphometry of the estuary.

The morphometry of the system which is comprised of several distinct entities (a chain of lakes) is presented in Fig. **3.**

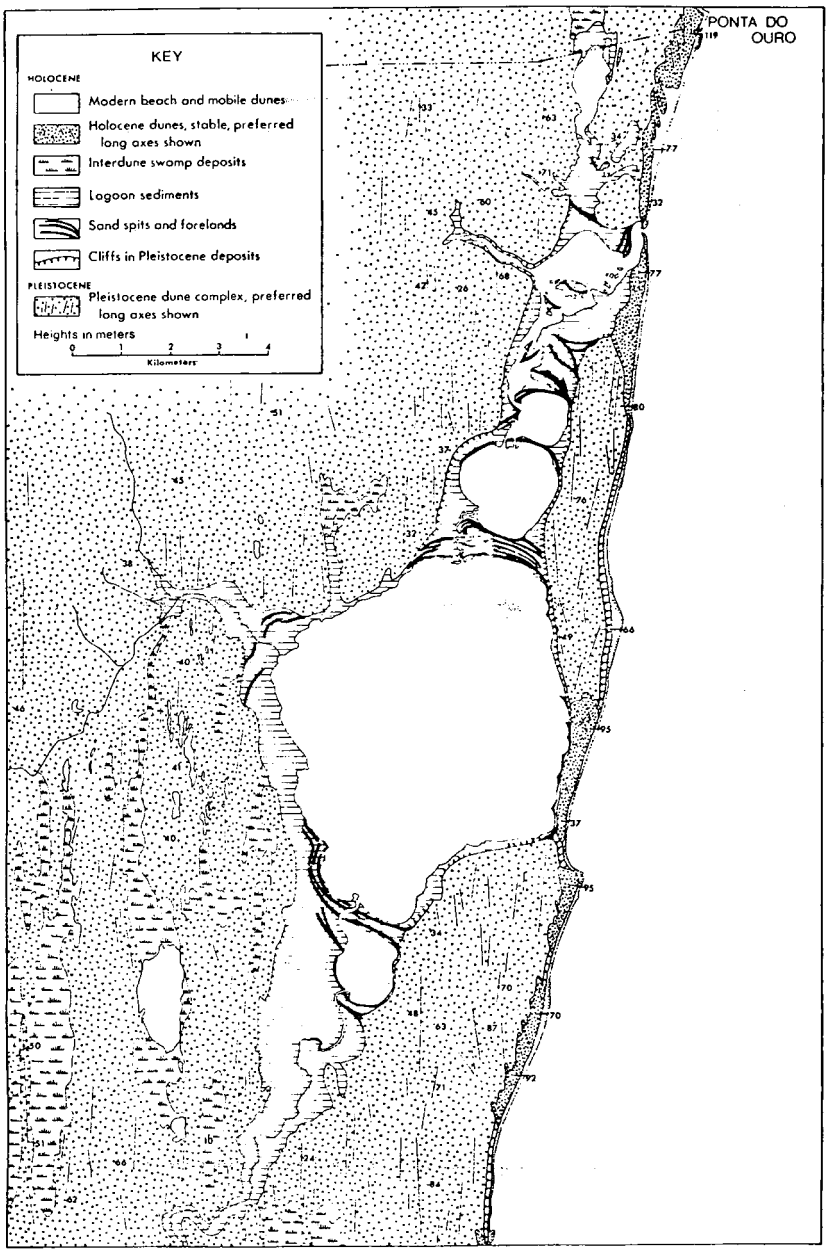


Fig. 4. Geomorphology of the Kosi system after Orme ([256]).

Area. There appears to be some confusion as to the size of the Kosi system, because it is said to incorporate 36 km² of water in (180), and 33,9 km² in (256). The area of Lake Nhlange alone is shown as both 37 km² and 30,7 km² in (183) and is estimated to be 26 km² in (305). Some clarification in this regard is necessary.

Hypsographic curves for Lake Nhlange and Lake Mpungwini are given by Hill (183).

Shape. The Kosi system illustrates the phenomenon of segmentation (256), a process which transforms the system into circular water bodies each separated by low beach barriers. The circularity of the lakes reflect the opposing wave energies generated by the prevailing winds.

Bathymetry. Campbell (71) gives the depth of Lake Nhlange as 60 m — but this is incorrect. The deepest area of Lake Nhlange (referred to as "the northern trench" by Boltt and Allanson (37) is 31 m deep. Due to the shallow nature of the tidal basin (see Fig. 3) about 70% of its area becomes exposed at low tide (33).

Geomorphology

Geology. (See Fig. 4). The Kosi system lies within the pale sandy soils of the Mozambique coastal plain, which overlie cretaceous beds. The coastal dunes are composed of both Holocene and Pleistocene sand deposits (256). West of the coastal dunes no rocks or stones are to be found (300), although on the coast, rock ledges, shelves and outcrops occur. One such rocky outcrop near the mouth, forms a small reef within the estuary upon which a very diverse fauna may be found (33, 53, 180).

Nature of bottom materials. (See Fig. 5). Unlike many of Natal's estuaries, the nature of the bottom materials in the Kosi system are principally clean, white sands; particularly in the northernmost reaches of the system where tidal influences are most marked (33, 159). Sandy substrates are also characteristic even on steeply shelving profiles (37) and in the lake margins. Profiles across Lakes Nhlange, Mpungwini and Makhawulani are noticeably terraced, (i.e. the littoral shelf of each lake extends to varying distances, but shelves suddenly to a series of lower platforms). This feature is particularly clear from the aerial photography of Scogings (dated May 1976) and the transects of Hemens *et al* (159) and Boltt & Allanson (37) drawn across Lake Nhlange. The only silt is found in deeper waters, or as a thin layer overlying sand in certain shallow areas (33).

The sandy substrates of Kosi are characterized by a lack of fine particles, and are low in nutrient content. They contrast in these respects to the bottom materials of the deeper parts of the system where unconsolidated organic debris has collected. In these instances, the bottom materials are characterized by low dry weights, high volatile and nutrient values (159). They can be of considerable thickness, are black and hydrogen sulphide bearing. These materials originate in the marshes and swamps alongside the system and then naturally gravitate towards the deeper areas. The reserves of fragmented plant materials in Lake Amanzimnyama and the Sihadhla river are considered to be important sources of organic debris for Lake Nhlange by Boltt & Allanson (37). Fish such as various mullet (Mugilidae), and the milkfish (*Chanos chanos*) are detritus feeding species which feed upon such materials (33). Although anoxic, and thereby limiting benthic productivity, these organic materials are the source of soluble mineral nutrients that diffuse upwards into the surface waters, or, in Lake Nhlange, are recycled at 'turnover'. In general, oxygen absorbed, nitrogen and phosphorus values are highest in Lakes Mpungwini and Makhawulani (159), and sediment sampling in 1976 (253) revealed little change in characteristics to those already described.

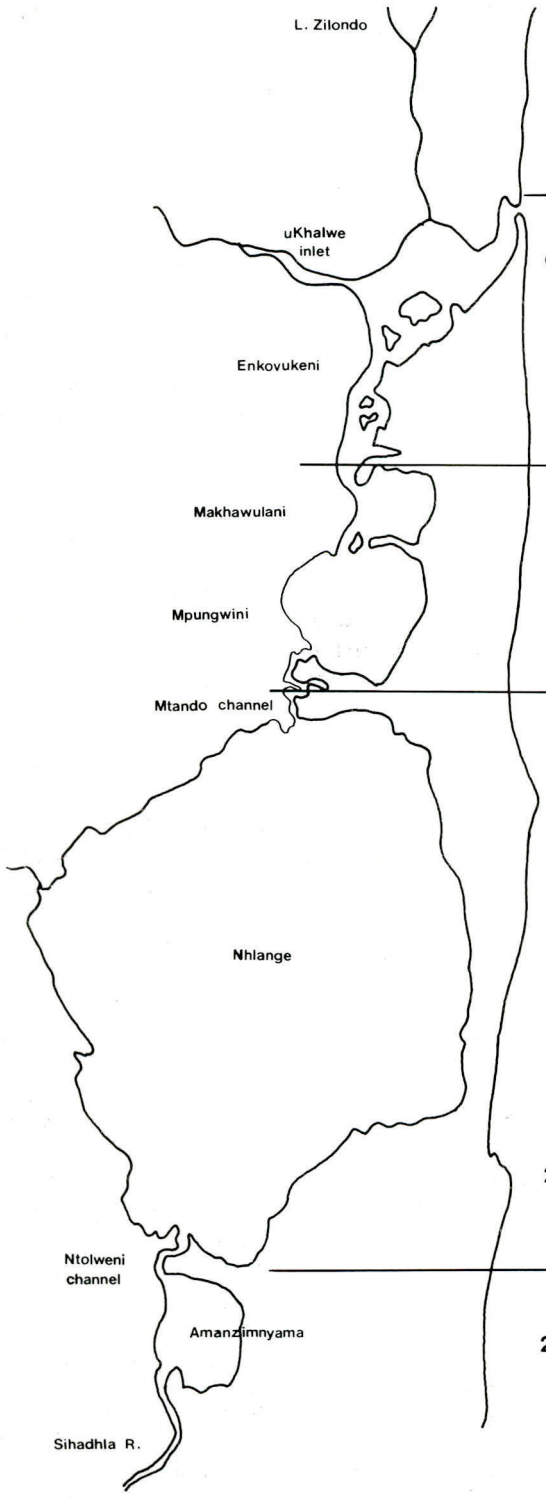
Broekhuysen & Taylor (53) refer to a pebble beach at the mouth of Kosi in 1949, and Boltt & Allanson (37) refer to a mudplain at a depth of 15 m — 20 m on the eastern side of Lake Nhlange.

Sandbar characteristics. Littoral drift is predominantly towards the north (256). However, the sandbar at the mouth of the Kosi system has both a south extending component (±100 m long) and a north extending component (±200 m long), between which the estuary channel winds its way to the sea. Orme considers the Kosi beach spits to be highly mobile (256). The Uguma rocks immediately south of the mouth protect it to a certain extent from the prevailing swell direction.

The mouth is generally open throughout the year and subjected to regular and strong tidal movements, though Orme (256) considers that this opening is maintained with difficulty. However this exchange with the sea is the lifeline on which the system depends. The mouth varies in size with every tide, particularly during the spring tides. It is generally 20 m — 50 m wide (300) and 3 m deep. It can vary in width from 5 m — 100 m.

On 17 August 1965, for some unknown reason (possibly due to exceptionally high seas

Fig. 5. Sediment analyses of the Kosi system after Hemens *et al* ([159]), in August 1971.



Depth	Dry wt. %	Volatile at 600°C % dry wt.	% Particle size microns			per gm. dry wt.			
			> 500	> 125	< 125	O.A. mg	Kjeld N. µg	Total P. g	Sulphides (mg)
0.6	80.7	2.0	17.6	78.0	4.4	0.3	76	45	0.0
1.0	76.6	0.5	7.1	91	1.9	0.2	82	16	0.0
2.5	78.0	0.3	0.5	97.7	1.8	0.3	130	11	0.0
16.5	8.1	24.9	organic debris			37.8	7,200	377	0.76
2.0	78.6	0.3	1.3	96.7	2.0	0.3	2	7	0.0
17.0	7.2	34.7	organic debris			63.7	22,100	47	0.4
24.0	56.0	2.9	3.7	78.3	18.0	8.7	978	43	0.03
2.0	13.8	35.0	organic debris			121.8	9,400	202	0.57

Key:

O.A. = Oxygen absorbed
Kjeld. N. = Kjedahl nitrogen
Total P. = Total phosphorus

([263])) the mouth closed, and remained closed until opened artificially on 4th January 1966. The gradual rise in water level during this period (0,3 m) and the dramatic water level rise of 1,6 m after "Cyclone Claude" precipitated this course of action ([51]). During this time much of the mangrove community was killed (see Fig. **7**).

Configuration of the adjacent shore. The sandy coastline lies at almost exactly 180° (due north-south) to the estuary mouth, being deflected only 10°E of north and 5°E of south to the south.

Surf zone currents. North going, but south going on certain occasions.

Physico-chemical characteristics.
Of the physico-chemical information on the Kosi system most of the research effort has been concentrated on Lake Nhlange ([4, 33, 37, 53, 159, 253]).

Thermal properties. Some of the earliest information on temperatures of the Kosi system dates back to 1949 ([53]). Lake Nhlange is a warm lake ([4]) which exhibits a complex pattern of stratification during summer. It is not stratified into a distinct epilimnion and hypolimnion, because of the strong northerly, or southerly winds which blow during this season. Instead several thermoclines develop. In the cool season Lake Nhlange tends to develop homothermal characteristics at 18,5°C to 19°C. In Lakes Mpungwini and Makhawulani temperature layering is evident, so that bottom temperatures may be significantly **warmer** than the surface waters ([53, 159]). In the well mixed, shallow, tidal portion of the system (Enkovugeni) sea temperatures become more evident. Water temperatures in the channels do not fall below 20°C in winter and attain 30°C in summer ([33]). In the shallow margins summer temperatures of 39°C have been recorded by Blaber ([33]).

Transparency. The Kosi system is renowned for its clear water, as illustrated by Secchi values of 4,2 m — 7,0 m in 1949 ([53]). The mean Secci disc measurements from Lake Nhlange for the period July 1965 to January 1967 ranged from 1,0 m — 1,4 m and in Lake Mpungwini was 3,7 m ([4]). These reduced values were almost certainly reflective of the effects of peat-stained floodwaters which reduced transparency throughout the system in January 1966, to 0,95 m. In 1967, 1% of sub-surface illumination was measured at 6 m in Lake Nhlange ([4]).

Salinity. Table **1** presents the results of the salinity readings made in the Kosi system by various workers since 1949. A classical transition from sea water at the mouth to fresh water in Lake Amanzimnyama (16 km distant) is evident. In the tidal basin (Enkovugeni), marine conditions (i.e. salinities close to that of sea water) may be encountered. These vary naturally with the tides; but it should be noted that on certain occasions (August 1976) on a low tide salinities in this section of the system dropped to remarkably low levels (8,4‰) ([253]).

The two lakes Makhawulani and Mpungwini, both exhibit salinity layering. In Mpungwini a sharp, permanent halocline occurs at ±10 m ([4]). The source of this deep salt layer is the sea and consequently these lakes are considered to be dominated by "ectogenic meromixis".

In Lake Nhlange salinities fall, and yet the waters of Lake Nhlange are not considered simply as diluted sea water ([37]) because the ion ratios between sea water and Nhlange water are markedly different ([4]).

The lowest salinities from Nhlange (0,9‰) were recorded in August 1976 by Oliff *et al* ([253]). It is surprising to find that during the floods of January 1966 the salinity of Lake Nhlange (see Table **1**) was not dramatically reduced. Blaber ([33]) considers that the low salinities of Nhlange adversely affect the osmoregulation of many marine species of fish that would otherwise enter the lake.

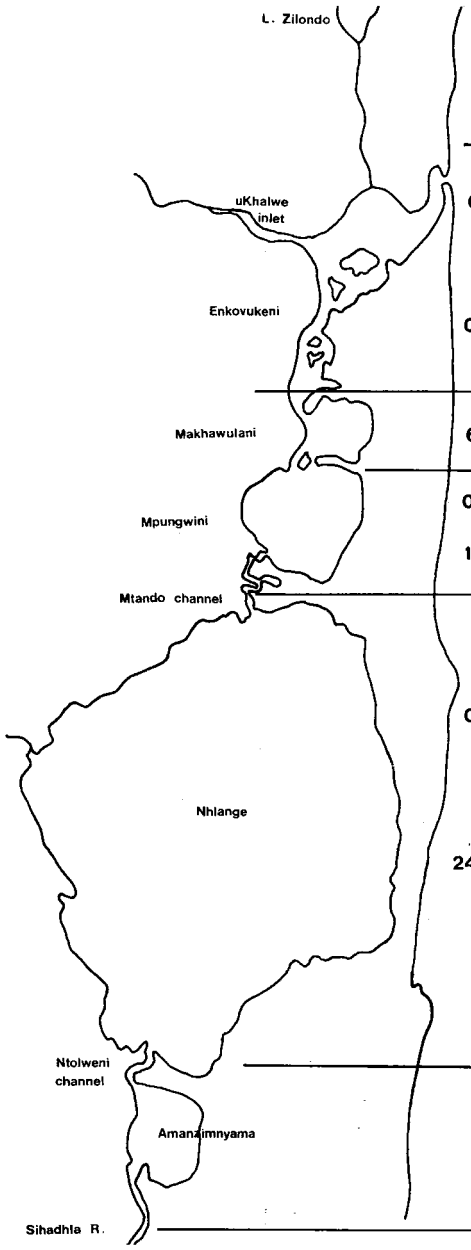
Dissolved oxygen. (See Fig. **6**) Other than the water in the hypolimnion of Lake Mpungwini, the waters of the Kosi system are well oxygenated. In Mpungwini oxygen falls to zero at 9 m — 13 m depending on the season ([4]). This is due to abrupt temperature and salinity layering at this depth. Below the thermocline, the water may be hydrogen sulphide bearing. Such characteristics are regarded as a barrier to juvenile fish and other small organisms in their movements through the system ([170, 323]) and consequently the shallows represent an important migration route ([33]). Very few fish are caught in depths greater than 6 m ([33]).

In Lake Nhlange, dissolved oxygen is found at all depths in the lake ([4, 72]) because the lake is not stratified and because circulation is effective throughout. This situation changed after the 1966 floods when oxygen saturation near the bottom fell to 18% (1,4 mg dissolved

Table 1. Salinity characteristics (in ‰) of the Kosi system.

Reference		(53)	(37)				(263)	(264)	(75)	(159)	(253)	Remarks
Date		Jul 1949	Jul 1965	Jan 1966	Jan 1967	Jul 1967	Aug 1967	Jan 1968	Jan 1970	Aug 1971	Aug 1976	
Enkovugeni		10.0 to 33.0							21.0	33.8 to 35.2	(low tide) 8.4 - 15.8 (high tide) 22 - 35	Salinities can drop to remarkably low levels during low tide periods (8.4°/oo).
uKhalwe inlet										24.8 to 27.8		
Makhawulani	Surface	7.4 to 8.1					8	19.0	13.0	18.9 to 21.5	(low tide) 4.2 (high tide) 13.7	Salinity stratified. Surface range 4.2°/oo to 21.5°/oo.
	Bottom (6m)	18.3								25.7		Bottom range 18.3°/oo to 25.7°/oo.
Mpungwini	Surface	6.6		4.8	11.6	4.2	4.0 to 5.5	12.0	7.0	13.1	(low tide) 0.8 (high tide) 2.5	Salinity stratified. Surface range 0.8°/oo to 13.1°/oo.
	Bottom (16m)	7.6		13.8	13.2	13.8				27		Bottom range 7.6°/oo to 27.0°/oo.
Nhlange	Surface	3.3	4.9	4.2	3.8	3.0	1.5 to 2.5	2.5		5.0 to 5.6	0.9	No discernible effect in January 1966 from Cyclone Claude. Unstratified. Range 0.9°/oo to 5.6°/oo.
	Bottom (24-30m)	3.5	4.9	4.3	3.9	3.0				5.3		
Amanzimnyama							0	0		1.0		Fresh water

Fig. 6. Water analyses from the Kosi system in August 1971 ([159]).



DEPTH	pH	D.O. mg/l	D.O. % Sat.	O.A. mg/l	µg/l Kjeld. N.	µg/l NH_3-N	µg/l NO_3-N	µg/l Total P	Si mg/l	Productivity rate mg C/m^3/day	REMARKS
0.3	8.2	7.5	104	0.1	85	94	0.3	12	58	13.2 — 14.4	Mixing mechanism - tide. (reduced mixing in uKhalwe inlet leads to percentage saturation falling to 50-61%, and hydrogen sulphide generation in the sediments. Primary production rises to 72.4mg carbon/m^3/day).
0.5	8.1	7.0	93	0.6	159	98	15	16	700		
6.0	8.1	6.3	80	1.6	251	147	39	9	1870	6.3	Chemocline at 3m
0.2	8.0	8.0	93	2.7	237	146	9	9	4550	7.2 — 9.9	Chemocline at 8m-12m. Total nitrogen increases dramatically with depth.
16	7.2	0	0	10.5	1825	>300	0	118	8870		
0.2	8.4	8.7	95	10.0	507	158	0	19	5250	24.3 — 62.4	Relatively high oxygen absorbed values. Mixing mechanism - wind. Unstratified - chemical quality generally similar at all stations and at all depths. Virtual absence of nitrate. Total nitrogen 50-100% higher than Mpungwini and Makhawulani. Classified at "moderately eutrophic" by Hemens and "mesotrophic" by Boltt.
24	8.3	8.3	91	5.0	592	174	0	9	5410		
	8.3	9.2	102	10.6	610	98	2	14	10,150		High oxygen demand.

Key:

pH = Hydrogen ion concentration
DO = Dissolved oxygen
OA = Oxygen absorbed
Kjeld. N. = Kjeldahl nitrogen
$NH_3 - N$ = Ammonia
$NO_3 - N$ = Nitrate
Total P. = Total phosphorus
Si = Silica

oxygen/litre) due to oxidation of the influx of allocthonous organic material ([4]). It has been suggested that if the bottom materials in Lake Mpungwini become greatly disturbed, the whole lake could become temporarily anoxic ([159, 170]).

Nutrient availability. (See Fig. 6). In general terms nutrient levels are low and no abnormal nutrient additions occur which affect the system adversely. However, a substantial reservoir of nutrients lies on the bottom of the system in the form of organic detritus ([33]).

Nitrogen: In the Kosi system the recycling of nitrogen is assisted by the anaerobic reduction of organic nitrogen in the deep, organically rich areas of the system. Consequently the proportion of ammonia is substantial and some 50% higher than normal ([159]). Because of incorporation into biologicial materials and low volume interchanges (through Mtando channel) the total nitrogen concentration in Lake Nhlange is 50 — 100% higher than that in Lakes Mpungwini/Makhawulani. An inexplicable phenomenon is the virtual absence of nitrate in Lake Nhlange.

Phosphorus: With nitrogen:phosphorus ratios of 50:1 the concentrations of phosphorus in the system are considered as limiting or inadequate ([159]).

Pollution:

Heavy metals. In August 1976 low levels of heavy metals were encountered throughout the estuary ([253]).

Pesticide residues. One of the most serious problems in Kosi relates to the fact that DDT (DDE and TDE) is apparent in the sediments of Lakes Mpungwini and Makhawulani; and present in fish tissues in relatively high levels (maximum: 860 µg DDT/kg of liver in *Mugil cephalus*) ([253]).

The malaria control (spraying operations) of the State Department of Health are clearly responsible. Hooey and Botha (pers. comm.) say that all spraying is done inside huts (aimed at controlling the adult mosquito) from which no run-off occurs. During the course of spraying 43 707 huts in the attack area in 1976, 15,75 tonnes of DDT were applied (Botha, pers. comm.). Of this amount some 0,75 to 1 ton of DDT is applied annually inside the ±2 000 huts, within the Kosi catchment. However, the principal manner in which DDT appears to be entering the system seems to be related to the habit of re-filling/washing out the 800 litre water trailers in the nearest stream or lake (Bruton and Jackson pers. comm.).

The spraying of tsetse fly in the area has long since ceased, and the dipping of the large herds of native cattle around the Kosi system ([300]) (in toxaphene) is also not considered to present any particular pollution threat to the system.

Public health aspects

Bacteriology. The only information on the bacteriology of the Kosi system became available in August 1976 after a NIWR survey ([253]). The results showed a marked absence of any significant faecal contamination. Total coliforms of 0 — 24/100 mls and the presence of *Proteus/Pseudomonas* spp. was normal and typical of terrigenous run-off. The Kosi results are strikingly different to so many of Natal's other estuaries in this respect.

With organic detritus acting as a reservoir of nutrient on the bottom of the Kosi system, the bacteriological processes involved in the decomposition thereof would lead to a better understanding of the system at some future date.

Bilharzia. The prevalence of bilharzia in the catchment is mentioned by Campbell ([71]), and both *Bulinus africanus* and *Biomphalaria pfeifferi* were taken from the Sihadhla river in 1971, amongst marginal vegetation, by Hemens *et al* ([159]). Consequently, with the presence of vector snail species and a large African population in the area, bilharzia is likely to be encountered in the catchment and certain parts of the Kosi system. Transmission of bilharzia north of the Mtando channel is, however, remote, because of the saline condition of that part of the system.

Malaria. Malaria is endemic in Tongaland ([71]) and the Kosi catchment is within the State Department of Health's attack area, in which the spraying of huts (adult mosquito control) is practised annually, during September to November (see also under pesticide residues).

BIOTIC CHARACTERISTICS

Flora

The most informative and detailed account available on the flora of the Kosi system (in 1958) is that presented by Tinley (300). Descriptions of the plant communities in and around the water's edge are given, as well as on the better drained, higher elevated areas which surround the estuary. Bearing in mind the changes over the last twenty years, and with the use of aerial photographs, an interpretation of these notes has been attempted in Fig. 7, by the diagrammatic representation of the principal floral communities in the immediate vicinity of the estuary. Vitally important to the estuary are the swamp forest, the marsh and the mangal communities (the word mangal being coined by MacNae (218).

Swamp forest. The swamp forest community is the forest cover alongside streams, marshes and in certain places the edges of the Kosi lakes. A characteristic feature of the swamp forest is the predominance of ferns as a ground cover, and conspicuous climbers (such as *Stenoclaena tenuifolia*). In wetter situations, stagnant, smelly water lies on the floor of the forest. The most common swamp forest canopy trees are the Umdoni, *Syzgium cordatum* (attaining 15 m in height) and *Ficus hippopotami*. The palm, *Raphia australis* (*R. farinifera*) (305) makes up part of the swamp forest west of Lake Amanzimnyama.

When referring to Kosi very few people omit to associate this estuary with its *Raphia* palms. These trees have an outstanding reputation as being the largest concentration of this species in South Africa. They have been used by the natives for, amongst other things, the construction of ferries with which they cross the river. In the Nkanini swamp forest the rare orchid *Platylepis australis* is abundant, and in the Nswamanzi swamp forest, the rare climber *Tiliacora funifera* is present (305).

Marshes, sedge and aquatic communities. Amongst the marshes and sedges which surround the estuary or are marginal emergent elements of the flora — *Phragmites australis*, *Cladium* and the fern *Achrostichum aureum* are dominant. *Scirpus littoralis, Cyperus papyrus* and *Juncus kraussi* are also conspicuous.

Various semi-emergent plants, especially water-lilies (*Nymphaea* sp.), are common along the edges of the system. The presence of submerged species of aquatic plants in deeper water is not striking — but *Potamogeton pectinatus* occurs at 2 m — 3 m in the margins of the more saline lakes in a stunted form (37), as a result of the nutrient deficient sandy substrate. *Ceratophyllum* and *Najas* also occur.

Mangal communities. (i.e. a littoral plant community below the high water mark, growing in waterlogged soils).

(a) **Mangrove association.** The mangrove community of the Kosi system comprises five species (300, 305), two of which (*Ceriops tagal* and *Lumnitzera racemosa*) are at the southernmost limit of their distribution, which means that Kosi is the only place in Natal where they grow. Of the two, *Lumnitzera* is the more common. The Kosi mangroves occupy some 32 ha (91) and are threatened by the natives who cut them down to make the guide fences for their fish traps (231, 300). Although regarded as an "outstanding development of mangrove forest" by Vahrmeijer (305), the Kosi mangrove community is stunted and unimpressive, largely as a result of the unsuitable substrate (silt free rivers and podsolized sands in the catchment). A detailed study of the mangrove community was undertaken in 1966 by Breen and Hill (51), to assess the effects of a 1,6 m to 2 m rise in lake level. Although reported to be regenerating well (91), the effects of the mass mortality described are still apparent today, some 10 years later, and photos of the mangroves in 1949 (53) contrast very markedly with the same scene today.

(b) **Barringtonia/Hibiscus association.** Of equal, if not of more, importance to the Kosi system is a *Barringtonia/Hibiscus* association which is very common on the water's edge and often interspersed amongst mangroves. Here these trees fulfill much the same ecological role as the five species of mangroves already mentioned, in terms of bank stabilization, habitat and the input of detritus.

Near to the estuary, and growing under saline conditions, is the rare tropical shrub, *Caesalpina bonduc* (305).

Coastal dune forests. Dominant species include *Euclea*, *Strelitzia* and *Mimusops*, and in places the cycad, *Encephalartos ferox* occurs.

One of the major problems in the Kosi area appears to be the destruction of the coastal

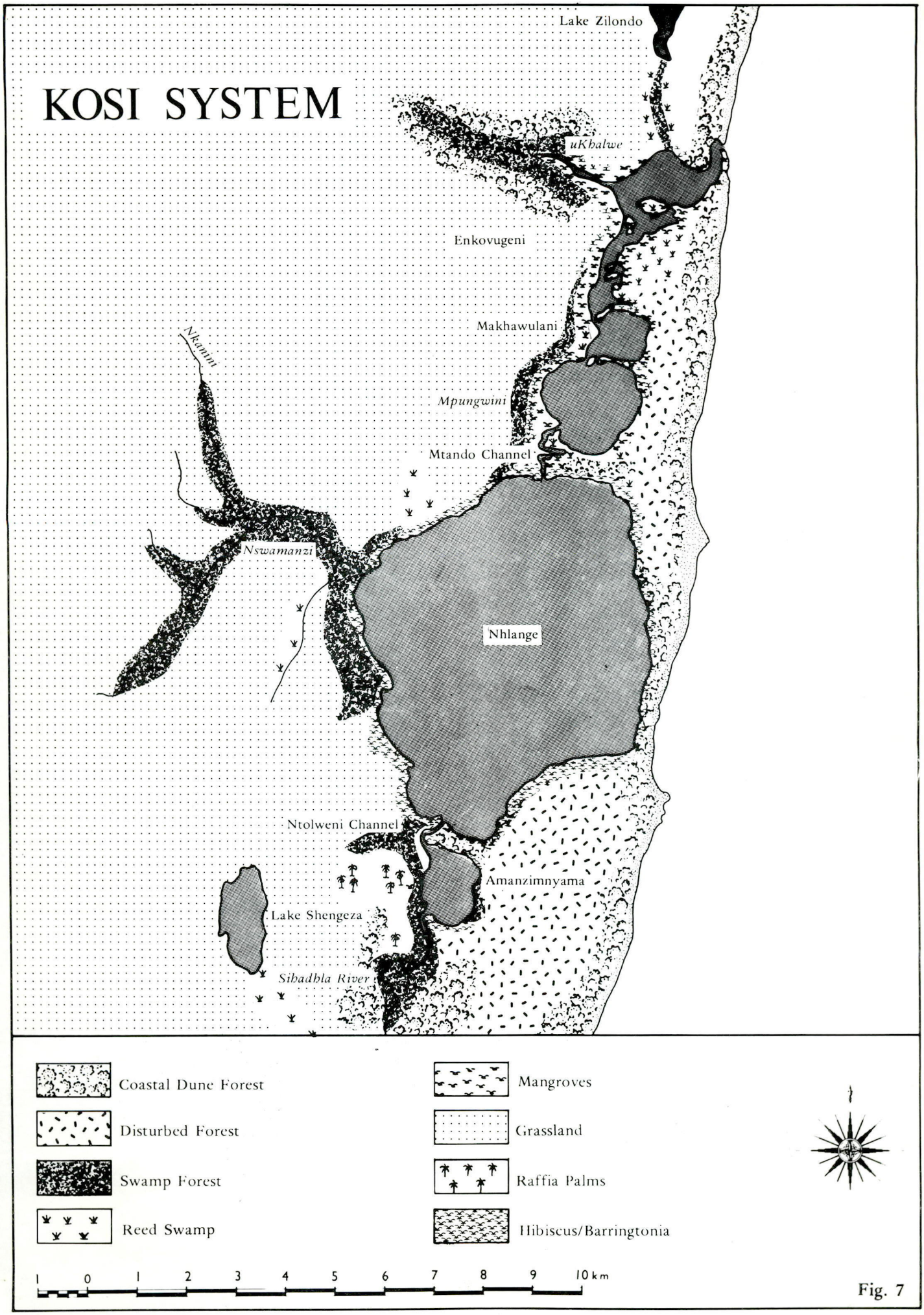

KOSI SYSTEM
Lake Zilondo
uKhalwe
Enkovugeni
Makhawulani
Nkanini
Mpungwini
Mtando Channel
Nswamanzi
Nhlange
Ntolweni Channel
Amanzimnyama
Lake Shengeza
Sihadhla River
Coastal Dune Forest
Disturbed Forest
Swamp Forest
Reed Swamp
Mangroves
Grassland
Raffia Palms
Hibiscus/Barringtonia
1 0 1 2 3 4 5 6 7 8 9 10 km

Fig. 7

dune forest communities alongside the system — particularly on the eastern side of the estuary ([70], [323]). This situation has arisen as a result of the "slash and burn" method of cultivation which is practised by the natives. This technique appears to be not only wasteful and destructive, but also unrewarding, because the sandy soils which the natives cultivate are unproductive. In places the destruction of the natural forests has come down to the water's edge, and where on steep slopes, is leading to erosion.

Recent aerial photography by Scogings (May 1976) clearly reveals the extent of this problem, and shows how much of the formerly forested surrounds have been reduced to natives' fields, with the occasional lone woodland tree.

Grassland/Open woodland/Palm communities. The undulating grasslands on the west of the Kosi system are made up principally of *Urelytrum*. Amongst this are palm patches of *Phoenix reclinata* (date palm) and *Hyphaene natalensis* (Ilala palm). Woodland vegetation predominantly comprises the Umdoni (*Syzygium*), *Trichilia*, *Albizia* sp. and *Dialium* ([300]).

Algae. In September, 1977 blooms of the filamentous algae *Enteromorpha* were noticeable, particularly in the tidal basin. On this occasion the guide fences of the fish traps provided the most suitable substrate on which this alga grew.

The commonest planktonic algae in the Kosi system is *Microcystis*, being particularly noticeable in the uKhalwe inlet. These algae were principally responsible for the various rates of inorganic carbon assimilation (primary production) which were measured in the surface waters of the Kosi system, in August 1971 ([159]) (see Fig. 6).

On the Uguma rocks in the estuary mouth, a marine flowering plant *Thalassadendron ciliatum* (formerly *Cymadocea ciliata*) which looks like seaweed, has been collected by Ward ([334]) and Vahrmeijer ([305]).

Fauna

Campbell described the Kosi estuary as "the most wonderful aquarium and gorgeous aviary" ([70]). This is borne out by the 173 animal species (excluding birds and incorrectly stated as 232 species in ([170])) recorded by Broekhuysen & Taylor in the estuary in 1949 ([53]). The estuary mouth was the richest area in this respect, and in general, the system is inhabited by a fauna more typical of tropical areas to the north ([180]).

Lower trophic levels.

Zooplankton: The earliest plankton samples from the Kosi system (taken at night) were taken in 1947/48 ([70]). In 1970 the Port Elizabeth Museum conducted a survey of the zooplankton in Kosi ([75]), the results of which are not yet available. Thus the conclusions drawn have not been included in this report. In August 1971 quantitative zooplankton tows were made by Hemens *et al* ([159]). Marine forms of zooplankton occurred in the tidal basin and these forms extended into Lake Mpungwini at salinities of 12‰ to 21‰. The zooplankton density was found to be highest on the eastern shores of Lake Makhawulani, where the residence time of the water is thought to be maximal. This was confirmed in 1976, when the zooplankton of the Kosi system was re-examined ([253]). The maximum number of zooplankters were 3 500 per 50 m haul — made up principally of the copepod *Pseudodiaptomus hessei* ([253]). Although over 50 taxa were present, settled volumes were less than 1,0 ml/50 m haul throughout the system. This sparseness of zooplankton (in terms of biomass) is to be expected in a nutrient poor system such as Kosi.

Benthos: Broekhuysen & Taylor ([53]) provide some of the earliest information on the benthos of the Kosi system. In comparing the results of their work to that of others such as Tinley ([300]) (in 1958), Boltt and Allanson ([37]) (in 1965 to 1969) and Hemens *et al* ([159]) (in 1971) the difference in the number of mollusc species present is perhaps the most striking. While there were 37 mollusc species present in 1949 ([53]), only three species have been reported since 1965 ([37], [159]). Consequently one begins to understand why some people regard the system as impoverished and others as rich; however, why such a difference should have resulted is more difficult to explain. Such changes could be reflective of an effect of the brief water level rise in 1966, or an effect of DDT accumulation. However the mollusc *Musculus virgiliae* (a lamellibranch) absent prior to 1960 ([53], [300]) is now present ([37], [159]) in vast numbers.

Boltt and Allanson ([37]) carried out benthic surveys in Lake Nhlange at six monthly intervals (from July 1965 to January 1969), in conjunction with some scuba investigations. A partial check list of the fauna was drawn up, as well as information on the distribution of the more common animals. The numerical density of benthic animals generally fell to zero below a depth of 15 m, especially if samples tended to be muddy. This was

exemplified by the presence of some benthic animals in winter on the sandy bottomed "northern trench" of Lake Nhlange (30 m deep) but the constant lack of any benthic animals on the "eastern mud plain" (15 m — 20 m deep) ([37]). During the flood period of 1965/66 the unusually large influx of detritus was considered to have forced the benthic fauna to retreat into shallower water. Where a layer of fine silt overlies sand, microscopic life such as protozoa and very small crustacea, is rich.

In 1971, 30 species of bottom dwelling organisms were recorded from the system ([159]). When the diversity and abundance of the benthic fauna (including the meiofauna) was re-evaluated in 1976 ([253]), sparse populations on the anoxic bottom of Lakes Mpungwini and Makhawulani were confirmed. However the benthic population was surprisingly diverse (30 taxa) and numerically rich elsewhere. For example 10 625 organisms were recorded in 4 litres of sediment from the Enkovugeni area, despite the nutrient deficient sands and the instability of these sands due to currents.

Callianassa (the sand prawn) while mentioned as present in ([253]) and said to be abundant in ([53]), is most conspicuous in the tidal basin (or lower reaches) of the Kosi system.

Epifauna/Fauna from marginal vegetation: In 1971 28 species of animals were located by Hemens *et al* ([159]) amongst the marginal vegetation in the Mtando channel and in the margins of Lake Nhlange. Amongst the dominants was *Musculus virgiliae*, and detritus feeding crustaceans (amphipods, isopods and tanaids). In this habitat, the crab *Rhynchoplax bovis* was also commonly encountered ([53, 159]).

Prawns: The fact that the Kosi system is well-known for its paucity of penaeid prawns ([75]) is indicative of the basic silt free, nutrient deficient condition of the Kosi substrates. Confirmation of this is the fact that juveniles of *Penaeus japonicus* were taken in the zooplankton in 1976 ([253]) from Lake Makhawulani. This result is not unexpected as this species prefers clean, sandy beaches as a habitat (de Freitas pers. comm.).

Thus the statement "both *P. indicus* and *P. monodon* occur naturally in the area" ([8]) is considered as incorrect. A great controversy subsequently arose in 1971 over the suggestion that a prawn farm be established within the Kosi system ([8, 9, 75,]). The proposals were to add organic fertilizer to the water (to increase plankton production); to establish breeding tanks and to erect fences across various parts of the system (to exclude predators). For various reasons (depth, dissolved oxygen, salinity, floods) ([9, 75]), the scheme was not considered to be feasible.

Insect life: A wide variety of insects inhabit the Kosi system, some of which are important elements of the benthos (e.g. *Clinotanypus*, *Chironomus*) ([37]). Others, such as the weaver or tailor ant (*Oecophyllum*) are common in the mangroves ([71, 300]), and from the collections of Pennington in 1947/48 a particular species of butterfly (a skipper) is regarded as endemic to Kosi ([71]).

Higher trophic levels.

Fish: The list of fishes compiled by the Oceanographic Research Institute ([180]), represents the findings of various expeditions by several organizations, to the Kosi system ([53, 69, 72, 263, 264, 300, 332, 265]). The most recent investigations have been those of Blaber ([33]). The Kosi estuary is considered to fulfill an important nursery function and it is said that "many thousands" of juvenile fish mature here before migrating back to the sea ([170, 180, 332]).

Amongst the angling fraternity, Kosi is best known for its queen fish (*Scomberoides*), barracuda (*Sphyraena*) and grunter (*Pomadasys*).

The latest results available have shown 133 species of fish to occur within the Kosi system ([33]). These compromise:

85 marine species which are found in association with the reef at the mouth, or penetrate the tidal basin;

39 resident estuarine species which penetrate the system to beyond the tidal basin, and

9 freshwater species.

Mammals: Dominant amongst the mammals of the Kosi system are the hippo, the numbers of which have increased from 19 in 1958 ([300]) to 31 today (Jackson, pers. comm.). These

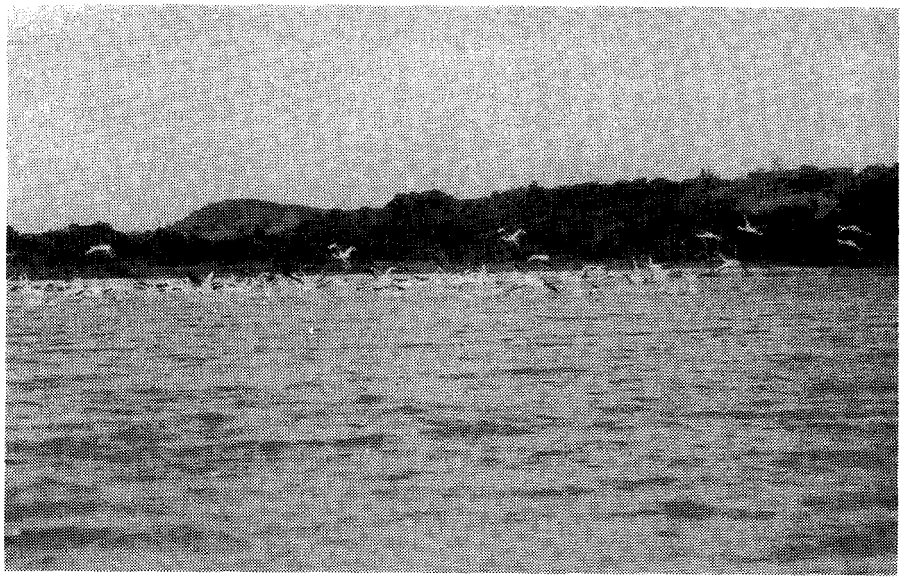
are concentrated mainly in Lake Amanzimnyama, in the south of the system ([33]). Only two hippo occur regularly in the estuary (*sensu stricto*) i.e. north of the Mtando Channel ([300]).

Of the remaining 25 mammal species around Kosi listed by Tinley ([300]) and Bruton ([61]), only the water mongoose is estuary associated.

Birds: The earliest records of birdlife (1947/48) were drawn up by Garland & Lawson ([71]) and Broekhuysen & Taylor ([53]).

The prolific birdlife of the Kosi system is essentially forest associated. Thus from the list of 247 species shown to be present by Tinley in 1958 ([300]), only ±85 are water or estuary associated. However, four species which were recorded as present in 1949 by Broekhuysen & Taylor ([53]), were not recorded as present by Tinley ([300]). These included species to be expected in such a habitat, such as Water Dikkop and three-banded Sandplover. Also noteworthy is the fact that Tinley never recorded pelicans as present, yet these birds were present in 1947/48 ([70, 71]) and said to be common by Cooper ([94]).

Amongst the water/estuary associated species some are rare — notably the Flufftail, White-backed Night Heron and the Crab Plover. Several of the bird species of the Kosi system, are also at the most southerly limits of their distribution ([94]) and not encountered elsewhere in South Africa. Although the avifauna is diverse, largely as a result of the undisturbed condition of the marginal vegetation along the water's edge, no single species is outstanding in terms of its abundance. This is possibly another result of a diverse habitat and one in which the overall nutrient status is low.



The occurrence of flamingoes on the eastern shores of Lake Makhawulani may relate to the generally higher plankton productivity reported from this locality.

Reptiles and Amphibia: Crocodiles are uncommon in the Kosi system ([300]) and are restricted to the fresh water lakes Zilondo and Amanzimnyama. Several adult specimens (2 m — 3 m) were seen in the Sihadhla river in September 1977 (pers. obs.)

Further information on the reptiles and amphibia of the Kosi system is available from Bruton (pers. comm.) who, amongst other things, has recorded three species of semi-aquatic snakes to be present.

Mention of the turtles of the Kosi area cannot be avoided although unrelated to the estuary (*sensu stricto*). Five species of turtles occur along the adjoining coastline, the commonest being the leatherback and loggerhead (Hughes, pers. comm.). The beaches of Tongaland are regarded as the only undisturbed nesting area for turtles in South Africa.

SYNTHESIS

In general, our state of knowledge of the Kosi system is good. The most pressing area of research which requires attention is that which may throw light upon matters relating to physical management of the system. Hydrological studies and straight-forward data collection should enable workers to construct a physical model of the Kosi system. This would enable an assessment to be made of the effect that fish traps are having on sanding up in the tidal basin,

whether disused guide fences should be removed and whether the channel between the traps should be made narrower.

The present day environmental condition of the Kosi system can be regarded as highly satisfactory. The estuary can be rated foremost amongst Natal's estuaries in terms of its conservation potential. It should thus be regarded as one system in Natal that should, without doubt, be preserved. This is mainly because of its present day potential as a natural resource. The Kosi system has no counterpart in Natal — and, in its relatively undisturbed state, maintains a diverse, and in many cases unique, flora and fauna.

The system is not without problems. These are:

(i) "Slash and burn" cultivation (forest destruction),
(ii) DDT pollution,
(iii) gradual sanding up of tidal basin,
(iv) bank erosion from the passage of boats through the Mtando channel.

Consequently research directed towards finding solutions to any of these problems should be encouraged. With respect to DDT pollution for example, it might be beneficial to examine the effectiveness of DDT on the mosquito population in the "attack area". DDT was banned in the mid-1950's in the United States of America partly because it was found that the strains of mosquitos being "controlled" had developed a genetic immunity to the compound ([83]).

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC											
			Physiography		Physics			Geomorphology			Chemistry					Other									Flora	Fauna										Food Webs
KOSI			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids					★					★				★				★																	
Source of Information	Summary of available information																																		
Broekhuysen & Taylor	1947	53		•		•					•											•		•		•	•	•						
Campbell & Allanson	1947	69																										•							
Campbell	1948	70,71	review																																
Day	1951	119				•	•																												
Tinley	1958	300	•	•		•		•											•	•		•		•			•	•	•	•	•				
Ward	1962	334																				•													
Boltt & Allanson	1965	37		•		•	•			•	•													•			•								
Allanson & van Wyk	1965	4		•		•	•				•																								
Hill	1965	183		•	•			•																											
Breen & Hill	1966	51			•	•																•													
Vahrmeijer	1966	305																				•		•											
Pike	1967	263,264 265				•																					•								
MacNae	1968	218																				•													
Cooper	1968	91																				•													
Tinley	1969	296																	•	•							•								
Orme	1971	256,257		•	•			•		•														•											
Champion	1971	75				•	•										•									•								
Anon	1971	8															•		•																
Moll *et al*	1971	231																				•													
Hemens *et al*	1971	159		•				•			•												•		•	•	•								
Anon	1971	9																	•																
Cloete & Oliff	1971	85	Summary of Hemens et al (159)																																
Wallace *et al*	1971	332																										•							
Heydorn	1972	170	review																																
Heydorn & Wallace	1972	180																	•	•								•							
Wager	1972	323	•		•														•	•				•					•	•	•				
Blaber	1975 to 1977	33		•		•	•			•	•																	•		•					
Oliff *et al*	1976	255								•	•		•	•	•										•		•								
Cooper	1976	94																												•					
Bruton	1976	59			•		•									•																			
Moll	1978	230								•						•				•															
Bruton	1978	61																																	
Aerial photos (Scogings)		No.																																	
Scale 1:10 000 Job 250	1976	272-285		•						•												•		•											
1:25 000 Job 251	1976	310-327	•	•						•														•											

2.1.1.2 **MGOBEZELENI**

Introduction

The Mgobezeleni estuary is really a small part of the very much larger and more important Mgobezeleni-Shazibe lake system (see Fig. **8**).

The two lakes Mgobezeleni and Shazibe are connected to the estuary by an extensive *Phragmites* dominated swamp, and have become almost totally separated from the sea. However, the characteristics of the aquatic fauna in both lakes would not be the same were it not for this tiny connection to the sea. Euryhaline fish species such as Tarpon (*Megalops cyprinoides*) occur in both lakes ([62, 133]); and in Lake Mgobezeleni *Eleotris melanosoma* (the dusky sleeper), mullet (*Myxus capensis*) and eels (*Anguilla* sp.) are all present due to this connection ([62]).

However, in keeping with the terms of reference of this report, comment and information gathering has been restricted to the estuary (see Fig. **9**) of the Mgobezeleni-Shazibe system.

Synonyms

Ngobeseleni ([91]); Sodwana or Sordwana ([235]); Lake Mgobezeleni was originally called Lake Johnstone by Coope and Henderson in 1888 ([169, 289]).

Zulu meaning

Mgobezeleni means "the deep lonely place" (Daniel, pers. comm.). Sodwana means "a little one, on its own" from the Zulu word "odwa" ([60]).

Location

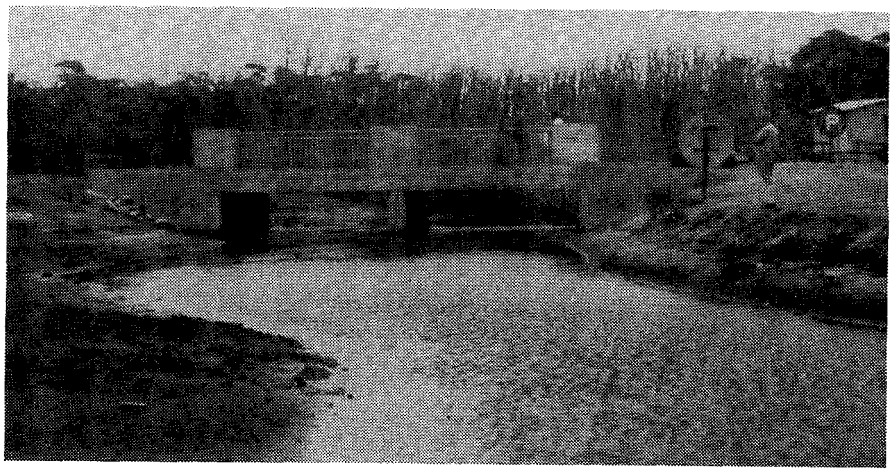
27°32'30"S; 32°40'30"E.

Accessibility

The system lies some 380 km north east of Durban in the district of Ubombo (Zululand). It is approached most directly from Durban via the lower Mkuze road. Mbazwane, the nearest town, is 17 km away. There is an airstrip just outside the Sodwana National Park adjacent to the Mgobezeleni system.

Bridges

A bridge has been built across the estuary 350 m from the mouth. The original bridge (built in two stages (September 1971; May 1972)) ([59, 62]) contained eleven 1 m diameter pipes to carry the flow of the river. This structure raised water levels upstream of the bridge by 50 cm to 80 cm ([57, 62]) and effectively prevented the tides and thus sea water from reaching a mangrove swamp established there. The constantly flooded freshwater conditions ([217]) led to the mortality of the mangroves and their associated fauna alongside the Mgobezeleni estuary ([305]) (see under 'Flora'). Since the construction of the present single span bridge (started in January 1976 ([58]) and completed in March 1977) in which two 2,4 m x 6,5 m culverts were contained a tidal regime upstream of the bridge has been re-established (Daniel, pers. comm.). During the course of construction (whilst a temporary earth causeway was in existence) heavy rainfall caused water levels to rise for a second time, to a maximum height of 175 cm behind the obstruction ([58]).



A photo of the new bridge which was built to reinstate a tidal regime upstream thereof. The dead mangrove community can be seen in the background.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 30 km² to 35 km².

River length. The two streams which enter the system are each ±6 km in length.

Mean annual run-off. No record.

Flow. Data on the fluctuation in river levels for the period November to December 1973 is available from Daniel (Natal Parks Board). Bruton refers to "fairly strong seasonal flow of underground and surface water into the lake and stream . . .", ([59]) and a guage plate was therefore temporarily installed during 1975, the recordings from which have been retained by Bruton (Daniel, pers. comm.).

Flood history. Flood discharge figures are unknown.

Level fluctuations. Measurements of tidal fluctuations in water level were made by Bruton between September 1973 and March 1974 ([59]). In addition, water level fluctuations in the mangrove swamp above the bridge during the periods September 1971 to May 1972 and January 1976 to June 1976 are available ([58]).

Dams. (Existing or proposed) — nil.

Siltation. No data is available, but siltation in the estuary is probably minimal because of seepage through the extensive swamps above the estuary. However, it has been suggested that the lake, acting as a sediment trap, has silted up ([59]). Indeed Orme ([256]) considers the surface of Lake Mgobezeleni to have decreased by 92,6% (from 40 km² to 3 km²) during Holocene times through infilling and reedswamp encroachment.

Land ownership/use. To the south of the system is the Sodwana National Park — one of the most popular venues on the Natal coast. In 1971, 17 435 people were accommodated in the camp ([235]) 76% of which were from the Transvaal. More recent figures suggest 25 000 people visit the park annually ([60]). Its popularity relates to the angling potential for ski-boat owners and diving on the offshore coral reefs. The park is 410 ha in extent and was proclaimed in 1950 ([60, 235]). To the north of the system is a Bantu Reserve (No. 14) destined to become incorporated into KwaZulu, and to the west is State Land (Forestry).

Local authority. "A tangle of who controls what" ([60]) but theoretically the Department of Agriculture and Forestry (KwaZulu).

Estuary uses. The estuary is not used for any specific purpose, but children occasionally bathe in it, and people wash off diving equipment and boat engines which have just come in from the sea. There was an old pumphouse at the head of the estuary, but the lake now supplies water to the Sodwana Park campsite. The estuary was surveyed as a harbour site in 1888 ([169, 302]) and with the vast number of skiboats presently launching from Sodwana each year, the need to create some small craft harbour facility at Sodwana may well arise (Zwamborn, pers. comm.).

Morphometry of the estuary (see Fig. 9).

Area. 1,3 ha.

Axial length. 750 m.

Shoreline length. 1,5 km.

Width.
Maximum: 25 m.
Mouth: varies considerably according to tide and season.
Floodplain: 300 m wide above the estuary.

Bathymetry. At low tide, the average depth is 30 cm ([59]). The maximum depth is 2 m.

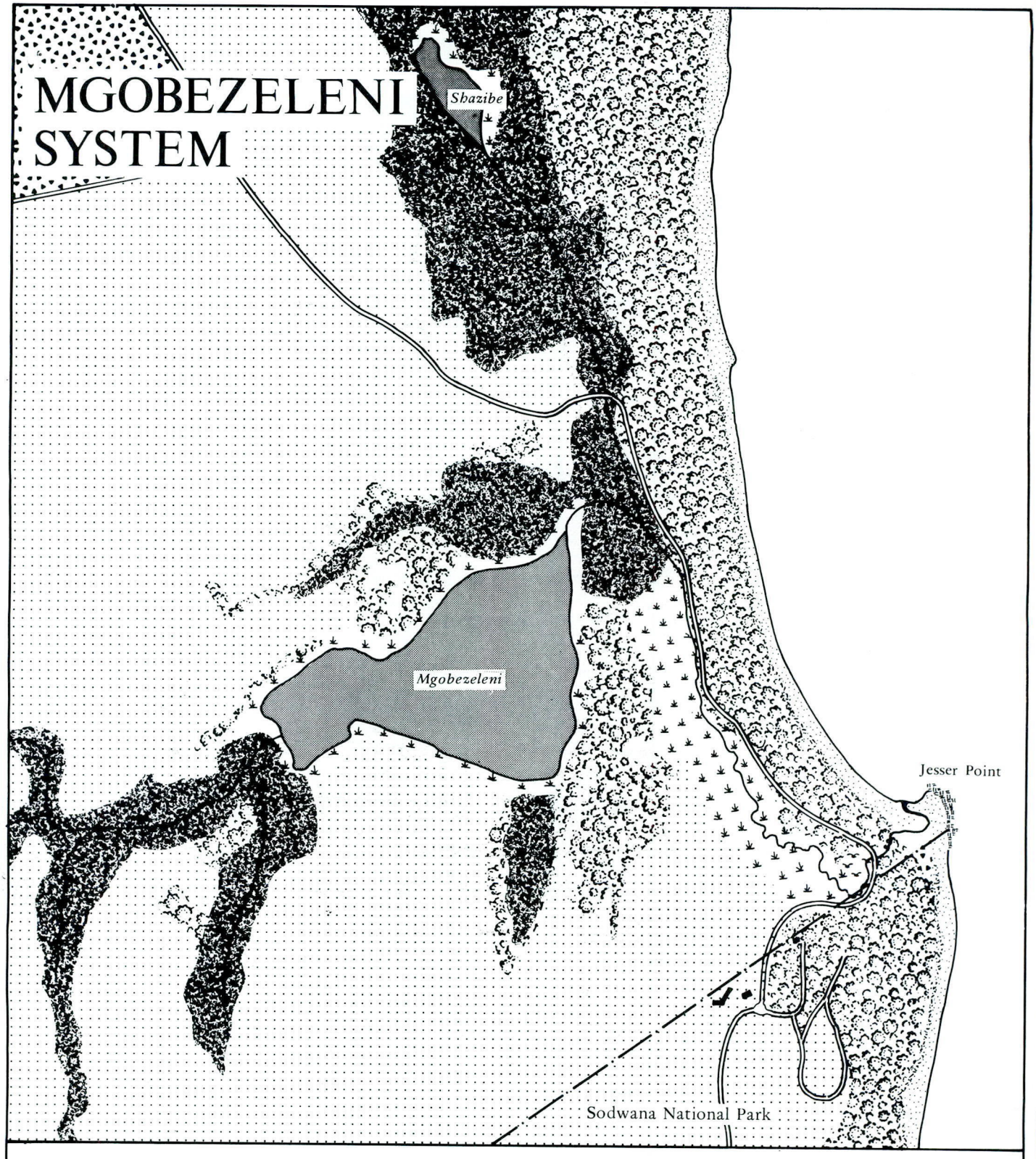

MGOBEZELENI SYSTEM
Shazibe
Mgobezeleni
Jesser Point
Sodwana National Park
Coastal Dune Forest
Coastal Dune Pioneer
Exotic Plantations
Swamp Forest
Reed Swamp
Mangroves
Ilala Palm, Grassland and Umdoni Parkland
500 0 500 1000 1500 2000 metres

Fig. 8

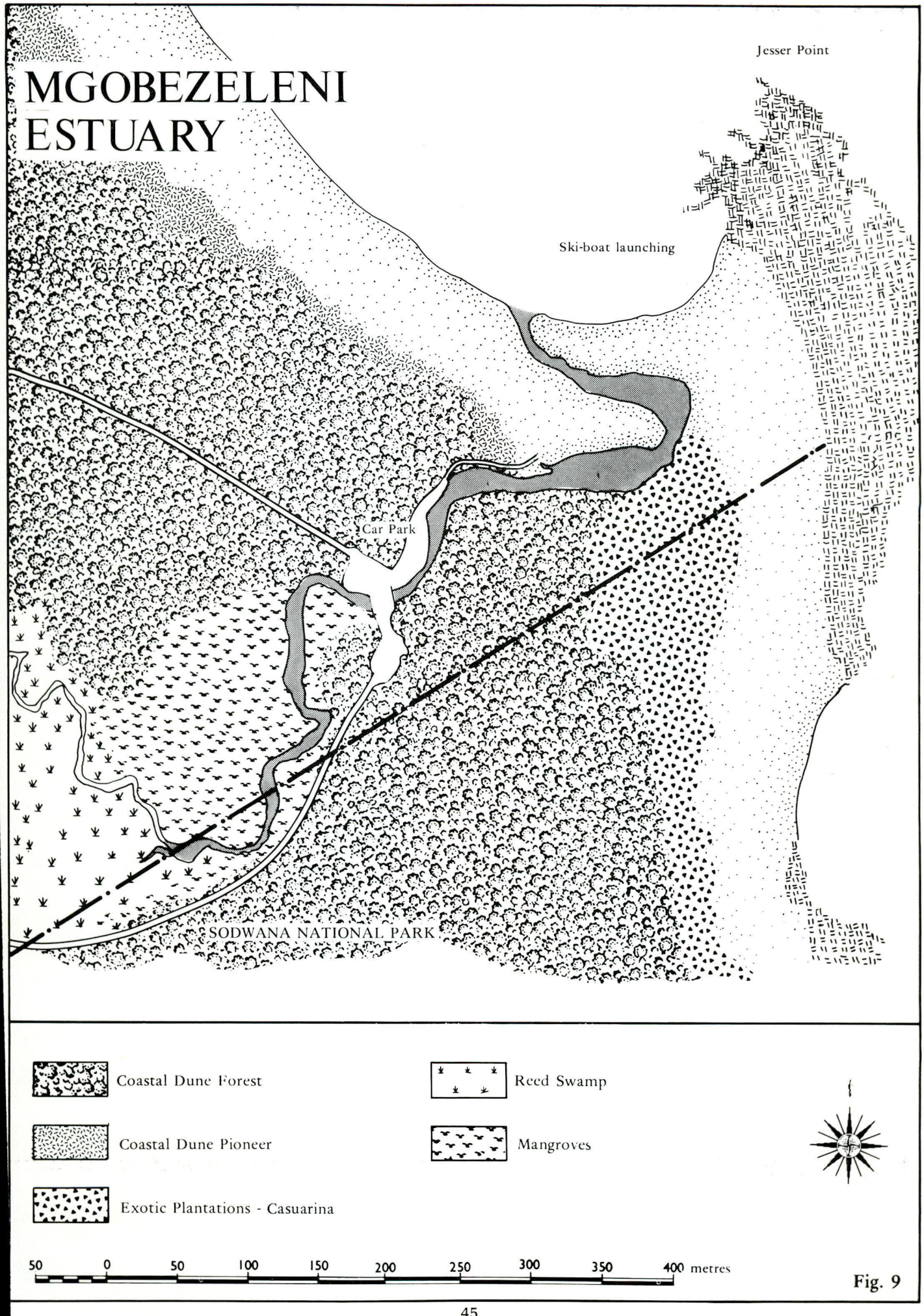
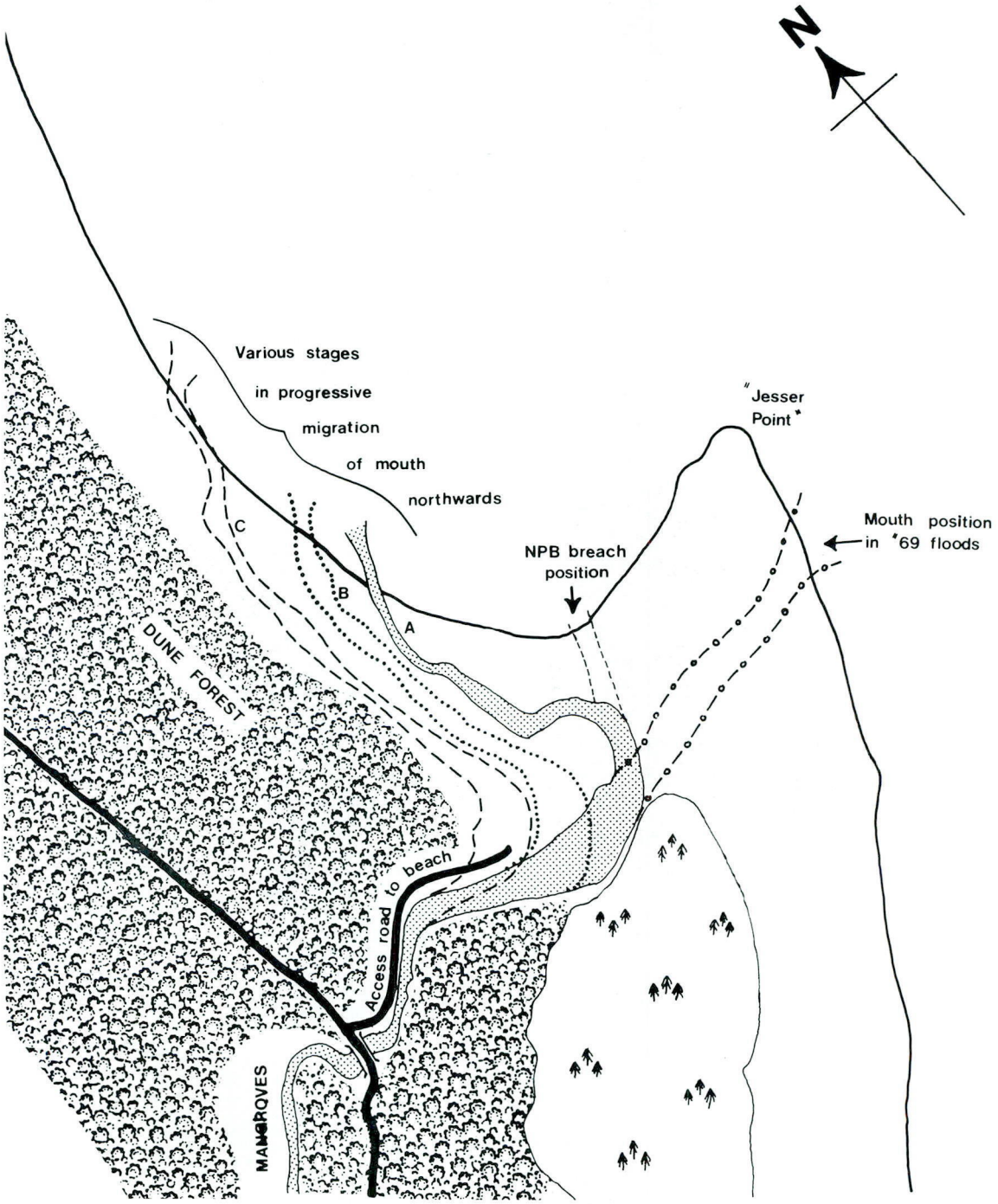

MGOBEZELENI
ESTUARY
Jesser Point
Ski-boat launching
Car Park
SODWANA NATIONAL PARK
Coastal Dune Forest
Coastal Dune Pioneer
Exotic Plantations - Casuarina
Reed Swamp
Mangroves
50 0 50 100 150 200 250 300 350 400 metres

Fig. 9

Geomorphology.

Geology. ([62, 235]). The system is contained within relatively recent deposits on the Natal ([235]) or Mozambique ([59]) coastal plain. These deposits comprise sandy to gravelly soils. No detailed geological surveys have been done — however, shales, sandstones and limestone (of cretaceous origin) are considered to underlie the coastal plain. The rocks which comprise Jesser Point are calcareous sandstone (du Preez, pers. comm.)

Fig. 10: Variation of mouth position — Mgobezeleni estuary.



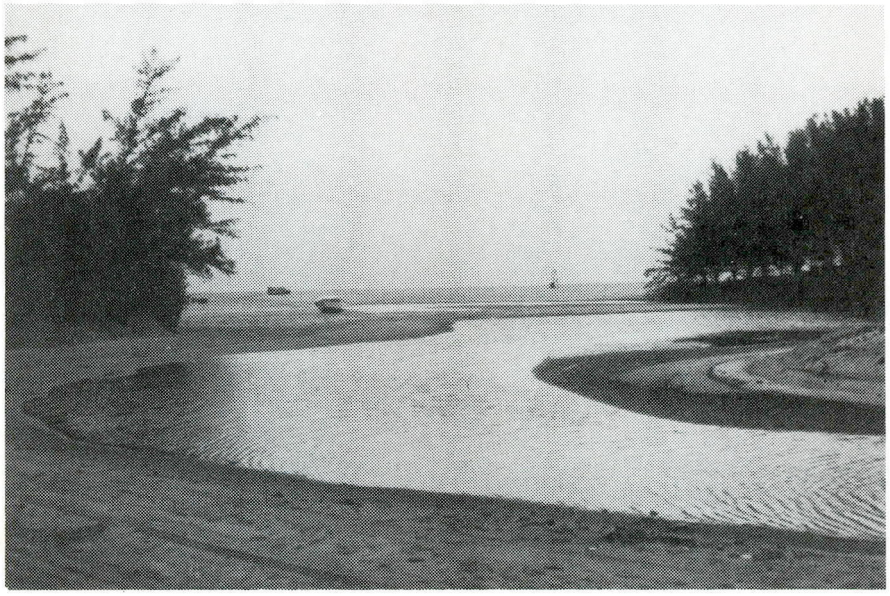
Nature of bottom materials. Apart from the rocks which form part of the bridge across the estuary, substrates comprise barren sand. Prior to bridge construction, the estuary floor was densely covered with decaying detritus, emanating from the mangrove and reed swamp areas above the estuary ([62]). This situation seems to be re-instating itself (pers. obs. September 1977).

Sandbar characteristics. The Mgobezeleni sandbar is very clearly north extending and may at times be up to 250 m long. The mouth position is variable ([59]), and after the floods in 1969 opened directly across Jesser Point (see Fig. **10**).

The latter is a rocky promontory which shelters the estuary from southerly storms and currents. The estuary channel winds across the beach and enters the sea north of Jesser Point. If permitted to move of its own accord the channel migrates steadily northwards (see Fig. **10**) under the influence of the strong, northward-directed transport of sand. It finally becomes positioned up against the dune forest, and begins to wash away the pioneer dune vegetation (Daniel, pers. comm.). At this stage the Natal Parks Board open a new mouth directly behind Jesser Point and the process begins again.

It is interesting to note that while Bruton ([59]) regarded flows to "contribute to the maintenance of an open estuary", and reports that the mouth is said to close only occasionally (as did Henderson ([169])), Daniel, (pers. comm.) says the estuary mouth closes very frequently — virtually with every spring tide. Orme ([256]) also refers to the outlet being intermittent, as does Jackson (pers. comm.). If permitted to remain closed, the levels in the estuary rise and overtop the access road down to the beach on the northern bank.

Breaching. The Natal Parks Board artificially open the estuary at a point just north of Jesser Point so as to prevent damage to the dune forest. The dune forest becomes damaged either by the estuary itself in its northernmost position or by the public trying to find an alternative way down to the beach if the access road is underwater.



Mgobezeleni estuary — downstream of the bridge.

Configuration of the adjacent shore. No record.

Surf zone currents. A strong, northward flowing inshore counter current ([59]), (Ballard, pers. comm.) is characteristic.

Physico-chemical characteristics

Very little information on this subject is available. However, because the estuary is tidal, marked changes in salinity occur, and temperatures are directly influenced by the sea. Prior to construction of the existing bridge, salinities above this point were reduced to less than 0,3‰ ([59]).

The pH (hydrogen ion concentration) in the estuary is said to be 7,0 and alkalinity 78,1 mg/litre ([59]). The water colour is dark brown — being typical of the humate staining from swamps above the estuary.

Pollution occurs in the form of litter, tin cans, bottles and outboard fuel ([60]).



Waste left behind by visitors to the Sodwana National Park.

Public health aspects.

All sewage (night soil) from the Sodwana National Park campsite is contained in conservancy tanks until transported to the vicinity of the airstrip where the contents are permitted to drain away into the sand. No contamination from this source occurs (Daniel, pers. comm.).

Bacteriology. Whilst no bacteriological studies in the estuary have been conducted, the estuary is considered to be faecally contaminated by Bantu, who collect alongside the banks to sell curios and souvenirs to tourists (Daniel, pers. comm.).

Bilharzia. On 15 March 1977 a survey by Jackson (State Department of Health) showed no snails of any sort as being present in the estuary and no vector species upstream. However, both species of bilharzia snail (*Biomphalaria* and *Physopsis*) were found to be present in the lake and reed swamp above the estuary by Bruton ([62]). This, together with a 60% incidence of bilharzia amongst local natives (District Medical Officer, Mbazwane) suggests that the possibility of transmission in the estuary does exist, especially with the assemblage of Bantu alongside the estuary for the purpose of trading, as already described.

BIOTIC CHARACTERISTICS

The Mgobezeleni system is transitional between the tropical and temperate zones of Natal. Consequently a diverse fauna and flora occur.

Flora

The major elements of the flora surrounding the Mgobezeleni-Shazibe system are depicted in Fig. **8** and that surrounding the estuary in Fig. **9**. On both sides, the lower reaches of the estuary is surrounded by dune forest, although on the south bank *Casuarina* has been planted, to stabilize the sand. The mangroves (*Bruguiera gymnorrhiza*) which occurred above the bridge were famous, largely because of their size (18 m tall) ([217]) and excellent condition ([57]). They played an important part in the fertility and stability of the estuary. Although reported to be secure (in the hands of the Natal Parks Board ([91])) they have suffered the fate of many mangrove communities in Natal — namely mortality by inundation. In this case inundation as a result of bridge construction in 1971/72 and in January 1976. Although regrowth from dormant rootstocks has occurred, the core of the mangrove forest is dead ([62]) and those that have survived include a few large trees, numerous small trees 2 m — 6 m high and plantlings that happened to have been on higher ground. The fern *Acrostichum aureum* is common in the understorey although it too died off during the periods of inundation ([58]). The swamp above the estuary is *Phragmites* dominated and lined by *Ficus tricopoda* and *Hibiscus tiliaceus*. Sedges (*Cyperus* and *Typha*) are common. In 1975 a fire swept through the reed swamp (Daniel, pers. comm.). Since 1972 an invasion of fresh water sedges and reeds has taken place amongst the mangroves and *Cyperus*, *Polygonum* and *Phragmites* were still very evident upstream of the bridge in September 1977 (pers. obs.).

Fauna

Lower trophic levels. Grindley (pers. comm.) took a single sample of zooplankton in 1967 from the estuary, the analysis of which has not yet been undertaken.

During the period 1972 to 1975 seven species of decapod crustacea were present. *Palaemon concinnus* (a prawn) was abundant, *Varuna littorata* (a crab) was common, as well as three species of *Sesarma* (crabs) ([62]). Being an unsuitable habitat for molluscs, only five species were present, the majority being representative of fresh water forms (such as *Melanoides* and *Lymnaea*). By June 1976 no crabs, prawns or molluscs could be found in the estuary ([58]).

Higher trophic levels. Being the only estuary between St. Lucia and Kosi, Bruton regards the Mgobezeleni as being considerably important (despite being 1,3 ha in extent) as a nursery area for marine species which spend part of their life cycle in estuaries ([62]). Reports on the number of fish species to be found in the estuary during the study period 1973 — 1975 have varied from 19 ([60]) to 28 ([58]). Of the 28 species listed, 5 were fresh water species, 11 were various types of mullet and at least 7 were restricted in distribution or rare elsewhere in South Africa. However although a distinct, relatively diverse fish fauna is found, no species were present in large numbers ([60]).

Up to six hippo were resident in the lake until ±1974, but have only made brief appearances since ([58, 61]).

Of the 98 species of birds recorded as present by Daniel (pers. comm.), 30 are water/estuary associated. Bruton ([56]) has details of the 32 species of reptiles present in the area and Pooley additional information on crocodiles from the lake system (a breeding population). The occasional crocodile has been seen in the estuary (Daniel, pers. comm.).

It is hardly surprising that those faunal elements of the Mgobezeleni estuary which were associated with the mangroves and noted as present in 1963 by MacNae ([217]) (e.g. *Periophthalmus* (the mudskipper), *Cerithidea* and *Pyrazus* (mangrove snails) and *Cardiosoma* (a crab)) are no longer present ([62]). Since construction of the new bridge Daniel, (pers. comm.) says there are signs of such species returning and of a gradual recovery of the fauna.

SYNTHESIS

In conclusion our state of knowledge of the Mgobezeleni estuary can be regarded as fair. There seems sufficient justification from a management point of view, to direct future research towards a hydrological understanding of the system, as mouth closure appears to have become a norm and much manipulation of the estuary occurs. In addition, the estuary may be selected as a small craft harbour site. From a scientific point of view, recovery of the mangrove fauna should be monitored under the newly reinstated tidal regime. From a public health point of view a bacteriological examination of the estuary should be undertaken to establish whether it is contaminated.

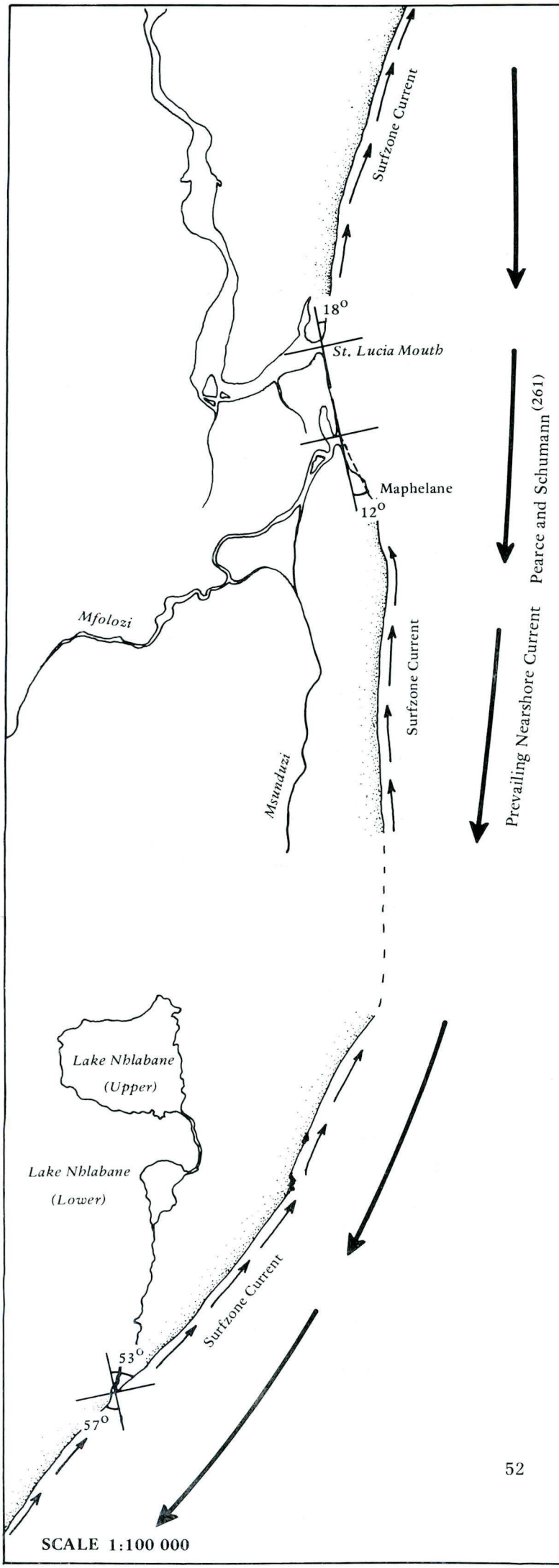
In terms of its present day environmental condition the estuary is highly disturbed, but because of interdependence the system as a whole warrants stringent conservation. This is because of the present day resource value of the entire system in terms of its flora and fauna, certain of which are unique, rare and endangered ([58]). Ideally the Mgobezeleni/Shazibe lake

systems should both be incorporated into the Sodwana National Park.

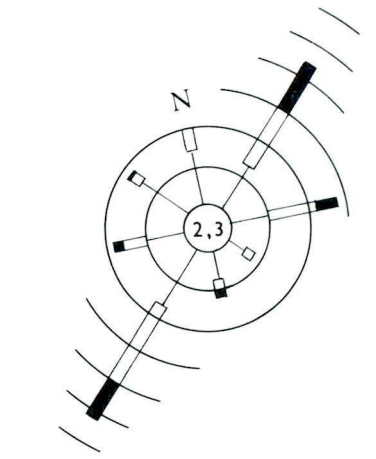
The system has its fair share of estuarine problems. These are:

(a) Impounded water levels (pre-1977).
(b) Pressures associated with 25 000 visitors annually.
(c) Vehicle access along the northern bank of the estuary.
(d) The lack of designated control (Natal Parks Board with no real jurisdiction over the Mgobezeleni system).
(e) Artificial control of the water levels and extent of the estuary.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other						Flora		Fauna								Food Webs
MGOBEZELENI			Catchment characteristics	Morphology	Hydrology	Density variation	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids					★										★							★				★	★						
Source of Information	Summary of available information																																
Henderson	1888	169					●													●	●												
Trevor-Roper	1889	302																		●	●												
MacNae	1963	217																				●			●		●						
Vahrmeijer	1966	305																						●									
Cooper	1968	91																				●											
Daniel	1970 to 1977	pers. comm.			●		●			●									●			●						●	●	●			
Orme	1971	256					●			●																							
NTRPC	1973	235						●											●	●				●									
Bruton	1974	55	●	●	●	●	●				●						●		●			●		●		●	●						
Bruton & Appleton	1975	62	●	●	●	●		●		●	●						●				●	●		●		●	●						
Bruton	1975 to 1976	56,57, 58,59, 60,61			●			●			●						●		●	●						●	●		●	●			
Gaisford	1975	133																						●			●		-				
du Preez	1977	pers. comm.						●																									
Aerial photos (Scogings) series		No.																															
1:10 000 Job 250	1976	267-270		●						●														●									
1:25 000 Job 251	1976	355-356	●																					●									



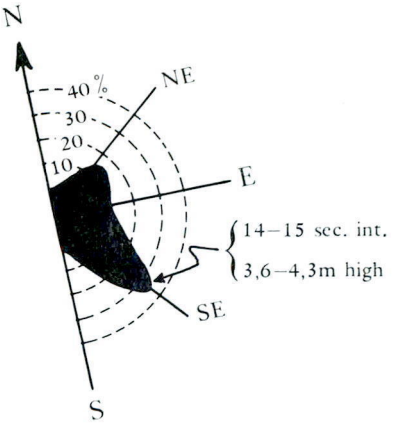
GENERALISED WIND ROSE



Arcs represent 5% intervals
Percentage calm within circle

SWELL OBSERVATIONS

(Distribution by direction, height and period)



2.1.2.1. **ST. LUCIA**

Introduction

St. Lucia is the largest estuarine system in Africa ([67, 328]) and without any doubt the most important in Natal since it comprises ±80% of the total estuarine area of the region. For this reason it has not been treated in the same way as the rest of Natal's estuaries — simply because with the time available a proper review of the system could not be made. In the St. Lucia Documentation Centre at the headquarters of the Natal Parks Board over 670 references are available — the processing of which is necessary before a summary of available information can be made and data voids identified. This process would need at least another year or more of concentrated effort. By virtue of its size and its importance, St. Lucia warrants such treatment so that the following is nothing but a very general overview of the system.

St. Lucia has a reputation, certainly throughout southern Africa, for its fishing and bird life, and as a national asset. It is not surprising therefore that the management of St. Lucia has been a source of perennial controversy, as the system has more than its fair share of estuarine problems. The most distressing consequence of these are phases of hypersalinity to the extent that from 1969 to 1972 parts of the system became virtually as saline as the Dead Sea ([6]).

Arising from a nation-wide concern for "what is happening to St. Lucia" an awe inspiring amount of research effort and public funds (±R500 000 per annum) ([104]) have gone into matters relating to formulating solutions to the system's problems. A Commission of Enquiry was appointed by the State President in 1963 ([208]), several recommendations from which have been implemented and in 1969 the St. Lucia Advisory Council (SCADCO) was set up to direct research and advise the Natal Parks Board (in whose hands the system has been entrusted) on matters relating to management of the system. Within SCADCO is a Technical Committee (qualified to consider aspects relating to the physical management of the system) and an Ecological Committee (qualified to gather together and co-ordinate biological information relevant to an understanding of the system). A Research Centre has been established at the estuary and a Documentation Centre (Data Bank) has become operative. In February 1976 an inter-disciplinary workshop meeting was held at Charter's Creek, the proceedings of which ([177]) have become the standard and most useful text on St. Lucia. Of equal importance has been the vast amount of work (sponsored by Natal Provincial Administration) done by the Hydrological Research Unit (University of Witwatersrand) in evaluating the effect of man's activities on water level and salinity at St. Lucia; the various remedial measures proposed (see Table **3**); and indicating what direction future management should take ([193]).

With hypersalinity being the condition which people wish to avoid (despite the remarkable tolerance to salinity most estuarine organisms display, and the remarkable short recovery time the system can exhibit) emphasis in this resumé of St. Lucia has been placed upon reiterating the causes thereof and the effects upon the various plant and animal communities of the system.

However, it is important to appreciate that excessively wet years, bringing with them high lake levels and very low salinities are almost as catastrophic as phases of hypersalinity ([102, 233]). Islands become waterlogged and deserted, birds cease breeding, hippo and crocodiles change their habits (young crocodiles get swept down into the sea and are collected from the beaches at night!), trees yellow and while certain fish die ([34]), freshwater species (such as the barbel *Clarias*) proliferate. In relatively recent years floods occurred in 1955, 1963 and 1975; and these alternated with droughts from 1949 to 1951; and from 1966 to 1970; like a pendulum swinging to and fro. Thus cyclical changes in weather (themselves related to sunspot activity) ([341]) is what appears to dictate the basic characteristics of a system as vast as St. Lucia; irrespective of whether man suggests "that numerous scientific surveys show that hydrologists, civil engineers and biologists can control this system" ([208]) and with all due respect, continues to show great faith in what computers and mathematical models say can be done ([194, 195]). All man can hope to do is to dampen the amplitude of the high salinity phases which develop ([102]), and to retain a viable southern cell of the system as a reservoir from which animal life can re-establish itself after a high salinity phase.

At present, while "the salinity memory is temporarily erased" ([193]), it is just as well to cast one's eye over the titles of some of the several hundred articles on St. Lucia — since in many ways, they speak for themselves in the story they tell; and, to help clarify the matter, an attempt has been made in Fig. **11** to represent the hydrological cycles operating within the St. Lucia system.

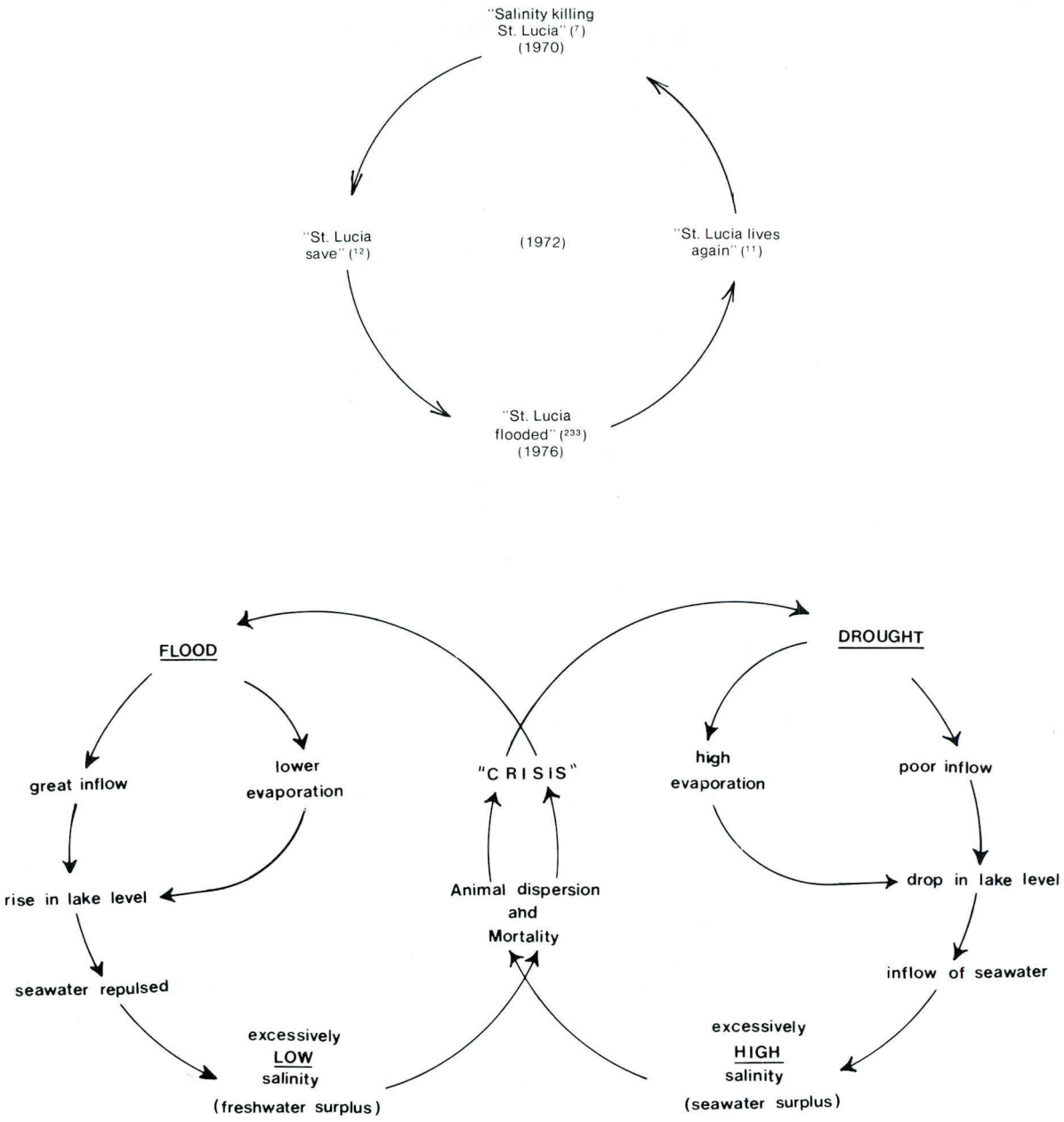


Fig 11. Hydrological cycles.

Synonyms/Nomenclature

Although the system is named after a Portuguese saint, Santa Lucia (319), it was first named by the Portuguese as "Rio de medaos do Ouro" (river of the dawns of gold). The Lala/Tonga name for St. Lucia was "Cwebeni las entelengeni" (the lagoon of rafts). Being so large, the St. Lucia system has names for each of its different regions, a guide to which is presented in Fig. **12**.

Location

Excluding the Mkuze swamps, the system occupies a position between 27°52'S to 28°24'S and 32°21'E to 32°34'E.

Accessibility

The mouth of the St. Lucia system lies some 240 km north east of Durban and 80 km north east of Richards Bay. It is served by a good tarred road, but access to any other part of the system becomes restricted to a secondary, untarred road network. There is an airstrip for light aircraft and a railhead ±30 km west at Matubatuba.

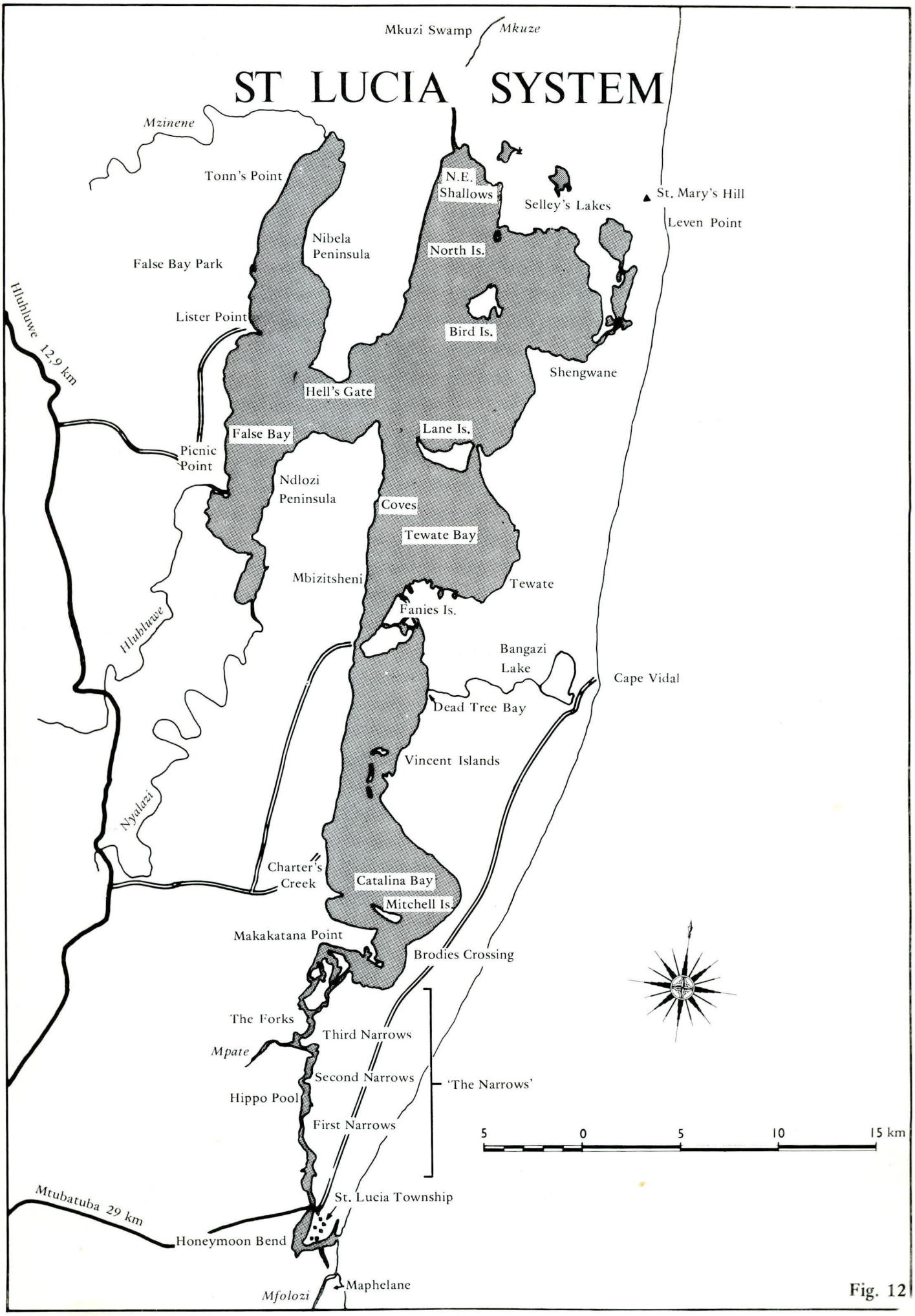

ST LUCIA SYSTEM
Mkuzi Swamp
Mkuze
Mzinene
Tonn's Point
N.E. Shallows
Selley's Lakes
St. Mary's Hill
Leven Point
Nibela Peninsula
North Is.
False Bay Park
Hluhluwe 12,9 km
Lister Point
Bird Is.
Shengwane
Hell's Gate
False Bay
Lane Is.
Picnic Point
Ndlozi Peninsula
Coves
Tewate Bay
Mbizitsheni
Tewate
Fanies Is.
Hluhluwe
Bangazi Lake
Cape Vidal
Dead Tree Bay
Vincent Islands
Nyalazi
Charter's Creek
Catalina Bay
Mitchell Is.
Makakatana Point
Brodies Crossing
The Forks
Third Narrows
Mpate
Second Narrows
'The Narrows'
Hippo Pool
First Narrows
5 0 5 10 15 km
Mtubatuba 29 km
St. Lucia Township
Honeymoon Bend
Maphelane
Mfolozi

Fig. 12

Bridges

There is one road bridge across the estuary (presently being replaced by a larger structure immediately upstream) 4,5 km from the mouth.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area
River length
Mean annual run-off
Flow
Dams (existing or proposed)

(see Table 2)

Water budget. Much research into the net losses and gains of water within St. Lucia has been undertaken in the past ([191]) because of the value of such information in evaluating any remedial measures proposed, as well as in obtaining an indication of what direction future management plans should take. Overlooking the substantial variation in mean annual run-off figures derived by various workers (see Table 2) the end result shows that St. Lucia system is still highly vulnerable, because without the Mfolozi river the net gains of water only just equate net losses. Consequently in the event of a drought developing (once every 10 to 15 years ([193]) or even less?) salinities are once again likely to rise with the same consequences as before. In fact, it has been estimated that this event is likely to occur six times every century ([194]).

Of the contribution by rivers, the Mkuze river is, at the moment, the most important, delivering from 164 x 10^6 m^3 ([191]) to 346 x 10^6 m^3 ([78]). However it is known that it practically stops flowing at times because it meets so many agricultural needs west of the Lebombo Mountains ([272]), and that demands upon fresh water in the St. Lucia catchment are not likely to diminish. In trying to resolve the conflicts that arise from attempting to find an alternative source of water to compensate for deficits that occur as a result of evaporation, rainfall variation, irrigation and afforestation, 18 suggestions have been made. These are listed as (a) to (r) in Table 3.

The cost of some remedial measures are exorbitant (o) and (p); others are ecologically unwise (c); or 'fraught with political problems' (b); and others like "robbing Peter to pay Paul" (f). Efforts to partially relink the Mfolozi river were made in 1970 and 1971 ([35, 339]) and consideration has been given to bringing the Mfolozi back to its former position, **but only if** siltation upstream can be overcome. Thus upstream storage dams become attractive propositions, both as a means of trapping silt and as a means of providing water (for schemes (h) and (i)) when the need is there. Whether such water will be sufficient is another question, but according to the HRU simulations ([192]) the Mfolozi link canal (i) is the most feasible proposition to adopt.

For this reason the Mfolozi link canal ([221]) is presently being built, in an attempt to dilute the incoming sea water, a task which, prior to 1952, was done by the Mfolozi itself. Mathematical models have suggested that if the magical figure of 156 x 10^6 m^3 ([272]) to 190 x 10^6 m^3 ([193]) of water can be provided in this way, it will be sufficient to maintain salinities within acceptable limits. However, although it is appreciated that by re-introducing the water right up into the Narrows so that there is no loss to the sea, one cannot help but have some doubt about how the Mfolozi link canal can be expected to do the job of the old Mfolozi, bearing in mind it took every drop of that river (729 x 10^6 m^3 ([191]) to 1060 x 10^6 m^3 ([78])) plus that from the Msunduze (89 x 10^6 m^3 ([78])) to do the job before, and even then the St. Lucia system experienced relatively shortlived high salinity periods. The Mfolozi link canal could however help maintain a viable southern cell in the system during the course of a high salinity phase. There is also some danger that in the future the Mfolozi will revert to its original course (thalweg) — the Msunduze ([339]), in which event it would naturally leave the Mfolozi link canal high and dry.

Siltation. ([35]) The present sedimentation rate (in response to accelerating erosion in the hinterland) is said to be two to three times greater than the mean rate over the past 5 000 years ([208, 258, 272]). Annual silt accumulation has been estimated at 0,98 x 10^6 m^3 ([258]) to 2,0 x 10^6 m^3/year ([35]). Because of the unfavourable depth: area ratio of St. Lucia, sediment accumulation naturally influences salinities.

Siltation was the beginning of St. Lucia's problems — this being the result of canalization, drainage and reclamation of the Mfolozi swamps for the purpose of sugar farming ([146]). Siltation in the Narrows of St. Lucia became apparent very soon after and accounted for the digging (by hand) of 'Potters Channel' at Brodie's Crossing (a natural sill between the Narrows

Table 2. Catchment characteristics of the St. Lucia system.

Water Source	Area km^2	(21) River length km	Mean annual run-off x $10^6 m^3$				(258) Mean Annual Flow m^3/s	(78) Dams
			"Virgin"	(191) Irrigation losses	(191) Afforestation losses	Net		
Mpate River	65 (personal estimation	15 (personal estimation	16 (191)	-	5	11	No record	Nil
Nyalazi River	670 (258) 704 (78) 725 (21)	97	32 (191) 54 (190) 65 (272) 83 (78)	2	6	24	2	Nil
Hluhluwe River	924 (78) 1 000 (256) 1 010 (21)	112	49 (191) 76 (190) 90 (272)	21 56 (190)	-	28 20 (190)	3	Existing with capacity of $25x10^6 m^3$
Mzinene River	700 (258) 764 (21) 808 (78)	72	15 (272) 24 (191) 30 (190)	2	-	22	No record	Nil
Mkuze River	5 380 (258) 5 545 (78) 6 086 (21)	306	194 (191) 216 (190) 271 (272) 346 (78)	30 18 (190)	-	164 198 (190)	9	3 potential sites
Eastern Shores (groundwater seepage)	1 135 (personal estimation	-	49 (191) 46 (190) 65 (272) 114 (102)	3	-	46	No record	-
Total	8 900 (258) 9 065 (272)	-	364 (191)	55	14	295	20	-
Sea	-	-	-	-	-	70	-	-
Rainfall (890mm p.a.)	-	-	-	-	-	268	-	-
Grand Total	8 900 (258) 9 065 (272)	-	-	55	14	626 (272)	-	-
Evaporation	-			397		567-633	-	-
Outflow to sea	-	-	-	170-236				

and the Lake). However, with the by-passing of the swamps, fluvial sediments originating in the Mfolozi catchment were deposited in ever increasing quantities, directly into the mouth of the St. Lucia system ([172]), until finally accounting for its closure in 1951. To alleviate the silt problem the Mfolozi was diverted in 1952 to its present day position. However, without the scouring action of the river in the mouth of St. Lucia, there was no agent to remove sand being brought in by the sea on each flood tide; and without the fresh water there was no agent to dilute the incoming sea water. Permanent closure of the mouth meant that a dredging programme had to be devised to maintain an artificial connection to the sea. Although dredging has been successful (an indication of which has been the disposal of some 10×10^6 m^3 of spoil by 1975 ([35])) the need to run a dredger continuously at the mouth of the St. Lucia is a somewhat horrifying thought. The problem of spoil disposal during this time can only be overcome by pumping it into the sea north of the mouth, so that the materials removed from within the mouth of the St. Lucia are transported further north by littoral drift.

Table 3. Remedial measures proposed to save St. Lucia.

To exclude sea water	(a) Build barrier from Makatana Point to eastern shores to prevent ingress of sea water ([127]).
To re-establish fresh water supply	(b) Link Jozini Dam (Pongola) via the Mkuze ([78, 194, 272]) to St. Lucia. (c) Dredge by-pass channel through Mkuze swamps ([2, 67, 92]). (d) Canalize Mkuze and re-link pans ([92]). (e) Clear Mkuze river of blockages ([35]). (f) Link Lake Sibayi to St. Lucia ([299]). (g) Construct a new estuary at Maphelane ([35]). (h) Dam Mfolozi and link via Nyalazi ([35, 38, 194]). (i) Dam Mfolozi and link via canal ([92, 221]).
To exclude silt	(j) Deepen the Narrows ([208]). (k) Dredging and groyne construction to maintain an open mouth ([273]). (l) Retain the separate mouth for the Mfolozi. (m) Build flood (silt) storage dams on Mfolozi ([35]).
To reduce evaporation	(n) Build islands (with dredged spoil) to reduce the surface area of lake and to make it deeper and smaller ([35]).
To use sea water to compensate for fresh water deficits.	(o) To pump sea water into St. Lucia ([104]). (p) Create a "Selley's estuary" by opening the lake to the sea at its northern end ([192]). (q) Dredge channel through Brodie's Crossing ([338]). (r) Construct a "biological lock" (control barrier and by-pass canal) in the Narrows ([35]).

Silt tracing within the St. Lucia system would be one form of research which should pay dividends — particularly in view of the obvious segmentation of the system into distinct cells ([258]), and general concern relating to physical management of the system.

Rainfall. Rainfall varies from 1 200 mm per annum at the mouth of St. Lucia to 625 mm per annum at Lister's Point in the north west ([191]) (see Fig. **12**).

From the mean annual run-off/water budget figures presented it is important to realize that the contribution by rainfall (a mean of 890 mm per annum), directly upon the lake surface, accounts for almost as much water as that which flows into the system from the present catchment area. 60% of this rain falls during summer.

Evaporation. Evaporation is the most influencial of the natural processes in St. Lucia during a dry climatic cycle; and is said to account for 397 x 10^6 m^3 per annum ([191]). Other estimates are:

(a) 200 x 10^6 litres/day ([12]).
(b) 1 320 mm ([258]) to 1 470 mm ([193]) per annum.
(c) 925 mm in a dry year and 350 mm in an average year ([102]).

Land ownership/use. In the catchment of St. Lucia 38% of the area is Bantu influenced ([258]); and reported to be overstocked with cattle. Around the estuary the Nibela Peninsula is itself a Bantu Reserve. Elsewhere are expanses of Forestry Reserve and cultivated lands, large acreages of which are under sisal.

The estuary itself (its water area and all the islands) is regarded as a game reserve and a 1 km strip of land around the shore is regarded as a park. In addition, access to the western shore of False Bay is restricted, as the region is regarded as a wilderness area. Near the mouth of St. Lucia, hotels, holiday chalets and a small township have become established to accommodate the thousands of visitors that frequent St. Lucia each year.

Local authority. Natal Parks Board.

Estuary uses. The Department of Defence uses St. Lucia for military purposes (missile and rocket launching and bombing) and control some 160 km^2 of the northern parts of the Lake. During the war the estuary was used as a base for flying-boats.

At the turn of the Century attention was given to St. Lucia's potential as a port, and in recent times a potato planting scheme on the eastern shores, was given serious consideration. Strip mining in the vicinity of the eastern shores is anticipated in the future.

However, today the principal use of the estuary is recreation ([319]) with the emphasis very much on angling and boat tours. When the mouth closed through siltation during the period 1951 to 1956 the recreational/angling industry (upon which the township of St. Lucia was completely dependent) collapsed. The area has natural surroundings with great aesthetic appeal to outdoor enthusiasts, an indication of this being 300 000 "visitor nights" recorded in 1976 ([313]). An everglades scheme has been proposed by the Natal Parks Board.

To research workers considerable educational value is attributed to St. Lucia because of the scientific value of such a system.

Morphometry of the estuary

Area. There is a great seasonal variation in the extent of the St. Lucia system. In a wet year the system is said to extend over 417 km^2 ([258, 272]) but in a dry year its area may become reduced to 225 km^2. Consequently most figures quoted range from 300 km^2 ([193]) to 350 km^2.

The original extent of the system (including the 'Mfolozi lagoon') has been estimated at 1 165 km^2 ([258]).

Axial length. 61 km to 66 km ([313]) (comprising a 21 km long channel ('The Narrows') and a 40 km to 45 km ([313]) long lagoon to the north thereof. The length of the original system was in the vicinity of 112 km ([258]).

Shoreline length. Estimations from a 1:50 000 map averaged 347 km, but seasonal variation probably causes the length of the shoreline to range from 300 km to 400 km?

Width.
Maximum: 22 km
Average: 3 km to 8 km
'Narrows': 100 m to 400 m wide ([193])
Mouth: generally less than 100 m wide.

Average volume. 295 x 10^6 m^3 ([193]) to 322 x 10^6 m^3 ([35]).

Bathymetry. The mean depth is less than 1 m. The lake floor is between 1 m to 2,5 m below mean sea level. 'The Narrows' are 1 m to 2 m deep ([193]). The original depth of the system has been estimated at 40 m ([258]).

Shape. H-shaped. With the axis of the system lying parallel to the prevailing winds, (north east/south-west) circulation and turbulence within the system is vigorous. This, together with

the fact that the system is so shallow, has promoted segmentation, or spit growth at right angles to the wind/wave direction. Today, after 5 000 years of sedimentation and reed swamp encroachment ([258]), there are six major segments or basins. These probably create semi-independent habitats with subtly different chemical, physical and biotic characteristics.

Tidal ranges. ([224, 258]) Tidal influences occur only within the Narrows (seaward of the Mpate river junction) and true tidal mixing is confined to that portion of the Narrows south of the bridge. 1 km from the sea, a range of 1,5 m may be experienced on a spring tide and "delays" in low water of approximately two hours.

In 'The Lake' seiches of 0,30 m ([224]) to 0,43 m ([322]) can be experienced due to wind action. Consequently the wind is the principal mixing mechanism in St. Lucia.

Currents. Depending on lake level, sea water has been known to flood into the estuary at a rate of 7 m^3/second ([258]). Current patterns within the Lake system have not been established.

Lake levels. Fluctuations in lake level cause water area changes of up to 35%. The mean lake level is 0,17 m above sea level. During the five year period of closure (1951 to 1956) lake levels varied from 0,6 m **below** mean sea level to 1,06 m **above** mean sea level ([102]). During the period March 1975 to October 1976 the lake level fluctuated between ±0,1 m below mean sea level to ±,85 m above mean sea level ([342]). With the mouth open, sea water plays an important quantitative part in maintaining lake levels, and compensating for fresh water deficits. Lake level is one of the most influential of factors governing the ecological state of the system.

Geomorphology

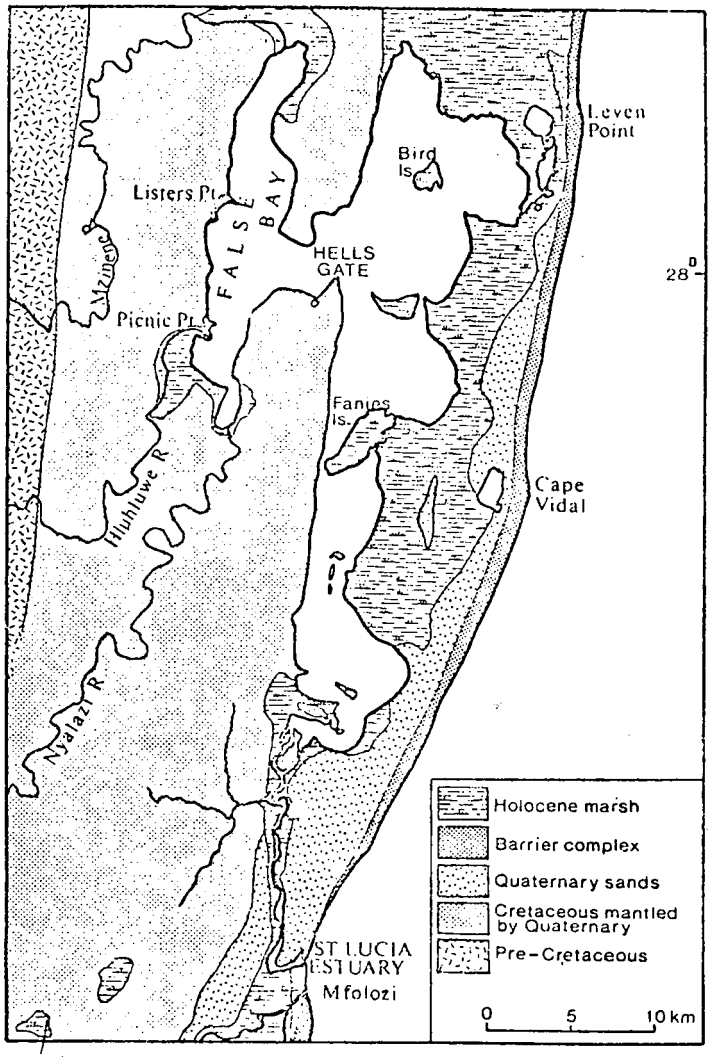


Fig. 13. Generalized distribution of the main geological and geomorphological elements of St. Lucia — after Winter ([343]).

Geology. ([82, 317]) The entire system, but for False Bay, is cradled in sand and gravel ([319]). False Bay and the two peninsulas (Nibela and Nhlozi) are composed of cretaceous sandstones, shale and limestones, so that in the vicinity of "the Coves" an area of sandy bays alternate with rocky outcrops. In very general terms ([343]) (see Fig. **13**) the west coast comprises a Pleistocene barrier complex, while the east coast comprises marshy terrain and a barrier dune (170 m to 188 m above sea level) which separates St. Lucia from the sea. The spongy lagoon margins shelve gently and have the important ability to release water during periods of drought.

Bedrock depths ([188]) range from 8 m (in Catalina Bay) to 32 m (in Hell's Gates). Examination of foraminifera contained in cores taken from St. Lucia by Phleger ([262]) indicated that since Holocene times, significant changes in lagoon productivity have occurred.

Nature of bottom materials. Soft muds extend to depths of 10 m to 30 m below the floor of the system. An estimate of the entire quantity of mud underlying the system is 3 115 x 10^6 m^3 ([208]). Organic debris from a depth of 8 m has been dated at ±3960 years before present ([208]). Whilst most reports refer to the fluvial origin of the St. Lucia sediments ([184, 272]), Cholnoky ([80]) says that on the basis of the diatom associations within the sediments, they are of marine origin. The interpretation of such materials by Orme (see Fig. **14**) is interesting in this respect. Being a shallow system, wind tends to keep much sediment in suspension, but salinity naturally promotes the flocculation of fine silt and clay. Excessive sedimentation tends to smother the bottom fauna and is thought to inhibit the migration of fish and prawns.

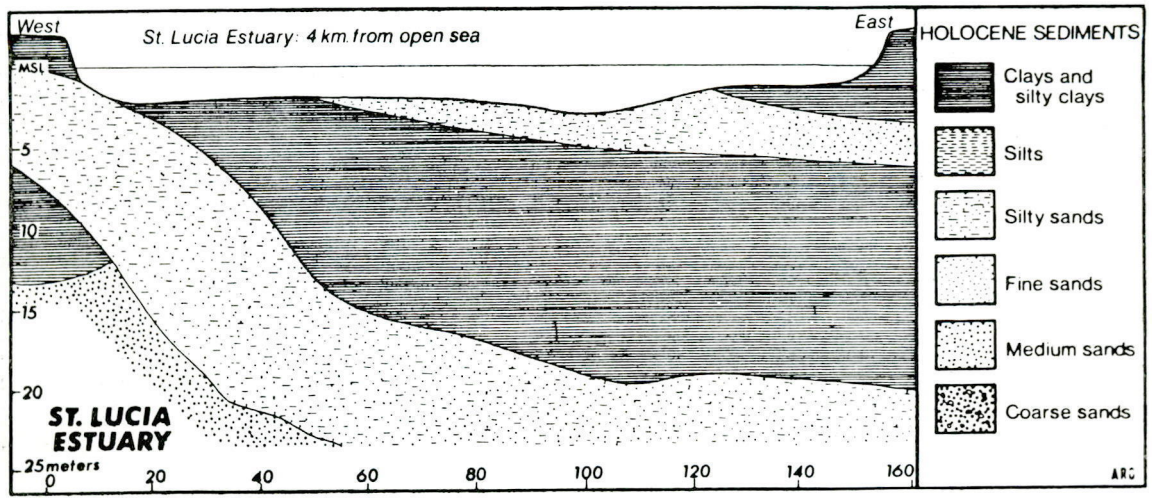


Fig. 14. Cross section through the St. Lucia estuary 4 km from the sea — after Orme ([258]).

Sandbar characteristics. The changing morphology of the St. Lucia mouth has been very clearly depicted by Orme ([258]) (Fig. **15**) both before and after the Mfolozi diversion in 1952. The mouth of St. Lucia was characterised by both north extending and south extending sandspits, which ever since the 16th Century have been known tc close the estuary mouth periodically ([338]). Closure can occur as a result of sand drift when discharges are minimal (August to November) or due to violent storms at sea. At such times, the Mfolozi discharged into the Narrows causing sedimentation therein. However, some 10 years after draining the Mfolozi swamps, and the massive invasion of silt which followed, mouth closure occurred on April 20th 1951. The system remained closed for five years until April 17th 1956 ([102]) at which time a connection to the sea finally re-established itself. During this period the mouth of the Mfolozi was diverted to its present day position.

The mouth of St. Lucia has since been fixed by groyne construction (completed in April 1969 ([35])) on either side of the mouth; and is artificially maintained in a permanently open condition, by dredging. After modelling the proposal ([273]), the CSIR had hoped that by groyne construction, tidal scour would be sufficient to keep the mouth open. However, the mouth may still close in winter (as in 1970 and 1973) and the Natal Provincial Administration Reclamation Unit at St. Lucia remain solely responsible for maintaining this life-giving link with the sea ([102]). Short periods of closure would however not be disastrous — particularly if they coincided with a drought cycle, because the Mfolozi (**IF it was silt free**) could then be forced to discharge up the Narrows into the lake.

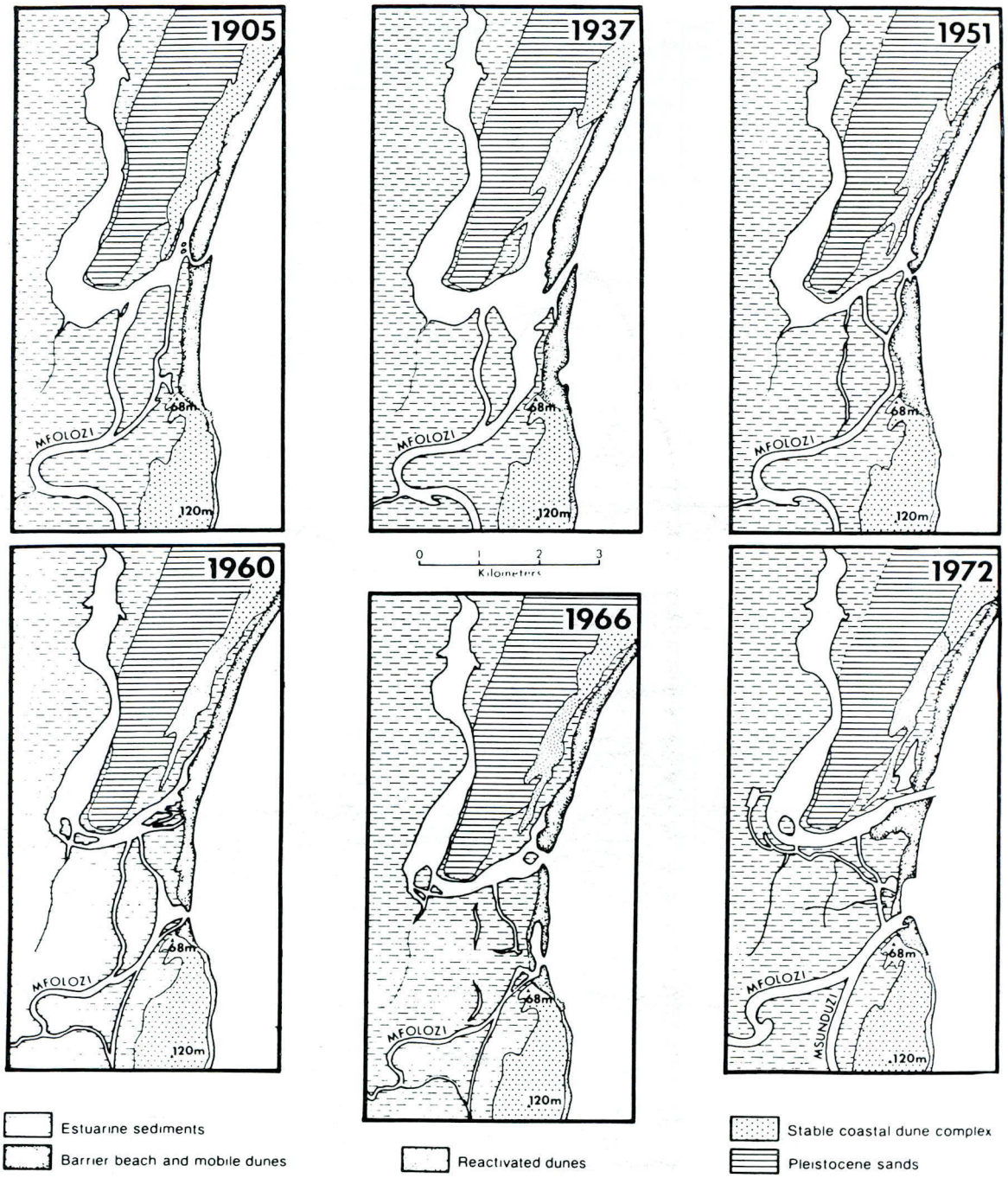


Fig. 15. Natural and man-made changes in the St. Lucia and Mfolozi estuaries, 1905 — 1972. Sources: 1905, C. J. Crofts, Zululand Coast Surveys; 1937, aerial photographs, Trigonometrical Survey; 1951, Irrigation Department Survey; 1960, aerial photographs, Trigonometrical Survey; 1966, Trigonometrical Survey; 1972, A. R. Orme.

Configuration of the adjacent shore. The shoreline trends north north-east but is indented 7° to 10° (257).

Surf zone currents. (257) The longshore current is set strongly towards the north. The median wave direction is east south-east; and the strongest swells are from the south east.

Physico-chemical characteristics

Temperature. Water temperatures normally fluctuate from ±29°C at the height of summer to ±17°C in the middle of winter (342). Temperature stratification does not normally

occur. As a further indication of the sort of water temperatures experienced in the system, the following figures are of interest ([203, 224]).

	Mean	Maximum	Minimum
June 1964 (°C)	15,9	20,5	13,5
February 1965 (°C)	28,0	30,8	25,1

Transparency. After floods the water of the St. Lucia system is characteristically a brown colour — and generally remains a murky grey for the rest of the year due to the resuspension of sediment by wind. Light penetration (and hence productivity) is consequently reduced. In 1969 Secchi values of 0,23 m were reported ([326]), while earlier records (during 1948 to 1951) revealed values ranging from 0,076 m to 0,5 m in summer and from 0,15 m to 1,37 m in winter ([121]). Water transparency in summer is less than half in winter ([342]).

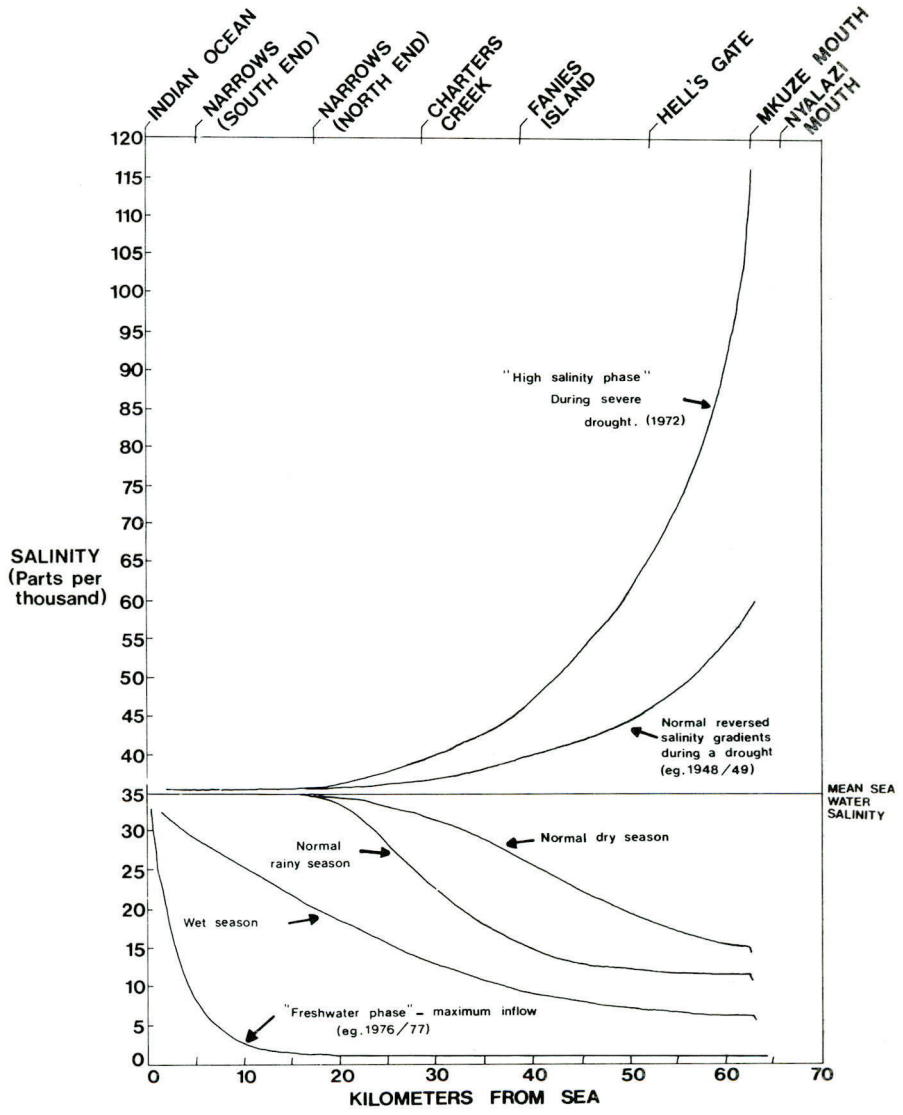


Fig. 16. Fluctuation in salinity regime: St. Lucia.

Salinity. Because of the hypersaline conditions (reversed salinity gradients) that periodically develop in St. Lucia, much effort has been devoted towards obtaining an appreciation of the range and amplitudes of salinity within St. Lucia. Whitfield ([341]) considers that salinity levels must be maintained below 50‰ for the system to remain viable.

With reference to Fig. **16** (adapted from Orme ([258])) it is clear that extremes in salinity are experienced only in the northernmost regions of the system. The salinity in this region may

range from 0‰ in a wet year (such as 1977) to 116‰ at the end of a series of drought years (such as in 1972) ([38, 306]). 1972 marked the end of the most recent and most dramatic high salinity phase the St. Lucia system has undergone. During the course of this time (1966 to 1972) salinity values of 80‰ to 100‰ were recorded in the vicinity of Hell's Gates, Selleys Lakes, and the Mkuze mouth ([143]). This situation developed as a result of constant inflow from the sea, so that salt accumulation (estimated to be 19 x 10^6 tons) became a very serious problem.

In contrast, the range in salinity in the south of the system (and in the Narrows in particular), are slight by comparison, due to the moderating influence of the sea. A wedge of salt water may penetrate a considerable distance up the Narrows, below outflowing low salinity lake water ([342])

Nutrients. The chemistry of St. Lucia's inflowing rivers was superficially studied in the 1960's by the National Institute for Water Research (NIWR) ([21]). A really thorough understanding of nutrient relationships within the system has yet to be acquired. However, some determinations of nitrogen and phosphorus levels in False Bay in 1975 have been made, in conjunction with algal bioassays ([199]). Nitrogen levels varied from 54 µg/litre to 200 µg/litre and levels of orthophosphate fluctuated from 9 µg/litre to 41 µg/litre. In the rivers, levels were naturally considerably higher. Between January and July, phosphorus was shown to be the primary limiting nutrient, while between August and December both nitrogen and phosphorus were equally limiting. Such results contrast somewhat with earlier determinations of total phosphorus in July 1964 and January 1965 ([224]) because phosphorus was **not** considered to be a limiting factor on those occasions.

Pollution aspects. Although identified as an "information gap" in 1976 ([177]), an understanding of pesticide or trace metal levels in St. Lucia has yet to be obtained. Agrochemical influences should be investigated.

Public health aspects

Bacteriology. The bacteriological conditions of some of the affluent rivers in 1969 has been reported on by the NIWR ([21]). Otherwise the subject has been neglected. With the location of St. Lucia township at the mouth of the system — *E. coli* levels at "Honeymoon Bend" would be revealing, although adequate flushing of water occurs. However, pollution from this source could effect the movements of certain biota in this vicinity.

In terms of productivity (detrital food chains) the role of bacteria as decomposers within the St. Lucia system will constitute an important study in the future.

Bilharzia. No records which throw any light on this subject are available.

Public safety. Hippo, crocodiles and sharks are all conspicuous elements of the St. Lucia system and each constitute very real public dangers. However, at the same time, to many people, they represent one of the attractions of St. Lucia. At one stage the CSIR had a laboratory at St. Lucia which concentrated upon developing an (apparently unsuccessful) electrical shark barrier system.

BIOTIC CHARACTERISTICS

Qualitative biological research at St. Lucia began ±30 years ago after the surveys of Day *et al* ([121])

St. Lucia contains the most southerly populations of several plant and animal communities characteristic of tropical Africa ([258]). It is generally true to say that south of this point, faunal assemblages become increasingly impoverished (Stuckenberg, pers. comm.). The habitats available within the system ([272]) are diverse and can be defined or categorized quite easily into:

(a) islands
(b) mudflats and shallows
(c) aquatic vegetation
(d) reed swamps
(e) open grasslands
(f) swamp forest
(g) coastal dunes
(h) riverine communities
(i) fresh water pans
(j) beaches.

Flora (Fig. **17**)

Reed swamps (*Phragmites australis*) are encountered along most of the edge of St. Lucia, but it is the 120 km^2 extent of the Mkuze swamps in the extreme north of St. Lucia, that are the most important. By virtue of their sheer impenetrability — the Mkuze swamps have never been subjected to any intensive research — the results of which would be very revealing. The basic function of such a community is to add decaying organic matter to the system, as well as to trap silt and floating debris, and act in the manner of a sponge, as a fresh water reserve. Reed swamps flourish best under periods of low salinity, and consequently become reduced (often to a stubble) during high salinity phases.

Of the submerged macrophytes ([121, 337]), beds of *Potamogeton pectinatus* (said to be *P. pusillus* in ([258]) and confused with *Zostera* in ([131])) are the most widespread and important in the northern reaches of St. Lucia. This is because these plants thrive best where low salinities are encountered. Consequently they are replaced by *Ruppia spiralis* in the south — the beds of which are in turn replaced by *Zostera capensis* nearer the sea. Over and above their function as primary producers, such plants all support important epiphytic communities in the form of insects, molluscs, diatoms and algae, on which many organisms feed. *Zostera* (eelgrass) appears to be sensitive to turbidity and succumbs when excessively silt laden water is encountered, while *Potamogeton* (pondweed) collapses during the high salinity phases that periodically develop in the northern regions of the system. Although *Eichornia* (water hyacinth) does occur in the system, floating plants of this nature are not considered as important elements of the St. Lucia flora and are not out of control (Forrest, pers. comm.).

Of the other lagoonal communities, swamp forests (*Ficus, Barringtonia, Voacanga* and *Syzygium* associations) occur in places on the eastern shores of St. Lucia, and a peripheral mangrove community (*Avicennia* and *Bruguiera*) survive in the Narrows where hypersalinity is not really encountered. In low-lying, badly drained areas marshes comprising sedges (*Scirpus, Juncus*) and hygrophilous grasses (*Sporobolus* and *Paspalum*) occur ([52]).

Further away from the estuary, the main vegetal components include a savanna community; coastal dune vegetation near the sea and forestry plantations further inland ([260]). Water uptake by the latter (pines and eucalyptus) is said to amount to 10% of the mean annual run-off ([258]), which in times of drought is critical to the estuary ([299]). According to Tinley ([297]) afforestation has been the most important factor in accounting for St. Lucia's problems. The evergreen Dukuduku Coastal Forest forms a component of the vegetation towards the south of the system, which is important to conserve.

Phytoplankton/Algae.

Macroscopic: *Enteromorpha* is the most conspicuous filamentous alga ([104, 342]), growing in the shallows, when lake levels are receding ([337]) or on the exposed tops of submerged vegetation.

Microscopic. From examination of diatom associations within the sediments of St. Lucia in 1964, Cholnoky ([80]) concluded that the diatom flora were principally composed of marine littoral species, and noticed that the number of species encountered dropped as one reached the northern regions of the system, where greater ranges in the salinity are known to occur. Since then, studies of the phytoplankton of St. Lucia (in 1973 to 1975) by Johnson ([199]) have shown that most of the phytoplankton volume is made up of autochthonous diatoms. The highest volumes were found in False Bay and North Lake.

Associated with high salinity, high water temperatures and calm weather, "red water" (*Noctiluca scintillans*) an algae responsible for causing fish kills elsewhere, has been known to appear in the north of St. Lucia. *Noctiluca* appeared in July/August 1969 ([142, 143]) together with other luminescent forms of algae.

Fauna

Being likened to "a naturalist's paradise" ([322]) the fauna of St. Lucia has received a considerable amount of attention.

Lower trophic levels. A total of 129 species of invertebrates have been recorded from the St. Lucia system ([121, 224]).

Zooplankton: A very stable, typically estuarine community of zooplankton is present, a thirty year record of which (recently subjected to cluster analysis) is held by Grindley ([142]). Some forms apparently have a remarkable tolerance to salinity changes — although most forms of zooplankton were unable to survive once salinities exceeded 80‰. A neritic marine community is encountered in the Narrows where water exchange with the sea is more pronounced.

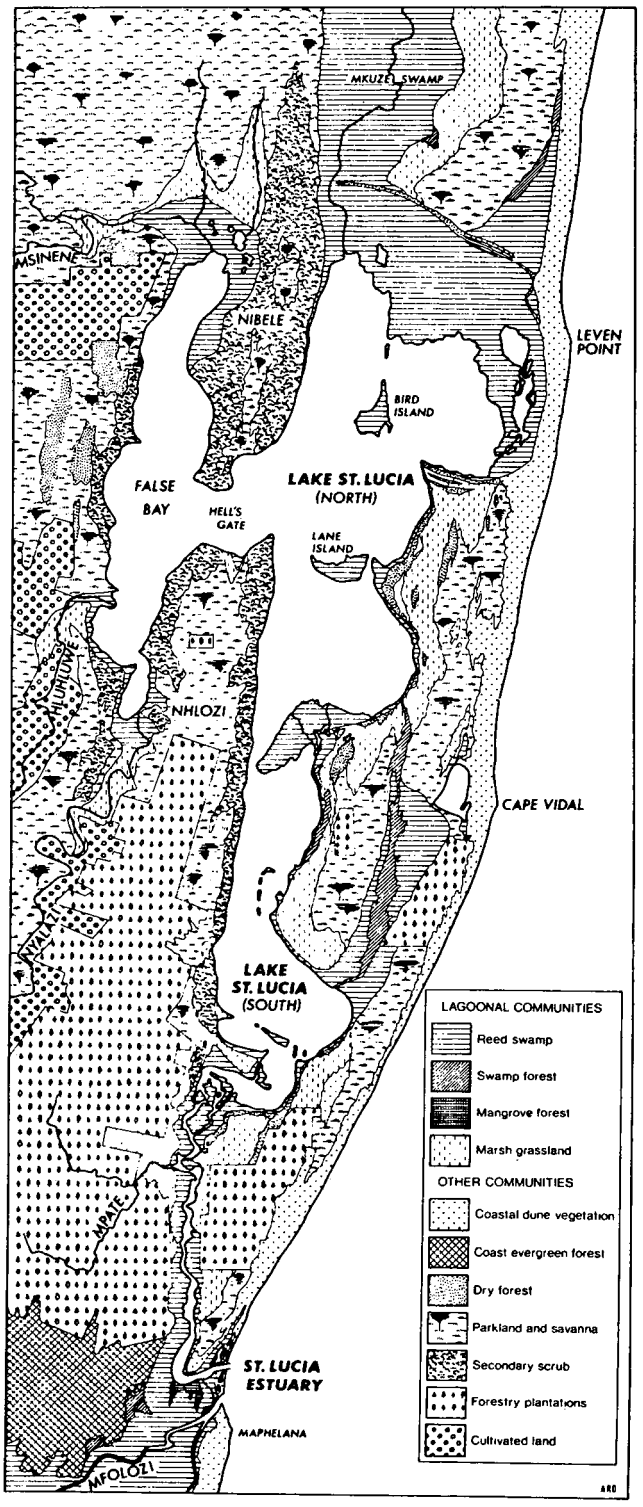


Fig. 17. Orme's interpretation of the vegetal components of the St. Lucia system; based on field and remote sensing data ([258, 260]).

Insecta: Curiously, insects are an aspect overlooked in many estuarine studies. In St. Lucia they are probably of great importance. An indication of this comes from the description of mass emergences of chironomids (*C. kaffrarius*) in July 1969 ([143]) during a high salinity phase of the system and the fact that insects comprise an important food item amongst several fish, young crocodiles ([269]) and birds.

Prawns: The St. Lucia system represents the largest estuarine penaeid prawn reserve in South Africa ([76]) — and is of very great importance as a nursery area for prawn life. Of the five species present, the system is normally dominated (to the extent of 76% to 84% ([76, 203, 258]) by the white prawn, *Penaeus indicus*. The adult prawns migrate seawards in December to April; and the juveniles invade the system in spring (June to August). However in recent years, during the present "low salinity phase" of the system, *Macrobrachium equidens* have become dominant (Forbes, pers. comm.). The prawn population is not only important as a food source to fish such as kob (*Argyrosomus*), springer (*Elops*), kingfish (*Caranx*) and tigerfish (*Therapon*), but also supports a bait fishery which is confined to the Narrows. In 1973 30 000 kg ([38]) of prawns (worth ±R50 000 ([313])) were taken from the Narrows by the Natal Parks Board. During the high salinity phase, prawn numbers became reduced in badly affected regions.

Benthos: The most significant contribution to the understanding of the benthos of St. Lucia has been that of Boltt ([36, 185]). The most abundant benthic species is the small gastropod *Assiminea* which, being eaten by a wide variety of animals, is also the most important ([32]). A decline in the quantity of benthos was found from winter to summer. Most benthic species were able to tolerate salinities of up to 55‰, above which only chironomids and ostracods survived as benthic components of the system. Rapid re-colonization occurs because the mollusc larvae are planktonic and are transported by wind-induced water movements into the lake. Wallace ([326]) found the system to be rich in shellfish, with *Solen* (stickbait) as the most important and forming the main food item of the grunter (*Pomadasys*). *Nassarius* and the clams *Eumarcia* and *Theora* are also regarded as important elements of the benthic fauna.

The edible crab, *Scylla serrata*, has recently been the subject of much research by Hill, the results of which are in press.

Higher trophic levels.

Fish: Since 1948 the fishes of St. Lucia have been the subject of many studies. According to the various surveys made, 82 species of fish have been recorded from the St. Lucia system ([121, 314, 342]). Numerous species of larval fish frequenting shallow, marginal areas use the system as a nursery area ([329]), and many adult fish enter the estuary merely to feed ([328]). The point at which these fish enter St. Lucia is a popular angling spot, and large catches are made during the seasonal "runs". There may be good reason to suspend dredging operations in the mouth of St. Lucia at such times ([83]). The most commonly caught species are spotted grunter (*Pomadasys commersonni*) (the post-spawning run of which is in summer ([327])), kob (*Argyrosomus hololepidotus*), perch (*Acanthopagrus berda*) and stumpnose (*Rhabdosargus sarba*) ([313]). In recent years disturbing changes in the abundance of perch have been noted and attributed to overall estuarine degradation in Natal ([313]). Although the St. Lucia mullet population forms only a very small part of the total spawning population in the surf zone ([331]), in terms of the Lake's overall ecology, *Mugil cephalus* (which "run" in the winter ([327])) plays a vital role ([340, 342]) as do smaller plankton feeding species such as *Thryssa* (the glassy), *Gilchristella* ([342]) and *Gobius giurus* ([121]). Such species are important because they form the prey of many predators, including fish, crocodiles, man and piscivorous birds. The feeding ecology of piscivorous birds at St. Lucia has recently been the subject of a two year study by Whitfield ([342]). When mullet begin to migrate, sharks, pelicans and crocodiles are attracted to the estuary and the Narrows and depart again when "the run" is over. During the 1976 mullet run it has been calculated that between crocodiles and pelicans 7 650 kg of mullet were consumed ([342]).

Illegal gill netting in the north of the system is regarded as detrimental to fish stocks ([340, 342]) and the angling pressure at the mouth of St. Lucia is generally regarded as being too intense ([124, 313]), and has recently become the subject of research investigation

The high salinity phase of the lake did not appear to affect the biology of mullet ([327]) or springer (*Elops machnata*) adversely; and bream (*Sarotherodon mossambicus*) were found breeding in hypersaline water of 116‰ ([306])! In general fish mortality as a result of high salinity was rarely encountered ([331]) (despite the opinion expressed in ([172])) as most

species of fish are capable of adapting to both low and high salinity regimes. Information on the salinity tolerances of ±62 species of fish at St. Lucia is available ([314, 342]). 10 species have their upper tolerance limits at 65‰ to 70‰, whereas 32 species have their lower tolerance limits at 1‰ to 3‰ ([342]).

Various species of sharks are common in the vicinity of the mouth of St. Lucia ([28]). The Zambezi shark (*Carcharhinus leucas*) and the sawfish (*Pristis pectinatus*) penetrate the whole system and gravid females of *C. leucas* enter the system to give birth to their young ([170]). Although able to tolerate salinities of twice that of sea water, sharks lose condition during high salinity phases.

Birds: Until recently an important information gap was an understanding of the St. Lucia avifauna. Since some of the earlier observations ([79, 121]) the studies of Berruti (Percy Fitzpatrick Institute), which are now virtually complete will represent the most complete and thorough investigation to date. In recent years Whitfield ([342]) has also provided much insight into the feeding ecology of 10 species of piscivorous birds of St. Lucia. Of the ±340 bird species in and around the St. Lucia system — approximately 90 of these are water associated ([342]) — the main attraction being the islands, mudflats and reed swamps that the system provides. Waders are commoner in summer (being migrants), whereas pelicans and Caspian terns are more common in winter ([342]). St. Lucia is a recognised breeding ground for ±20 aquatic bird species such as Openbill, Woodstork and Pink-backed pelican, the breeding of which takes place nowhere else in South Africa. Several species are at their most southerly limits of distribution ([258]). Spoonbills, White pelicans, Grey-headed gulls and Caspian terns are very dependent on the islands of St. Lucia for breeding purposes. The system is renowned for its pelicans and flamingoes. The pelicans of St. Lucia have been known to feed on the Pongola pans 60 km away ([234, 342]) — and return to St. Lucia each day. During the high salinity phases most of the birds migrate away from St. Lucia and cease breeding.

Crocodiles: St. Lucia's crocodile population (approximately 500, from aerial census) is recognised as one of the largest and most important breeding populations in South Africa, and has been the subject of intensive research by Pooley ([269]). Crocodile breeding sites are protected, and a certain number of young crocodiles are returned to the lake after artificial hatching and rearing. The favourite haunt of crocodiles appears to be the Mkuze delta ([272]) but there is a marked seasonal movement from summer breeding grounds to winter basking grounds. The high salinity phases were catastrophic as far as the crocodiles of St. Lucia were concerned although natural dispersal to adjacent dams and pans was possible. Mortality of adults and juveniles was reported and the air lifting of crocodiles out of St. Lucia was attempted at one stage.

Mammals.

Hippo: Aerial counts have shown that the numbers of hippo in St. Lucia have gradually increased over the last 20 years to an estimated 600 ([293, 342]). These are concentrated along the eastern shores — in particular "Tewate Bay". Here they are said to perform an important role in carving channels through the swamps, modifying drainage lines and in general nutrient relationships, by releasing large quantities of plant material (detritus) into the lake in their faeces ([328]).

Game: The eastern shores of the St. Lucia system are a recognised game reserve in which antelope such as reedbuck, nyala, impala and suni are common. Buffalo have been introduced recently.

SYNTHESIS

In general, the state of knowledge on the St. Lucia system is excellent and unsurpassed in Natal, simply because nowhere else has such a vast amount of expert opinion been channelled towards scientific research and towards developing management plans. The fact that research effort presently lacks co-ordination points to the need to review our overall state of knowledge of the St. Lucia system, as an independent exercise, in the same manner as that which has been done for the rest of Natal's estuaries. Consequently a summary of available information, and the identification of data voids has purposely not been made, although some of those that are immediately obvious have been mentioned in the text. Heydorn ([176]) has pointed out (with reservations) the need for quantitative work which may explain the mechanisms of energy transfer within the system and the need for an understanding of trophic relationships (foodwebs) within St. Lucia. There is the need to construct a simple ecosystem model of the

Introduction

The Mfolozi-Msunduzi estuary complex is regarded as a separate system despite the close and vital relationship of the Mfolozi with St. Lucia. Whilst the Mfolozi and Msunduzi are at present two separate river systems, with one mouth to the sea, during the course of natural movement across its floodplain, the Mfolozi once flowed through what is today the Msunduzi channel ([106, 256, 339]) (see Fig. **18**). In 1952 the Mfolozi was artificially diverted away from the St. Lucia estuary and discharged directly into the sea 1,5 km south of St. Lucia at Maphelana. It has since been further isolated from St. Lucia by a series of protective embankments and dykes over 3 m in height ([339]). In 1971/72 an unsuccessful attempt was made to reconnect the Mfolozi to St. Lucia.

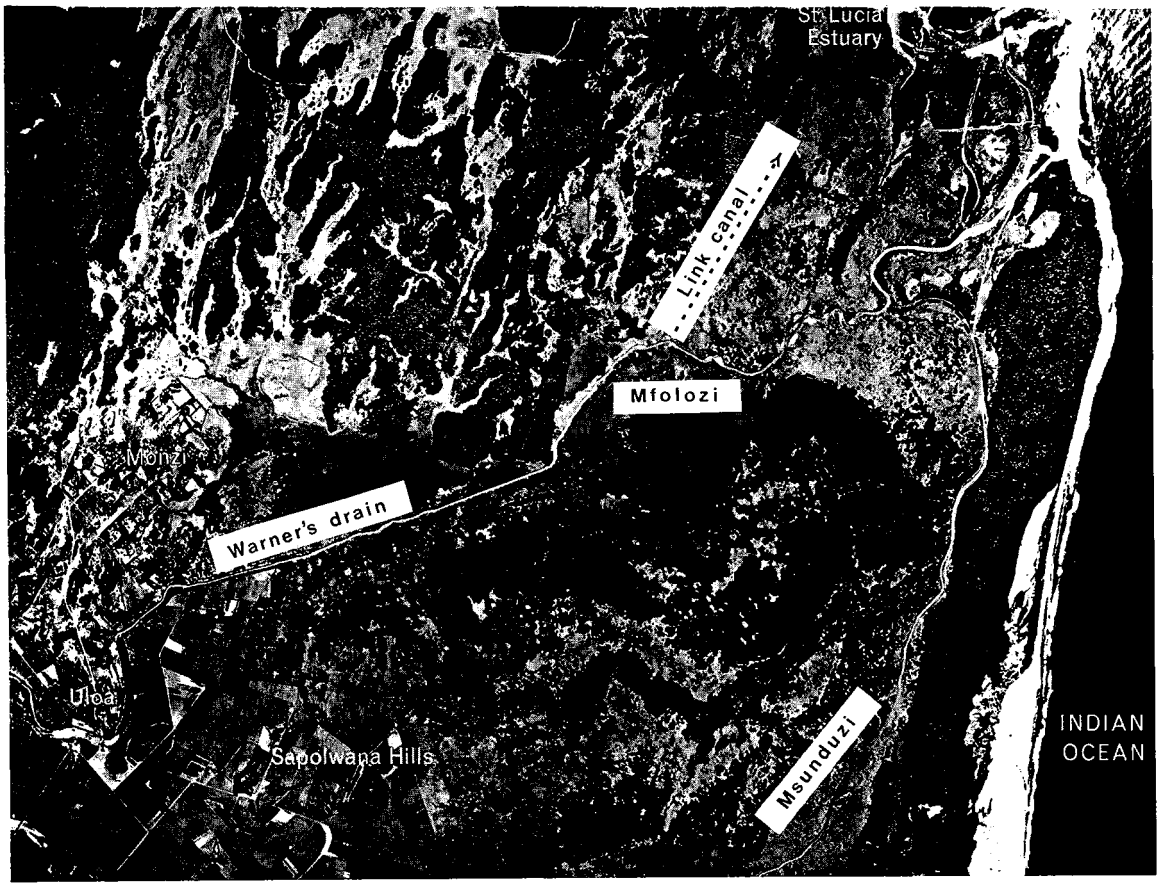


Fig. 18. Aerial photograph showing former courses (— — —) of the Mfolozi river across its floodplain ([106]).

Synonyms

Umfolosi ([286]).

Zulu meaning

Zig-zag — referring to the river's tortuous course ([289]).

Location

28°24'S; 32°25'30"E.

Accessibility

The Mfolozi estuary is 80 km north east of Richards Bay or 245 km north east of Durban. It is relatively inaccessible being surrounded by swamps and approachable only by means of a

system before such threads could be tied together.

In its **present** day environmental condition, St. Lucia is thriving — but this situation is liable to fluctuate from "good" to "bad" as dictated by the vagaries of climate. Attention must be drawn to the fact that the mouth of St. Lucia is becoming highly modified (with diverted rivers; groynes, dredging; levees and bridges), because it is one of the most vital regions, and one which cannot be allowed to deteriorate. Development in this area is however being most carefully planned ([211, 319]).

Contributing to the present day value of the system is its wealth of animal and plant life and its far-reaching effects on the coastal ecology of Natal.

Various problems are apparent. These are:

(a) Freshwater starvation which gives rise to periods of high salinity. This situation has arisen from erratic rainfall as well as general catchment utilization conflicts, which include:
  (i) afforestation
  (ii) irrigation and dam construction
  (iii) drainage diversions (such as the Mfolozi in 1952)
  (iv) destruction of riverine vegetation (on Mkuze)
  (v) the fresh water needs of townships, stock and industry.

(b) Silt remains as one of the most dangerous of 'pollutants' in St. Lucia — originating from accelerating erosion in the catchment area and swamp destruction.

(c) Military use of the St. Lucia system creates relatively minor, but obvious conflicts and;

(d) the likelihood of mining activity on the eastern shores of St. Lucia at some stage in the future will probably create further conflicts.

In addition a number of lessons have been learnt:

1. That "there is no steady state of biological bliss" ([272]), and that a "doomed and dying lake" ([6]) can recover should nature be willing.
2. That in times of hypersalinity in the north, the southern part of the system remains viable and functions as a reservoir from which animal life re-establishes itself, once conditions return to normal.
3. That man can do little to **manage** (control) a system the size of St. Lucia; but can do much to aggravate and increase the amplitude of the high salinity phases which nature periodically dictates.
4. That the "St. Lucia story" is a classical example of how estuary problems are catchment or land use problems, unintentional as they may be.

sandy jeep track that runs along the foot of high coastal dunes to a group of fishermen's shacks at Maphelana. This track runs for much of its course alongside the Msunduzi channel. Although only a few kilometres south of St. Lucia, the drive from St. Lucia to Maphelana is over 80 km.

Bridges.

There are no bridges of any description across the Mfolozi estuary.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. Mfolozi — The Mfolozi catchment is the second largest drainage basin in Natal, with estimates as to its size ranging from 9 918 km^2 ([78]) to 10 700 km^2 ([257]) to 11 318 km^2 ([21, 270]).

Msunduzi — 559 km^2 ([78])

River length.

Mfolozi — 395 km ([21, 270]); made up of two principal systems — the Black Mfolozi and the White Mfolozi.

Msunduzi — 70 km (pers. est.).

Mean annual run-off

Mfolozi — 1 060 x 10^6 m^3 ([78]). According to Hutchinson ([191]), 746 x 10^6 m^3 of water emanated from its catchment in a "virgin" state, 17 x 10^6 m^3 of which are lost to irrigation. The net mean annual run-off is 729 x 10^6 m^3.

Msunduzi — 89 x 10^6 m^3 ([78]).

Flow.

Mfolozi: Flow data goes back to 1947 ([21]). Both the Black and the White Mfolozi have erratic flow characteristics. Occasionally they cease flowing altogether in the dry season ([21]), and in wet seasons flood violently. Summer flows are given as 63,0 m^3/sec and winter flows as 3,0 m^3/sec. The mean annual flow is 33,0 m^3/sec ([257]) and the "probable average total flow" given as 56,6 m^3/sec in ([205]). "Bank full capacities" are given a 500 m^3/sec ([339]). The benefits of the Mfolozi link canal (presently under construction) were demonstrated by Chew and Bowen ([103]). The canal has been designed to divert water from the Mfolozi into the St. Lucia narrows at those times when salinities in St. Lucia begin to rise (see Fig. 18). Such events normally take place during a drought cycle and it is difficult to foresee at present where such water will come from. The construction of storage dams on the Mfolozi are the only means by which such water can be provided. These dams would also have potential benefit in acting as a silt trapping mechanism.

Msunduzi: No record.

Flood history. The Mfolozi floods have a reputation of being both vicious and devastating. The actual flood levels achieved are apparently undocumented although a suggestion has been made that they are in excess of 2 000 m^3/sec ([339]). Attempts by sugar cane farmers to combat flooding of the Mfolozi flats, by means of levee construction, date back to 1927. Canal construction on the Mfolozi in the form of Warner's drain (1936) and on the Msunduzi in the form of Wilson's drain, were undertaken for this reason. To illustrate this point the following is quoted from a memorandum of the Irrigation Department ([286]): . . . "By the construction of open drains, waterlogged areas were dried out and rendered fit for cultivation, and by protecting river banks, flooding was diminished. Cane cultivation was gradually extended to the sea" . . . "Part of the programme" was "to assist in getting flood water to the sea as quickly as possible . . ." "Levees have been built to prevent floods from spreading over the adjoining land . . .".

Weiss and Midgley ([339]) point out that the original flow path (thalweg) of the Mfolozi is the Msunduzi (see Fig. **18**) and that it is only natural therefore, for flood waters to pour across the canefields towards the Msunduzi whenever the Mfolozi bursts its banks. In doing so, it deposits its burden of sand and silt on the land.

There is now constant agitation from sugar farmers on the floodplain to have dams built higher up because such dams would trap silt and sand, lessen the magnitude of the floods and could be used for irrigation.

Dams.
Existing: Nil. Lake Teza functions as a dam on the Msunduzi river.

Proposed: 12 potentially good dam sites have been located in the catchment by the Department of Water Affairs (Porter, pers. comm.).

Siltation. The mean annual sediment yield from the Mfolozi has been estimated to be $1,5 \times 10^6$ tons ([257]). Although the old Mfolozi has become "extinguished by Holocene sedimentation" ([257]), there is confusion about the actual time when this infilling occurred ([286]). The lower part of the Mfolozi delta was described as consisting "of a large swamp, overgrown with reeds and papyrus, and much of the water eventually reaching the mouth of the river passed over the swamp area, at a low velocity, so that silt was deposited there instead of being carried forward" ([286]). At one stage the deposition of fresh silt over the floodplain was considered to be beneficial by farmers, but heavier materials in the form of sand are now being deposited by each flood and large areas are thereby being ruined for sugar cane production (Hitchins, pers. comm.). The causes of silting ([286]) in 1948 were ascribed to:

(a) increased denudation in the catchment;
(b) the fact that the major portion of the swamp area has been built up to an elevation out of reach of all but exceptional floods; and
(c) canalization and drainage.

Land ownership/use.
In catchment: 46% of the Mfolozi and 38% of the Msunduzi catchment is "Bantu influenced". These areas are to become incorporated into KwaZulu. Around Vryheid there are coalmines and agricultural activities such as wattle plantations, general cultivation and stock farming. The Mfolozi Game Reserve occupies a triangle between the branches of the Black and White Mfolozi. There are extensive sugar estates and wattle and pine plantations on the coastal plain ([21]). The Mfolozi Sugar Mill is 30 km above the estuary. The Mfolozi drainage scheme began after the second world war in order to provide ex-servicemen with land and an occupation (Munroe, pers. comm.).

Around estuary: Undeveloped swamp land.

Local authority. Natal Parks Board control the mouth of the Mfolozi. The remaining area is regarded as State land.

Estuary uses. Nil.

Morphometry of the estuary (see Fig. **19**)

Area.
Axial length.
Shoreline length.

The precise limits to which the Mfolozi/Msunduzi systems are tidally influenced have not been accurately determined. The estuary of the Mfolozi is not likely to extend more than 4 km from the mouth because of the flow characteristics and sediment yield. The Msunduzi estuary extends ±8 km from the mouth.

Width.
Maximum: 130 m
Mouth: 100 m but very variable
Floodplain: In places 8 km wide.

Bathymetry. Both systems are not more than 2 m deep at low tide (pers. obs., September 1978).

Geomorphology.
Geology. With a catchment extending back into the Drakensberg, geological characteristics are extremely varied. 34 km from the sea bedrock is of Stormberg basalts, while 43 km from the sea, decomposed granite underlies the floodplain ([257]). These are overlain by silt and sand typical of lagoonal deposits.

Nature of bottom materials. From the estuary, *sensu stricto*, there is no information available on this subject. The nature of the sediments which comprise the floodplain are

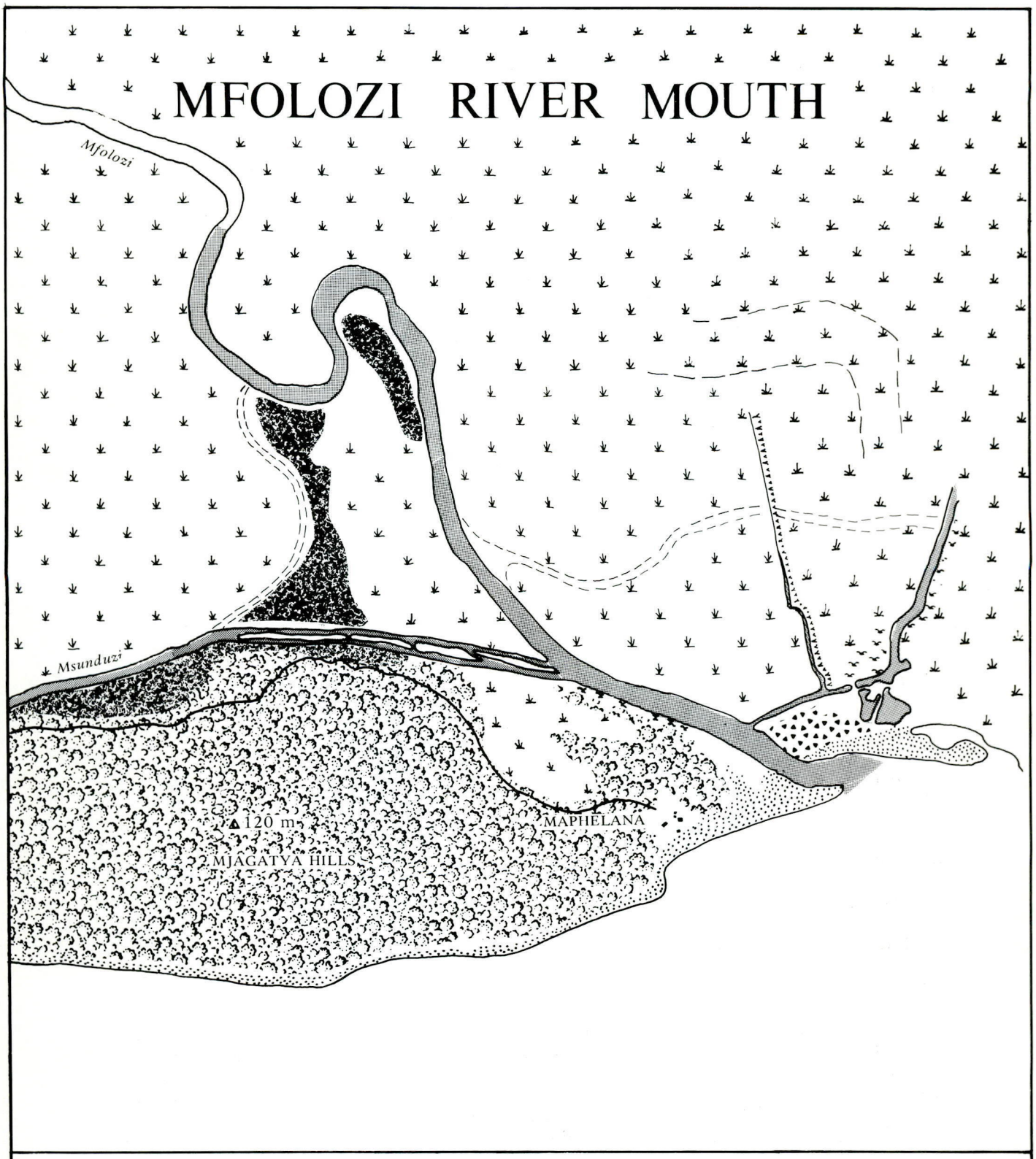

MFOLOZI RIVER MOUTH
Mfolozi
Msunduzi
▲120 m
MJAGATYA HILLS
MAPHELANA
Coastal Dune Forest
Casuarina
Swamp Forest
Reed Swamp
Mangroves
Former Courses of Mfolozi
500 0 500 1000 1500 2000 metres

Fig. 19

illustrated by Orme ([257]) (see Fig. **20**) at a distance of 30 km to 40 km from the sea. According to the Zulus the colour of the mud from each of the Mfolozi rivers is different — consequently the 'Mfolozi emnyama' carries black mud and the 'Mfolozi emhlope' carries white mud ([289]).

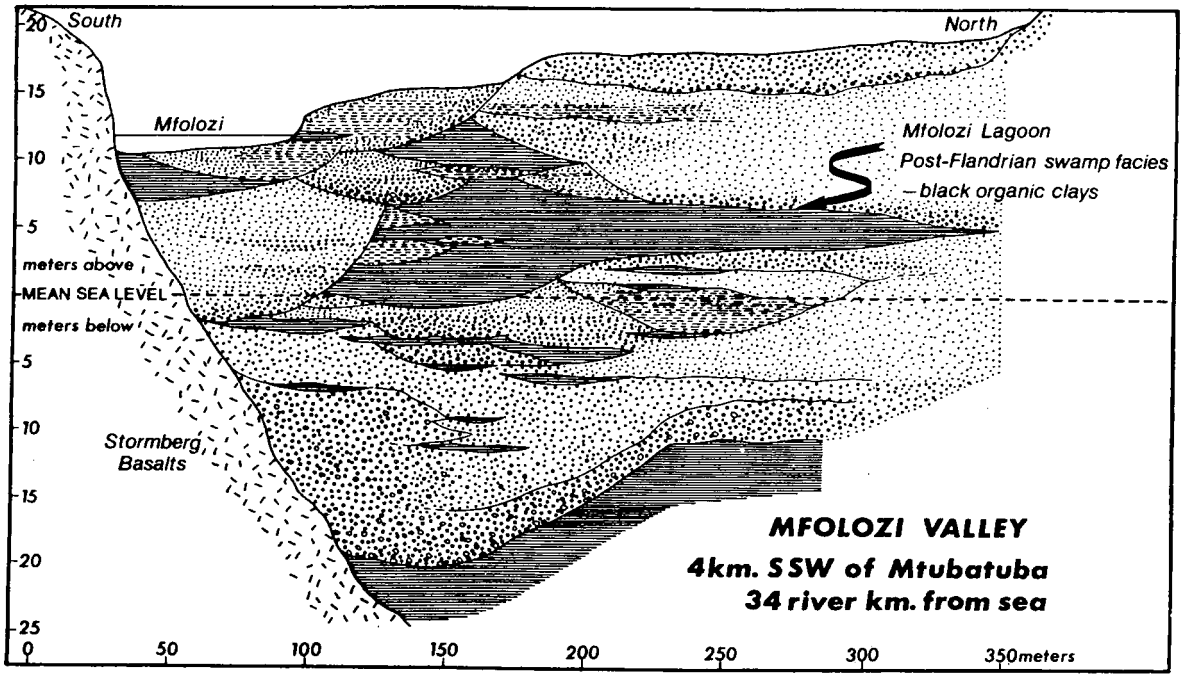


Fig. 20. Cross-section through the Mfolozi valley near the head of the former Mfolozi lagoon (after Orme, 1974 ([257]).

Dredging is an on-going activity in the Msunduzi estuary; the spoil being dumped as levees on both sides of the system.

Sandbar characteristics. The sandbar at the mouth of the Mfolozi-Msunduzi system is ±600 m long and north extending. The combined flow from the Mfolozi-Msunduzi keeps the mouth of the estuary open, although during drought years the mouth may tend to close. Whether it is artificially re-opened by sugar farmers on such occasions, could not be established.

Configuration of the adjacent shore. No record.

Surf zone currents. North directed ([257]).

Physico-chemical characteristics

The Mfolozi river system was subjected to a comprehensive study in 1967/68 by Archibald *et al* ([21]). There was little evidence of disturbance in the White Mfolozi and the Black Mfolozi was polluted only at its source, by sulphates from coal mines. Below the confluence however, heavy pollution from the Mfolozi Sugar Mill was apparent in the winter of 1967. The water smelled of molasses and the river bed was covered with organic slime and sewage fungus. Due to the flat gradients of the river bed, the likelihood of self purification was poor. Consequently the conditions revealed (see Table **4**) were probably reflective of those in the estuary at the time. No samples were taken during the rainy season at this station, however, appreciable variation in chemistry is said to be typical of the Mfolozi river ([270]).

The high content of dissolved solids (sodium and chloride) from the Msunduzi river (see Table **4**) above Lake Teza are unusual, but this data is virtually all that is available on this system.

Public health aspects

Bacteriology ([21, 270]). There is hardly any information available which throws any real light upon bacteriological conditions in the Mfolozi or Msunduzi estuaries. From the following table, it can be seen that *Salmonella* was isolated in both the wet and the dry season from a point ±60 km above the estuary. Sampling below the mill was for some reason either not undertaken or not reported upon.

Table 4. Physico-chemical characteristics ([21]).

Locality: Mfolozi/Msunduzi	MFOLOZI 17km above estuary	MSUNDUZI above Lake Teza	
	Winter 1967	Winter 1966	Winter 1967
Hydrogen ion concentration (pH)	7.6	8.1	8.0
Saturated pH value	7.6	-	7.0
Conductivity micromhos/cm	500	1 946	1 887
Total dissolved solids ppm (calculated)	294	-	1 194
Dissolved oxygen mg/litre	3.0	-	6.7
% Saturation	29	-	70
Oxygen absorbed mg/litre	1.1	-	0.5
Kjedahl nitrogen "	0.8	-	0.3
Nitrates "	.18	-	.32
Phosphates "	.27	-	.30
Total alkalinity "	176	469	463
Total hardness "	180	452	437
Calcium "	32.6	76.6	68.8
Magnesium "	24.0	63.3	64.4
Sodium "	42.5	257	305
Potassium "	4.9	1.3	2.4
Sulphate "	11.5	23.7	21.8
Chlorides "	54.7	133	434
Silica "	-	9.9	-
Fluorides "	0.4	-	0.3
Free carbonic acid (as ppm carbon dioxide)	8.6	-	9.3
Temperature ^{o}C	13.0	-	17.1
Appearance	Poor	-	Good

Values underlined significant of disturbance.

Date	*E. coli* I per 100 ml (Confirmed)	Total Coliforms per 100 ml	*Salmonella* per 250 ml
26 September 1967	378	480	+
20 February 1968	1 050	1 450	+

+ = significant of disturbance.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora [130, 344].

The Mfolozi estuary is surrounded by classical floodplain communities in the form of papyrus and reedswamps. However these are but a tiny remnant of what the Mfolozi swamps (pre-agricultural exploitation) really were like. Overlooking the floodplain of the Mfolozi and Msunduzi is the well preserved evergreen coastal dune forest of the Mjagatya Hills [289] —

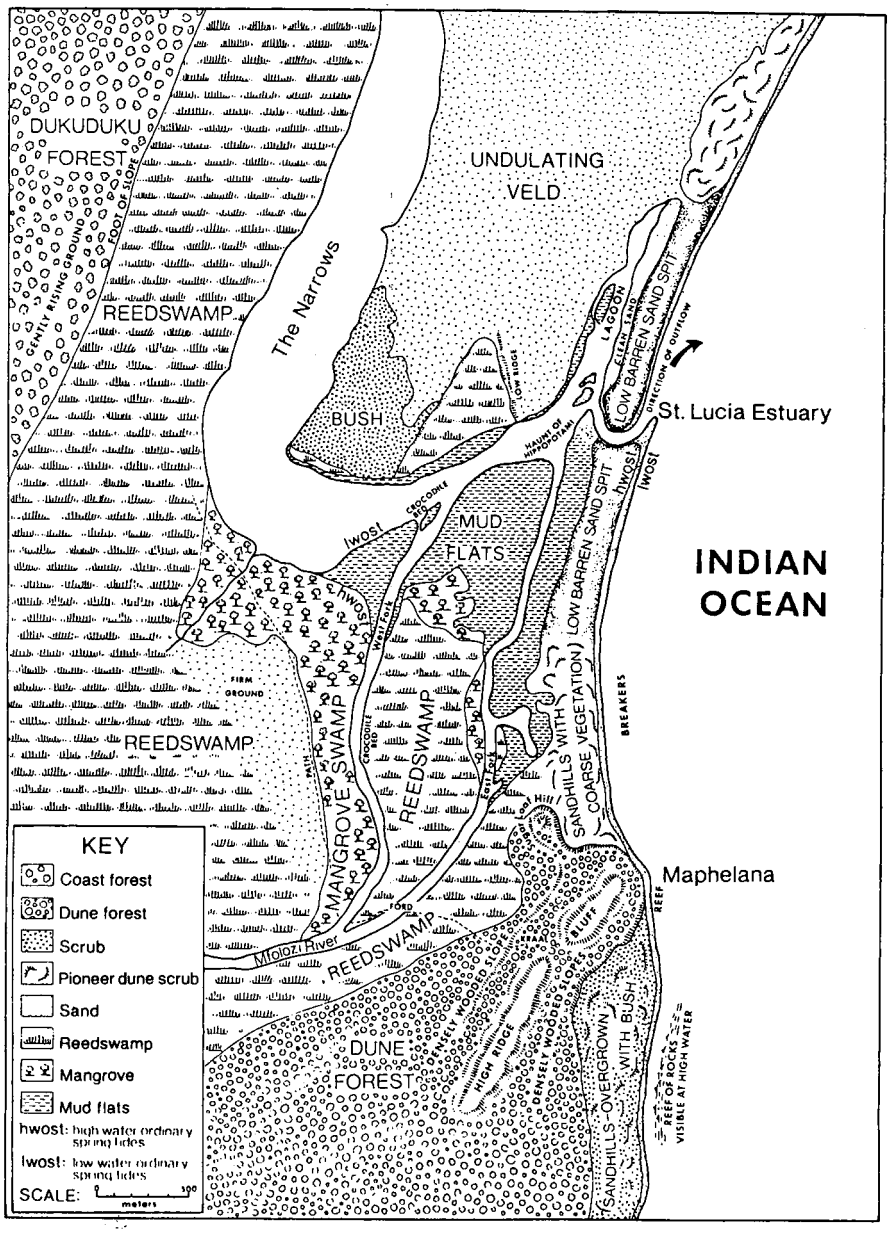


Fig. 21. Plant communities in the vicinity of the Mfolozi estuary (after Croft's survey in 1905) [257].

among the most beautiful in Zululand. On the edges of the dune, alongside the Msunduzi, *Barringtonia* is well established and a belt of swamp forest extends onto the floodplain in a westerly direction. True mangroves between the Mfolozi and St. Lucia ([257]) have become greatly reduced in extent. Some tall specimens of *Bruguiera* (the black mangrove) do however occur on the old distributary channels of the Mfolozi delta (Ward, pers. comm.). Fig **21** (reproduced by Orme ([257]) is reflective of the botanical communities in the vicinity of the Mfolozi estuary in 1905. In general the vegetation surrounding the Mfolozi estuary is worthy of protection as associations of this particular form are seldom encountered elsewhere. *Casuarina* on the northern bank of the Mfolozi mouth are presently in the process of being mechanically removed, on the pretext that they obstruct movement of the channel (Daniel, pers. comm.).

Fauna

There is hardly any information on the fauna of the Mfolozi or Msunduzi estuaries. Both are known to be inhabited by crocodiles and the Mfolozi has some 25 hippo resident in the estuary ([293]).

Bird counts by Sinclair in 1972 to 1973 (pers. comm.) have revealed the presence of 62 species of estuarine associated birds. Such diversity is to be expected, however none of the species were present in exceptionally large numbers. A wide spectrum of waders, duck, geese, fish eating birds (kingfishers, fish eagle, cormorants, herons) and large birds such as pelicans, flamingos and storks were present.

SYNTHESIS

Both the Mfolozi and the Msunduzi estuaries are poorly understood, and both warrant attention, if only to establish the limits of salt water penetration, and to what extent they are utilized by estuarine species of life. In their present environmental condition both systems are degraded, but still worth protecting, principally because of their flora in the form of the Maphelana dune forest and the swamp forest and papyrus on the floodplain. Virtually all of the problems which reflect themselves are sugar cane associated. These are:

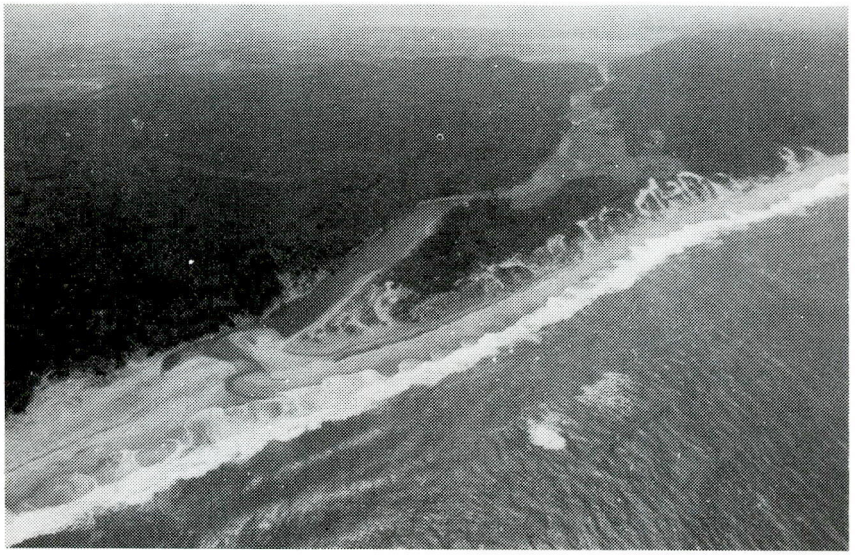
(a) swamp destruction;
(b) dredging and levee construction (flood control);
(c) organic pollution;
(d) cane encroachment, and
(e) siltation.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora			Fauna							Food Webs
MFOLOZI/MSUNDUZI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids							★				★											←★→			←★				→		
Source of Information	Summary of available information																															
Dept. of Irrigation	1948	286			●					●														●								
Davies	1964	106	●	●					●																							
Feely	1965	130																						●								
Kemp & Sibbald	1966	205			●						○																					
Archibald *et al*	1967 to 1968	21	●		●						○				○								○									
Wiseman & Garland	1968	344																						●								
Orme	1971	256,257	●		●			●	●	●																						
Chew & Bowen	1971	78	●																													
Sinclair	1972 to 1973	pers. comm.																									●					
Porter	1976	270	●																													
Weiss & Midgley	1976	339	●		●					●																						
Hutchison	1976	191			●																											
Taylor	1976	293																											●			
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 250	1976	211,218, 227		●						●												●		●								
1:25 000 Job No. 251	1976	379-382	●	●						●														●								

2.1.2.3 **NHLABANE**

Introduction

The Nhlabane estuary was, until recently, one of the most unspoilt and least known systems in Natal. It was an estuary connected to a lake system which comprised a large upper lake (totally fresh in its characteristics) and a lower brackish lake — both being connected to the sea by a narrow 4 km long estuary which wound its way between the coastal dunes. On some maps (e.g. 1:500 000 of Natal) it is shown as having no connection to the sea, although admiralty charts dating back to 1884 in the Natal Archives, show such a connection quite clearly.



A general aerial view of the Nhlabane system (photo by P. Camp).

Its presence and its prospective fate (barrage construction) had gone unnoticed to most estuarine workers, largely as a result of the attention then being given to the Richards Bay Harbour Development and the great faith expressed in the outcome of the Richards Bay Sanctuary proposal. When one considers the potential the Nhlabane system had as an estuarine system, and the willingness expressed by the Richards Bay Minerals (RBM) Project to mine in its vicinity in such a way as to impose the least environmental disturbance ([19]), it is a great pity that more consideration was not given to preserving what we could of the Nhlabane estuary.

Synonyms

Hlobane ([200]).

Zulu meaning

No record although "Nhlaba" means "to stab" (Jansen, pers. comm.).

Location

The Nhlabane system lies between 28°36'S and 28°40'S; and 32°15'30"E and 32°17'30"E.

Accessibility

The Nhlabane is 30 km north north-east of Richards Bay and accessible either along the untarred private roads of the RBM Project or along similar roads through the Kwambonambi Forest Reserve. By road this means the system is some 215 km north east of Durban.

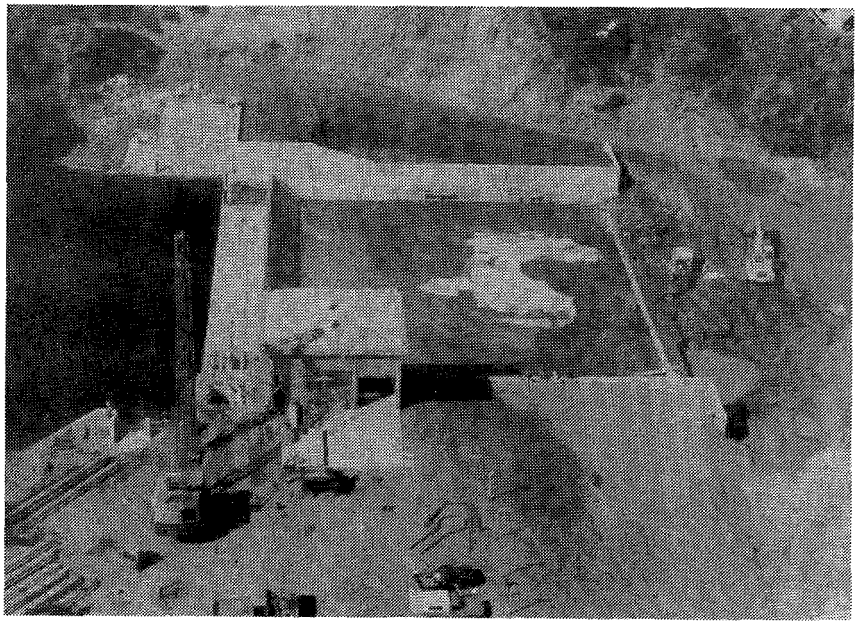
Bridges

There is a solid concrete barrage (the crest of which serves as a footbridge) across the estuary, 3 km from the mouth. This was completed in August 1977 to increase the water level in the Nhlabane lakes to 3,8 m ([74]) above sea level in order to meet the demands of the RBM Project (Tisand (Pty) Ltd).

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 85 km^2 ([200]); 93 km^2 ([74]); 135 km^2 (NTRPC).



Nhlabane barrage under construction in September 1976 (photo by P. Camp).

River length. There are several feeder streams entering the system the longest being ±12 km.

Mean annual run-off. 29 x 10^6 m^3 ([74]). Drainage is from marshes and underground water supplies, the water table being particularly high in the area.

Flow. No record.

Flood history. 1:100 year floods have been estimated to discharge 347 m^3/sec (Campbell, Bernstein & Irving, pers. comm.)

Dams. The RBM barrage was built to supply up to 2 300 m^3 of water **per hour** to the Tisand smelter and dredgers ([74]). Without supplementation from some other source, there seems to be some doubt as to whether the lake can maintain this requirement (Campbell, Bernstein & Irving, pers. comm.).

Siltation. No quantitative records are available. However because much of the system's former area is now an extensive reed bed along the original shoreline, siltation appears to have been severe at some stage in the past. Orme has suggested that since the Flandrian transgression (which culminated 5 000 years before present) the surface water area of Nhlabane has been reduced by 83,5% ([256]). The present day surface water area of both lakes is given as a 4 km^2 ([256]) to 4,4 km^2 ([74]). Although the Bantu Reserve surrounding the system does not appear to be in an eroded condition, reports of silt laden water extending into the sea as a plume opposite the Nhlabane mouth, when in flood, do exist. If this is the case, barrage construction may well accelerate the rate of deposition within the Nhlabane lake system.

Land ownership/use. 73% of the catchment area is at present Bantu influenced (Bantu Reserve No. 4) but being one of those areas that is to be excised from KwaZulu, any such influences should diminish in the future. The remainder of the catchment is under gum/pine plantations which comprise the Department of Forestry's Kwambonambi Reserve. RBM (Pty) Ltd are also land owners in the catchment, nearer to the coast, where mining of the coastal dunes for titanium is in progress.

Most of the land adjacent to the estuary is undeveloped and undisturbed and in virtually pristine condition.

Local authority. Department of Forestry (KwaZulu).

Estuary uses. The Nhlabane lake/estuary system has become an essential source of water for the RBM mining operation.

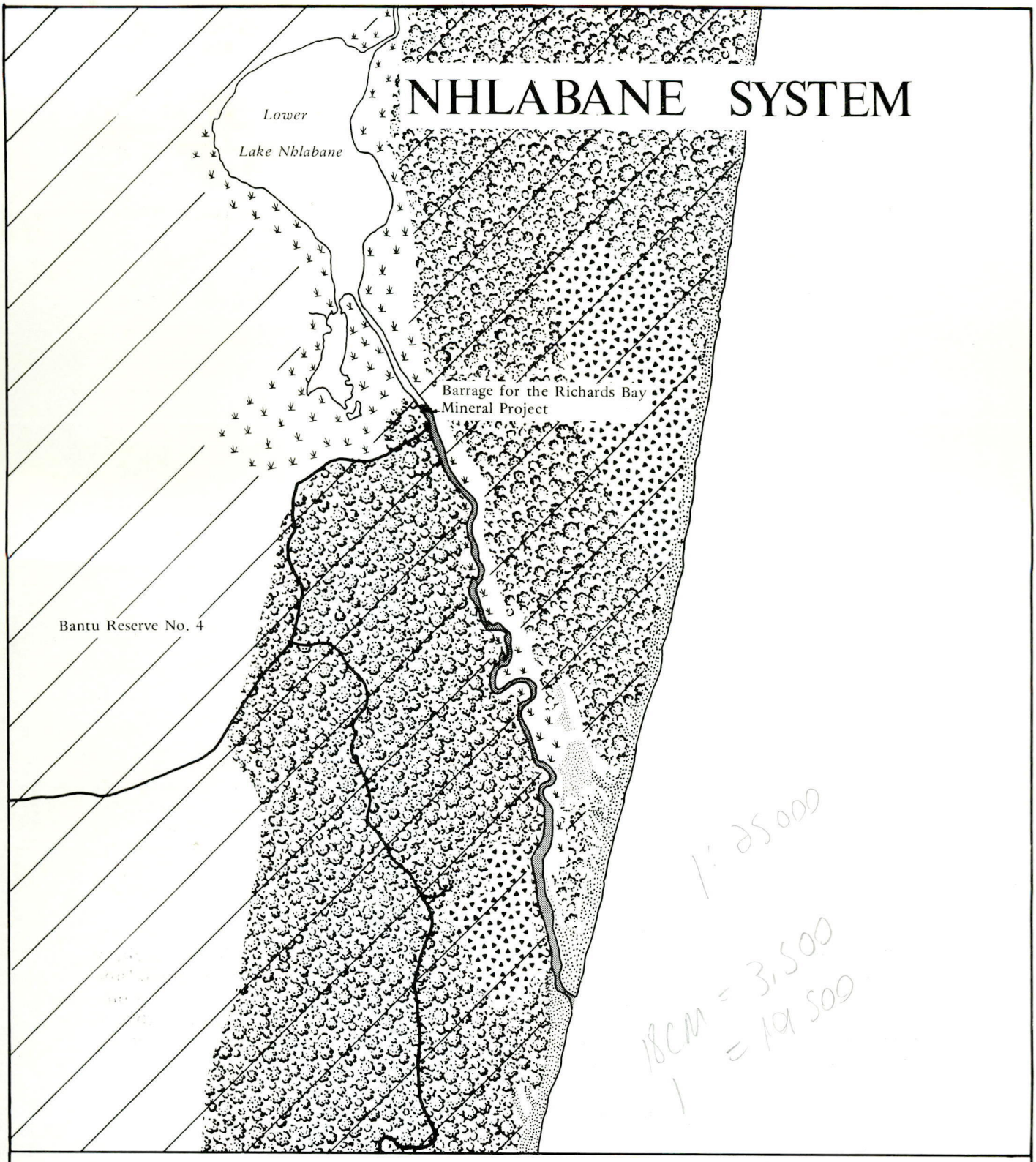

NHLABANE SYSTEM
Lower
Lake Nhlabane
Barrage for the Richards Bay
Mineral Project
Bantu Reserve No. 4
Coastal Dune Forest
Reed Swamp
Exotic Plantations Casuarina
KwaZulu
500 0 500 1000 1500 2000 metres

Fig. 22

Morphometry of the estuary (see Fig. **22**)

Area. Originally 120 ha, this having become reduced by barrage construction to 17 ha.

Axial length. Originally 6 km, this having become reduced by barrage construction to 3 km.

Shoreline length. Originally 14 km, this having become reduced by barrage construction to 6 km.

Width.

Maximum: In its lower reaches the estuary is in places 55 m wide. In the upper reaches (pre-barrage construction) some places were up to 1 km wide.

Mouth: 15 m

Floodplain: Over 1 km wide above barrage.

Volume. Volume estimates of the lower lake Nhlabane are 10×10^6 m^3 ([74, 200]).

Bathymetry. 200 m above the barrage depths of 3,5 m were measured in September 1977 (pers. obs.). Below the barrage the estuary is seldom deeper than 1,8 m.

Geomorphology

Geology. According to interpretations of the Department of Geological Survey, the Nhlabane system is surrounded by Upper Pleistocene-Holocene sands and aeolianite (du Preez, pers. comm.).

Nature of bottom materials. No record.

Sandbar characteristic. The Nhlabane sandbar is not a particularly massive structure, but has both a ±150 m long south extending component as well as a ±100 m long north extending component, between which the mouth of the estuary (when open) winds its way to the sea. The whole estuary lies orientated along a north north-east to south south-west axis and approaches the sea at an oblique angle behind a south directed sand dune. The mouth is generally closed, but opens two or three times per year after heavy rain. The mouth position varies but is generally against the south bank.

Breaching. According to local sources of information the Africans have regularly breached the Nhlabane bar, in order to permit the entry of estuarine fish which they can then catch. Breaching was undertaken by RBM (Pty) Ltd during the period of barrage construction.

It is noteworthy that Campbell, Bernstein & Irving mistakenly considered that adverse ecological effects would not arise from barrage construction, because the tendency for the system to empty itself to the sea would be overcome ([74]).

Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

The only information available on the physico-chemical characteristics of the Nhlabane estuary are those kindly provided by RBM (Pty) Ltd, who routinely monitor water quality because of their interest in its corrosivity. The range in these parameters measured at the barrage site pre- and post-barrage construction, are presented in the following table:

		Pre-barrage construction	Post-barrage construction
		Feb. 1976 to Jan. 1977	March 1977 to Aug. 1977
Hydrogen ion concentration		6,5-7,2	5,5-7,1
Total dissolved solids	mg/litre	92-1 554	99-261
Suspended solids	mg/litre	2-26	3
Total hardness	mg/litre	25-276	12-34
Calcium hardness	mg/litre	12-68	7-13
Magnesium hardness	mg/litre	13-208	5-21
Chloride	mh/litre	42-682	44-94
Sulphate	mg/litre	17-104	17-42
Sodium	mg/litre	20-380	27-55
Potassium	mg/litre	3-9	1-2
Conductivity µmhos		1 630	210-420
Carbonic acid	mg/litre	—	5-40
Iron	mg/litre	—	0,3

With pre-barrage construction indices such as total dissolved solids (as high as 1 554 mg/litre), chloride (as high as 682 mg/litre) and sodium (as high as 380 mg/litre) it can be seen that the Nhlabane was clearly sea water influenced. From the analyses made after barrage construction it is equally clear that such characteristics have been eliminated. Barrage construction has brought about the transformation of the system from a "brack" condition to a "fresh" condition, which in an estuarine context is an unsatisfactory state of affairs.

Public health aspects

Bacteriology. Bacteriological examination of the water from the Nhlabane has been undertaken by the State Department of Health as well as other consultants, on behalf of RBM (Pty) Ltd. The results have revealed that no faecal pollution is evident (Camp, pers. comm.).

Bilharzia. Vector snails have never been found (Camp, pers. comm.) — but it is likely that they do occur in the upper lake, and now with barrage construction (impoundment), probably in the lower lake as well.

BIOTIC CHARACTERISTICS

Flora

Below the barrage the estuary winds across a narrow floodplain, dominated by *Phragmites*, and completely surrounded on both sides by *Acacia karroo* and luxuriant coastal dune forest. The vegetation is indicative of water seepage from the dunes. At the coast *Casuarina* has been planted on the southern bank.

Above the barrage the lower lake Nhlabane is dominated by reed swamp communities along all shores. The main constitutent is *Phragmites australis*, but *Cyperus*, *Scirpus* and *Juncus* also occur. Submerged aquatic plants (*Potamogeton pectinatus*, *Utrichularia*, *Ceratophyllum et al*) are present. West of the lake open grassland (*Helichrysum*) is found with an occasional stunted umdoni (*Syzigium*) in an area denuded of its forest cover by Bantu ([200]). A section of swamp forest has been adversely affected by a road serving the RBM pump installations.

Fauna

Regrettably, there is very little information available on the fauna of the Nhlabane system — although some has been obtained from local sources and from a few notes contained in unpublished reports ([68, 201]).

Fish. In 1958 netting in the upper lake by Crass (pers. comm.) yielded both fresh water and estuarine species of fish, such as tarpon (*Megalops cyprinoides*), mullet (*Mugil cephalus*) et *al*. Africans living alongside the lake net heavily, catching primarily barbel (*Clarias*) and bream (*Sarotherodon*) and by artificially breaching the Nhlabane sandbar permit the entry of estuarine fish. Locals who fished the estuary a few years ago, claim to have caught garrick (*Hypocanthus*), springer (*Elops machnata*) and mullet. After the barrage was completed (August 1977) fish mortality upstream revealed the presence of perch (*Acanthopagrus berda*) and glassies (*Ambassis commersonni*) (pers. obs. September 1977). Amongst a sample of fish brought in by RBM (Pty) Ltd to the Oceanographic Research Institute (on 14 October 1976) prior to barrage construction, were nine estuarine species all "typical of a small low salinity estuary" (van der Elst, pers. comm.).

After consultation with the Natal Parks Board, RBM (Pty) Ltd were advised that a fish ladder around the barrage would serve no purpose ([201]). This decision was based upon the difficulty entailed in maintaining a constant outflow of water down the ladder; the doubt that juvenile fish would use the facility; and because raised water levels and the lack of salinity upstream, would enhance conditions for the fresh water fauna.

Birds, mammals and reptiles. Species lists compiled by Camp ([68]) are available on each of the above components of the fauna in the mining lease area.

20 of the 66 species of birds recorded were lake or estuary associated. The absence of terns and waders is noteworthy but duck, geese and fish eating birds are well represented.

The whole system contains many crocodiles — a good proportion of which are apparently found in the estuary.

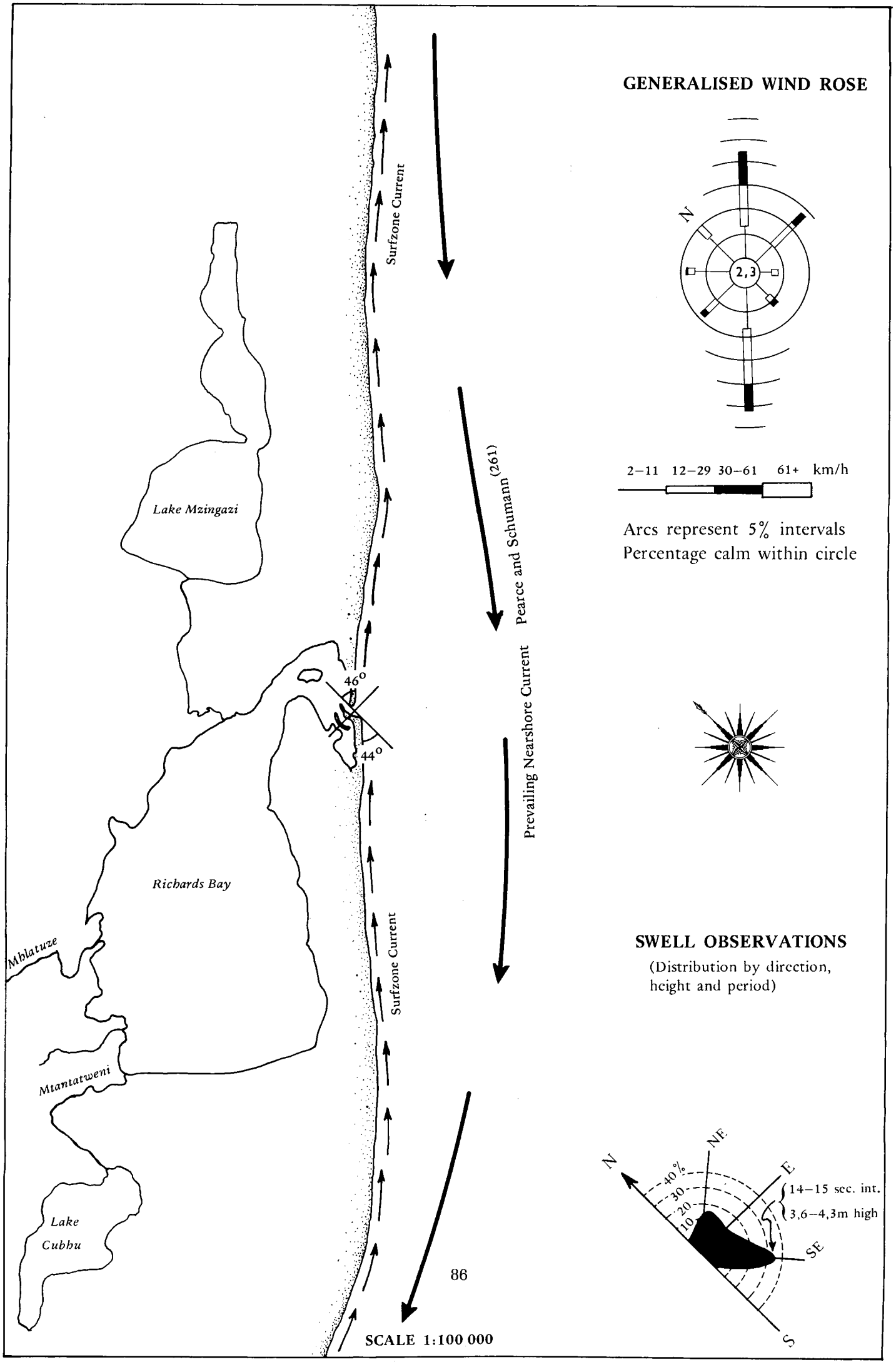
Hippo (moving from St. Lucia) have been known to use the upper of the two Nhlabane lakes.

SYNTHESIS

In conclusion our state of knowledge of the Nhlabane estuary is regrettably very poor, largely due to it having been completely overlooked in the past. The Nhlabane certainly warrants investigation, not only to establish to what degree estuarine life utilizes the lower reaches of the Nhlabane below the barrage, but also to establish how much water should be permitted over the barrage to ensure the periodic opening of the mouth to the sea.

Although disturbed in its present day environmental condition, the Nhlabane system has distinct conservation value, due to the quality of the water, the vegetation and the fauna which it supports. Utilization should be confined to water abstraction, and that sector below the barrage, including the adjacent forest, should be protected as a coastal lagoon. Barrage construction across the Nhlabane estuary remains as the system's only problem, a solution to which, cannot really be contemplated at this belated stage.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																								BIOTIC									
			Physiography		Physics				Geomorphology			Chemistry					Bacteriology	Other								Flora			Fauna								Food Webs
NHLABANE			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles					
Data Voids					←	★	→																				★			→					
Source of Information	Summary of available information																																			
Crass	1958	pers. comm.																									●								
Orme	1971	256								●																									
Campbell, Irving & Bernstein	1972	74	●	●	●																														
Joubert	1972	200			●															●			●												
Joubert	1976	201																		●															
van der Elst	1976	pers. comm.																									●								
Tisand (Pty) Ltd.	1976 to 1977	pers. comm.									●																								
Camp	1977	68																											●	●					
Anon	1978	19																		●			●												
Aerial photos (Scogings)		No.																																	
1:10 000 Job 250	1976	200 to 209		●						●																									
1:25 000 Job 251	1976	310 to 396	●	●																															


GENERALISED WIND ROSE
N
2,3
2–11 12–29 30–61 61+ km/h
Arcs represent 5% intervals
Percentage calm within circle
Surfzone Current
Pearce and Schumann (261)
Prevailing Nearshore Current
Surfzone Current
Lake Mzingazi
Richards Bay
Mhlatuze
Mtantatweni
Lake Cubhu
46°
44°
SWELL OBSERVATIONS
(Distribution by direction, height and period)
N
NE
E
SE
S
40%
30
20
10
14–15 sec. int.
3,6–4,3m high
SCALE 1:100 000

RICHARDS BAY

Introduction

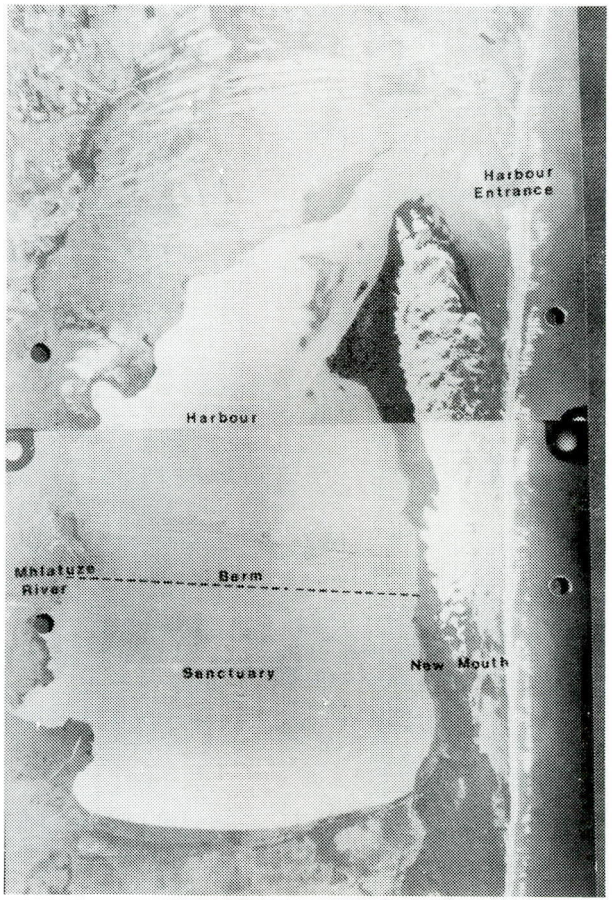
Ever since the turn of the 20th Century, surveys of Richards Bay have been carried out to determine its potential as a deep water harbour ([88]). Development began in earnest in the 1970's after a consortium of overseas companies was awarded the contract to build the new port. The estimated cost of the project is in the order of R600 million ([16]), its principal function being to serve the Transvaal coal mines. The harbour was officially opened in April 1976.

The development of Richards Bay has been the centre of much interest as "Natal's great environmental experiment" ([15]) and as an exercise in interdisciplinary communication ([173]). This is because, although not originally planned ([173]), the development of Richards Bay involved its division into two sections by a 4 km long causeway, "levee" ([166, 170]) or "berm" (see Fig. **23** & **24**). To the north east of this berm, unrestricted harbour and industrial development was to proceed; whilst to the south west of the berm, the bay was to be left "undisturbed" as a nature reserve (or sanctuary area), but only after the creation of a new mouth to the sea and the diversion of the Mhlatuze river ([20]).

In this review the Richards Bay system has been treated in the following way:

(a) A review of conditions pre- and post-harbour development, to determine the changes or impacts that can be associated with harbour development.
(b) In the section on post-harbour development — a review of conditions in the harbour (where a Durban Bay type situation is developing) as distinct from conditions in the Sanctuary (where transitions more normally associated with Natal's estuaries occur).

Separation of 'the harbour' from 'the sanctuary' by the berm wall (which required six million cubic metres of fill ([14])) was considered desirable for several reasons ([10, 97, 179]).



Richards Bay in its predeveloped state (22 December 1964) with proposed alterations shown (Photo by Air Survey Co. of Africa).

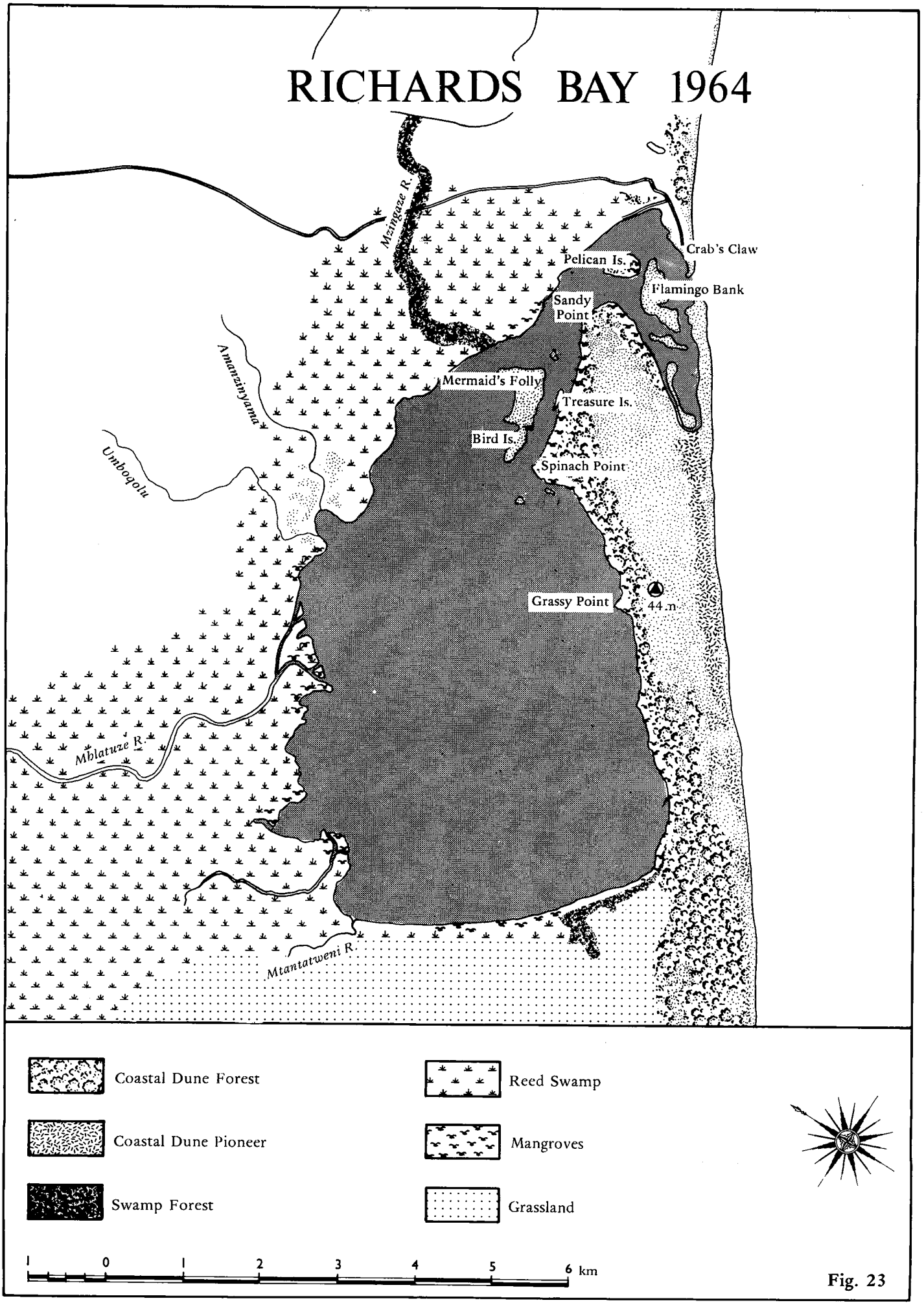

RICHARDS BAY 1964
Mzingazi R.
Crab's Claw
Pelican Is.
Flamingo Bank
Sandy Point
Amanzinyama
Mermaid's Folly
Treasure Is.
Bird Is.
Umboqolu
Spinach Point
Grassy Point
44 n
Mhlatuze R.
Mtantatweni R.
Coastal Dune Forest
Coastal Dune Pioneer
Swamp Forest
Reed Swamp
Mangroves
Grassland
1 0 1 2 3 4 5 6 km

Fig. 23

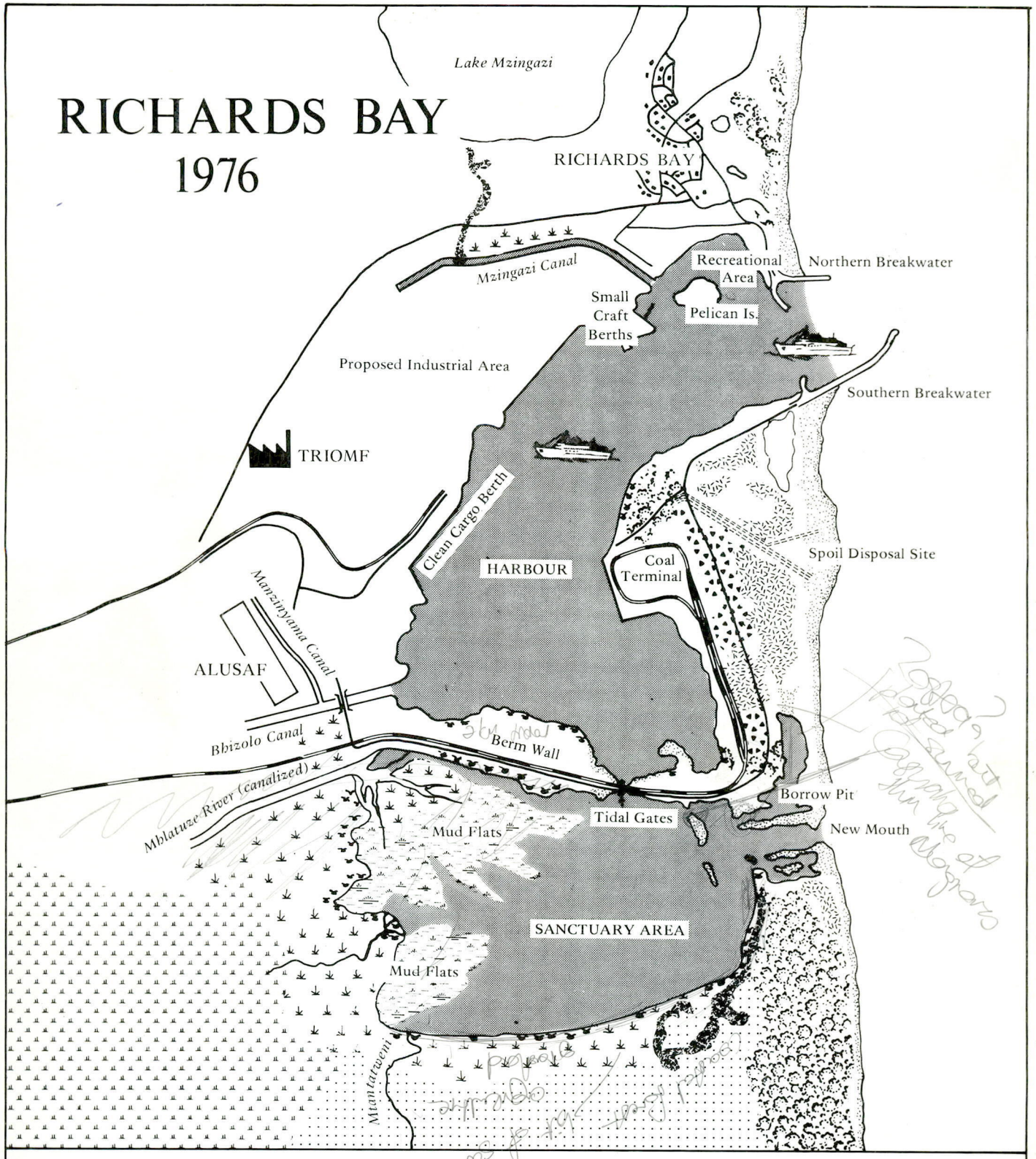

RICHARDS BAY
1976
Lake Mzingazi
RICHARDS BAY
Mzingazi Canal
Recreational Area
Northern Breakwater
Small Craft Berths
Pelican Is.
Proposed Industrial Area
Southern Breakwater
TRIOMF
Clean Cargo Berth
HARBOUR
Coal Terminal
Spoil Disposal Site
Manzimyama Canal
ALUSAF
Bbizolo Canal
Berm Wall
Mblatuze River (canalized)
Mud Flats
Tidal Gates
Borrow Pit
New Mouth
SANCTUARY AREA
Mud Flats
Mtantaweni
Coastal Dune Forest
Coastal Dune Pioneer
Exotic Plantations - Casuarina
Swamp Forest
Reed Swamp
Mangroves
Grassland
Cane
1 0 1 2 3 4 5 6 km

Fig. 24

(1) The berm was necessary to provide the means by which road and rail could be taken across the bay to the eastern side of the harbour.
(2) The berm effectively prevented the Mhlatuze silt load from entering the harbour and consequently minimized the necessity for maintenance dredging ([20]).
(3) The berm meant that approximately one third of the original system could be left "undisturbed" and isolated from pollution stemming from the harbour; and thus effluent disposal into the harbour became feasible.
(4) The berm prevented wind generated waves from building up within the bay to the extent that they could have become hazardous when large ships moving at low speeds were attempting to dock.

The earliest biological surveys of Richards Bay were undertaken by Millard and Harrison after two summer and two winter visits during the period July 1948 to January 1951 ([225]).

No more scientific attention was given to the bay until 1969, when pre-development surveys commenced. Such surveys have continued to the present day, and consequently the majority of information available relates to conditions in the 1970's.

The Richards Bay Conservation Committee formulates ecological management policy for the harbour/sanctuary complex, and stimulates further research relevant to management of the area ([20, 172]). The management objectives are:

(a) to maintain water quality in a condition that is adequate for the well being of the fauna that use the complex for all or part of their life cycles;
(b) to maintain or increase biological productivity in the area;
(c) to maintain or increase the areas favoured by juvenile fish and crustacea because of the food and protection afforded by such areas and
(d) to protect the sanctuary and its shoreline environs against unauthorised exploitation of the flora and fauna and consequent environmental deterioration.

What the Committee is in fact trying to do is to make the best of what amounts to a grossly disturbed remnant of Richards Bay.

Synonyms

Richards Bay was named after Sir F. W. Richards ([16, 210]) at one time Commodore of HMS Boadicea who, involved in survey work along the coast, landed British troops at the bay (in 1879) to participate in the Zulu War. Charts dating back to this period (in the Natal Archives) show the bay as the Umhlatuzi lagoon ([16]), and even 25-30 years ago the bay was still depicted as the Umhlatuzi lake ([225]). To early Portuguese navigators it was known as Rio dos Peixos ([16]) and to the Zulus as eChwebeni ([289]).

Meanings

Mhlatuze is said to mean "the river that acts with relentless force". eChwebeni seems to be a general term applied to any large lagoon, meaning "the place of the large sheet of water". Rio dos Peixos means a "river of many fish " ([16, 289]).

Location

The bay system lies between 28°47'S to 28°51'S and 32°00'E to 32°06'E.

Accessibility

Richards Bay is 190 km ([152]) north of Durban, and within the last decade has become served by good road, rail and air services. In a Mercury Pictorial (dated 1 Dec. 1910) access to the Umhlatusi lagoon was considered to be very difficult "owing to the large papyrus swamps" that barred the way. Access into most of the area is presently restricted to permit-holders, due to the normal security measures imposed by harbour authorities.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 4 258 km^2 ([225]); 4 489 km^2 ([257]).

Rivers. Millard and Harrison ([225]) referred to the bay as receiving several large rivers but in fact only the Mhlatuze river can be regarded as large. Virtually all have become canalized or partially canalized as reclamation has proceeded.

Entering the harbour are:

(a) The Mzingaze river (or Umsingasi ([225])) which drains Lake Mzingazi to the north of Richards Bay ([260]).
(b) The Amanzinyama
(c) The Bhizolo (formerly Umboqulu ([225])) or Mhlagabezani ([88]).

} both of which are effluent or drainage canals today.

Entering the sanctuary are:

(d) The Mhlatuze river (or Umhlatuzi) 209 km ([21]) in length and draining a catchment area of 3 660 km^2 ([78]) — 3 936 km^2 ([21]) in extent. It has two major tributaries, the Mfule and the Enseleni (or Nsezi). The lower portion has been canalized and diverted into the sanctuary area.
(e) The Mtantatweni (or Mthantathweni ([152])). formerly the Qupu ([225]) draining Lake Cubhu (or Icubhu ([152]) which lies south of Richards Bay ([260]).
(f) An un-named channel in the south west corner of the sanctuary (formerly an ancient course of the Mhlatuze) which drains the sugar cane lands on the floodplain.

Mean annual run-off. There is a great variation in estimates of run-off. For the Mhlatuze, run-off has been estimated at 157 x 10^6 m^3 ([10]), 435 x 10^6 m^3 ([78]) and 535 x 10^6 m^3 ([152]) (misprinted at 5 356 x 10^8 m^3 in ([85])). Both the Mzingaze and the Mtantatweni are said to yield 3,7 x 10^6 m^3 ([152]). Run-off from the whole catchment is given as 616 x 10^6 m^3 ([225]).

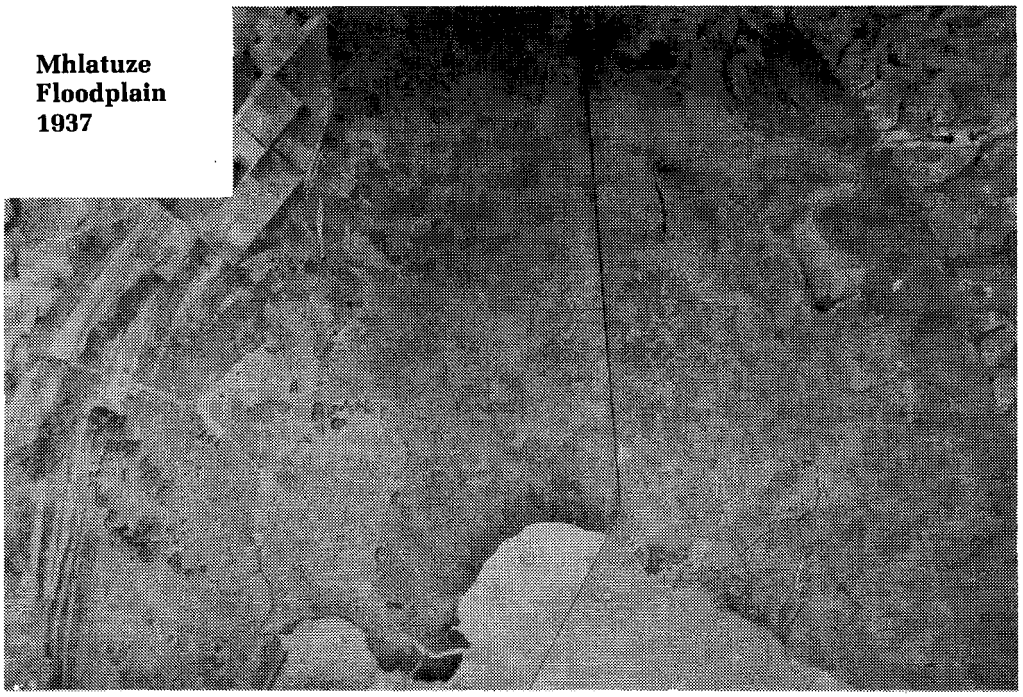
Flow. Flow data since 1921 is available but only for the upper part of the catchment ([21]). The rivers are said to almost cease flowing in the dry season, but never run dry completely ([225]). In times of flood they carry considerable volumes of water into the bay. As an indication thereof mean inflow rates for October 1975 are 351 m^3/sec., for May 1976 489 m^3/sec. and for June 1976 256 m^3/sec. ([168]). The probable average total flow of the Mhlatuze river is 24,7 m^3/sec. ([205]). Flows naturally play an important part in keeping the new mouth of the sanctuary area open. Tidal water velocities in the new mouth have been estimated to reach 7 or 8 knots on certain occasions (Cox, pers. comm.).

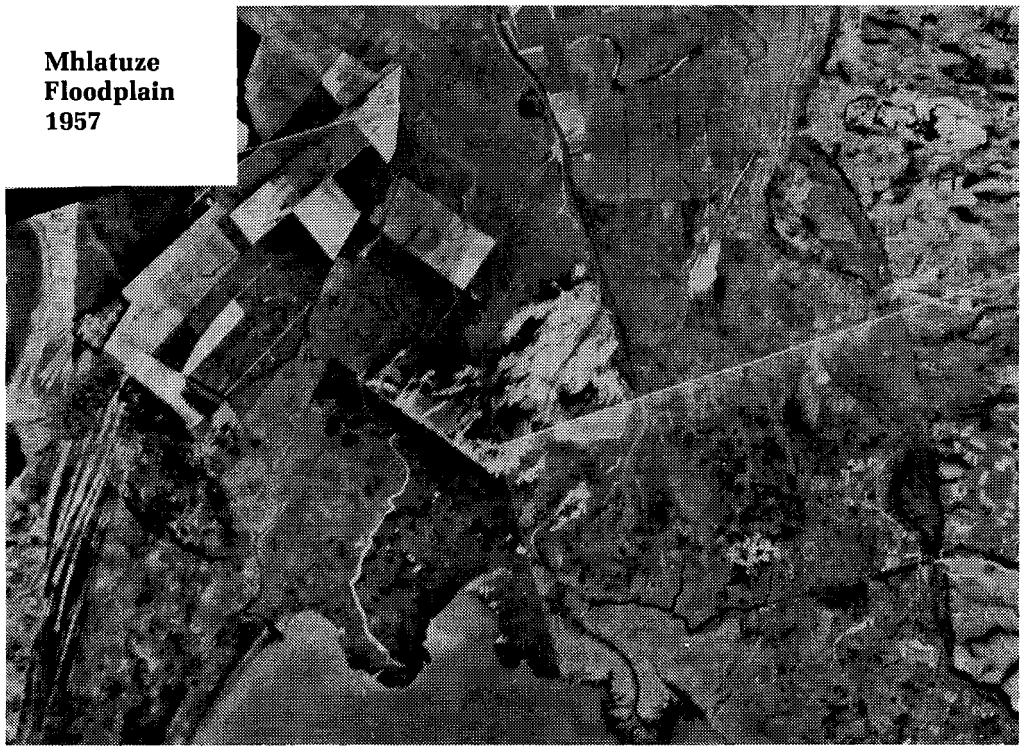
Flood history. Migrations of the Mhlatuze river across its floodplain and old delta are evident from aerial photographs dating back to 1937, and serve to indicate the magnitude of the forces to which the lower reaches of the river system were subjected. Over and above this, the most striking feature of such photos is that no distinct river course is apparent, in fact the river clearly disappeared into a swamp long before it reached Richards Bay.

The Mhlatuze floods are characteristically violent and dramatic events (1:100 year floods are estimated to discharge 4 300 m^3/sec. ([10, 100]) worsened by the fact that the floodwaters are no longer permitted to discharge and disperse across the former 6 km wide floodplain, due to canalization. This, added to the fact that such floodwaters would previously have infiltrated extensive areas of papyrus swamp, have resulted in the much increased soil carrying capacity of the water, because of increased velocities. As a result of confining the floodwaters to within the river, bank erosion has become a serious problem ([179]).

The nature of the Mhlatuze floods resulted in the proposal of a flood control system on the berm wall. This structure was built at great expense and with great difficulty (1 644 pilings, wing walls, abutment walls and hydraulically operated gates set just above the future high tide level) in the centre of the berm to enable the dissipation of floodwaters in the event of the new mouth closing, and to "maintain a salinity balance" ([10, 20]). With the unforeseen range in high tide levels that has since materialized, "topping" of the gates occurs. This means that the harbour is presently **not** isolated from the sanctuary and, in the event of a disaster such as an oil spill, pollutants could enter the sanctuary area.

With the recent influx of silt into the sanctuary, manipulation of the 'tidal gates' has resulted in sediment entering the harbour, to the extent that the gates cannot be properly closed because of siltation at the foot thereof. Once flood control dams on the Mhlatuze are built the tidal gates were to become redundant ([10]). In retrospect therefore it seems that the installation of a flood control system was not warranted — particularly when one considers that if the sandbar did close off the estuary, it could be breached mechanically at very little cost.

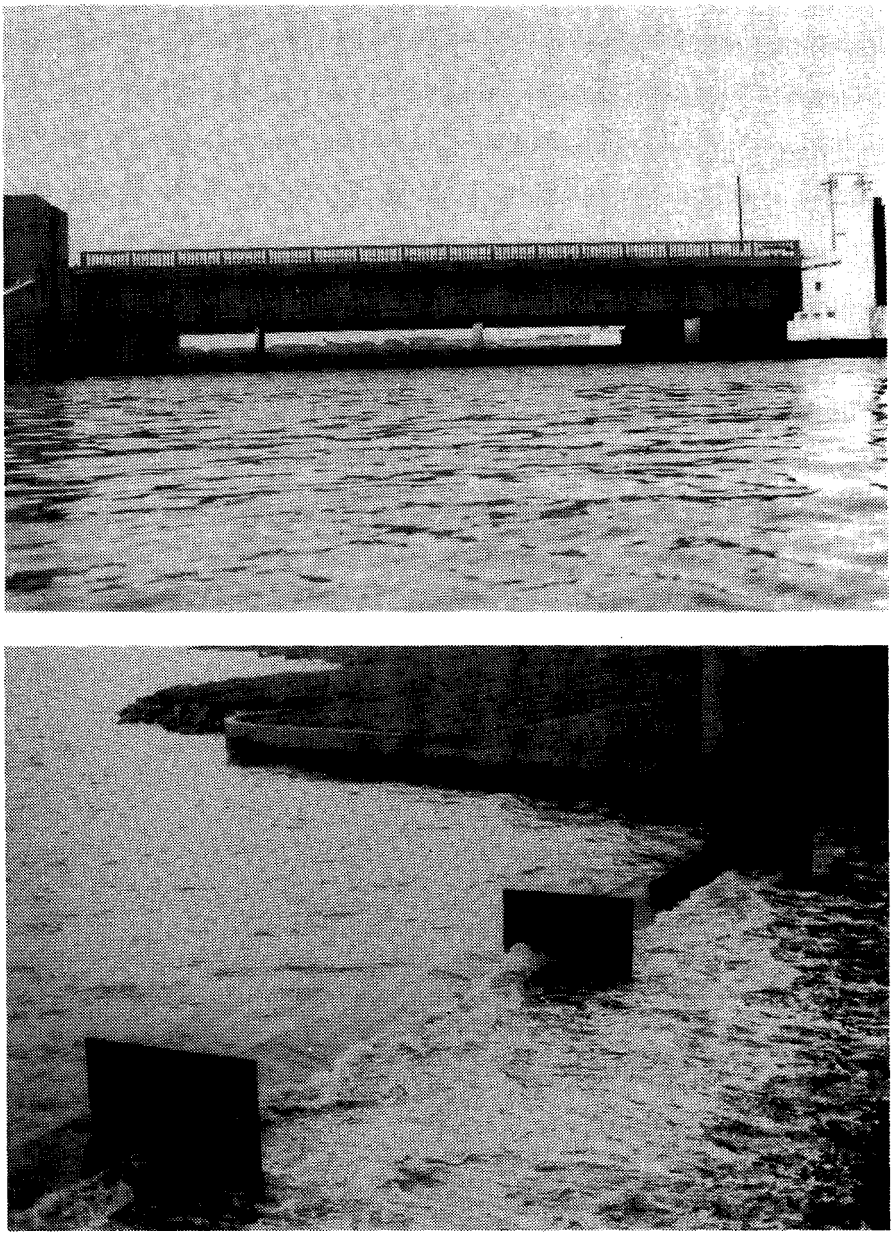




Agricultural encroachment onto the Mhlatuze floodplain.

Tidal range.

Pre-harbour development. The range in tide was restricted by the shallow, partially blocked mouth of the system and was estimated to be 0,35 m ([10, 88]). More specific information as well as the time delay in the tide at low water and high water springs in January 1949 is available ([225]). It is noteworthy that the range of the spring tide in 1949 at Pelican Island increased from 0,1 m in January to 0,27 m after heavy rains in April had scoured out channels and deepened the mouth. Ranges in the vicinity of the sanctuary area were in the order of 0,2 m to 0,3 m ([254]). The average water level in the bay was more than 1 m higher than that outside the bay mouth ([152]).



The tidal gates between Sanctuary area and harbour at Richards Bay. Note overtopping of the gates occuring at high tide on 26 September 1977.

Post-harbour development.

Harbour — The full tidal range of 2,1 m is now being experienced ([10]). In the south west of the harbour, tides are slightly retarded due to hydraulic gradients.

Sanctuary — Although the tide level recorders have been installed (by the SAR & H), no records are as yet available. However, during 1974/75, before the new mouth had been cut, tidal exchange was restricted to a narrow gap in the berm wall (provided for tug access to the dredgers and later for the tidal gates) ([166]). With the opening of the new mouth (August 1975) the sanctuary area has gradually become exposed to an ever increasing tidal range: (i.e. 1,0 m in March 1976 ([254])), which, by April 1977 was 1,63 m on the spring tide ([161])). Estimates of a tidal rise and fall of 1,8 m have recently been made ([20]). In consequence much of the shoreline is flooded at high tide, and over half of the bay floor exposed at low tide ([152, 163]). (Additional information on the subject may be found under those sections devoted to siltation and mouth characteristics.)

An impact with substantial consequences at Richards Bay has been the increase in tidal range in both the harbour and the sanctuary. One of the immediate effects is the mortality of

certain plant communities on the edges of the system which had never previously been exposed to flooding by saline water. Mangroves however have benefitted under the new regime.

A more important consequence is the amount of water exchanged on each tidal cycle (estimated to be 88% by May 1976 ([168]). Whilst beneficial in the harbour as this mechanism will regularly rid the water body of pollutants, it is an adverse relationship in the sanctuary. Here the lack of water retention prevents a plankton population from building up, and denies the system the opportunity to function as "the nutrient trap" which it formerly was ([152]). In other words, incoming nutrients cannot become incorporated into living material by photosynthesis because they are not in the system for long enough. However, it has been suggested that the increased tidal flow into the sanctuary has possibly increased the passive influx of juvenile fish and prawns ([330]).

Dams.

Existing: — The Goedetrouw Dam is presently under construction ±85 km above the bay. It is scheduled for completion in 1980, and will have a capacity of 320×10^6 m^3 (Munroe, pers. comm.).

Proposed: — Two other suitable sites have been located ([78]):
(a) Nduna site on Mfule river ±65 km above the bay.
(b) Normanhurst site ±75 km above the bay. However once the Goedetrouw dam is complete it is doubtful whether this will be built.

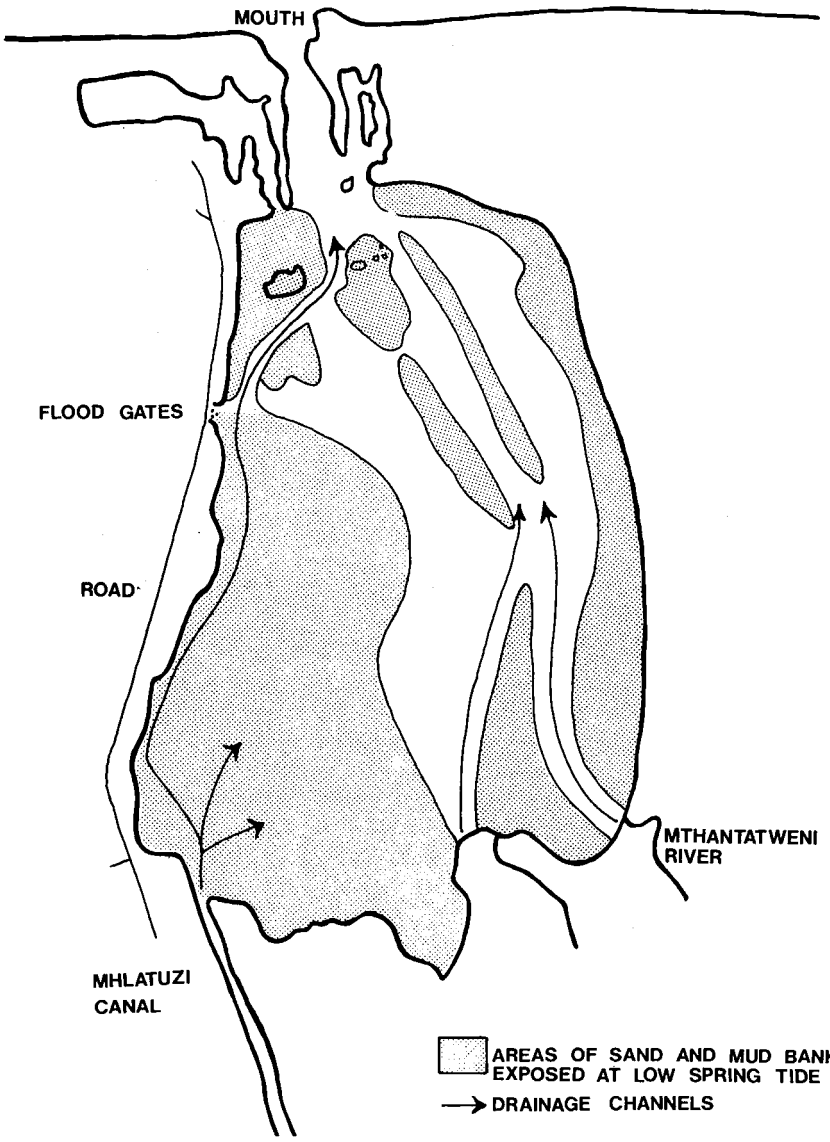


Fig. 25. Areas of sand and mud exposed at low spring tide (2 April 1977) in Richards Bay sanctuary area ([163]).

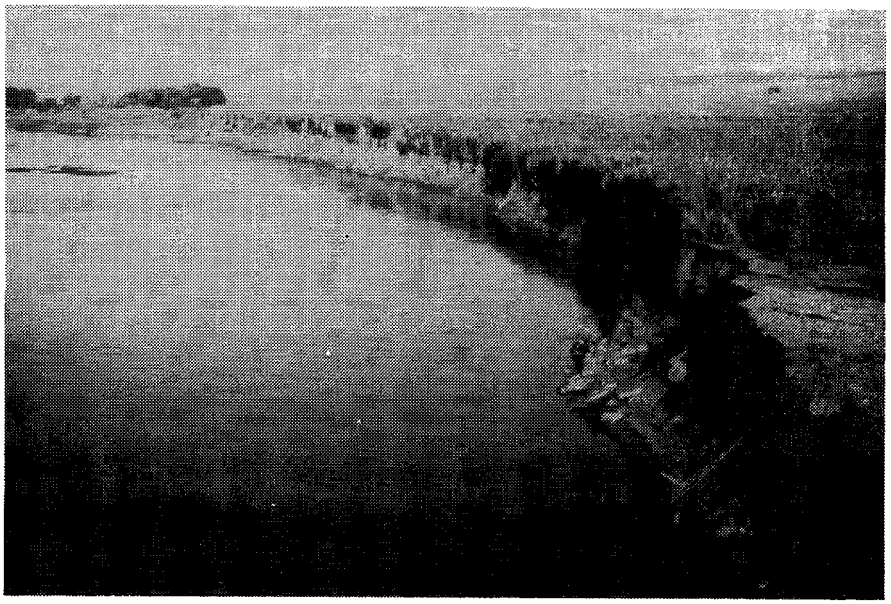
The Department of Water Affairs intended building flood and water supply dams on the Mhlatuze ([10]), because they were necessary to augment the supplies needed for Richards Bay, and to generally promote development in the catchment area.

Siltation.

Pre-harbour development. The average estimated silt load from the Mhlatuze was given as 20 500 tons per annum and the average rate of siltation in the lagoon as 0,7 mm per annum ([10]). Such statements, plus the indication that in 1969 soundings were only ±0,5 m shallower ([152]) than soundings taken in 1903, confirm the opinion of Millard and Harrison ([225]) who considered that Richards Bay has "not suffered so extensively from silting as most of the other estuaries on the east coast of South Africa".

Post-harbour development. This is regrettably no longer the case because over the 1976 and 1977 rainy season alone, in excess of 3,2 million tons of silt and sand were deposited in the sanctuary area ([163]) (see Fig. **25**). This tremendous influx of materials was due to several foreseeable events, which had been repeatedly forecast ever since 1949 ([97, 179, 225]):

(a) Canalization of the Mhlatuze river and the re-establishment of bed levels ([20]).
(b) The destruction and/or flood bypassing of the Mhlatuze papyrus swamps ([178]).
(c) The planting of sugar cane onto the floodplain and river banks ([88]).

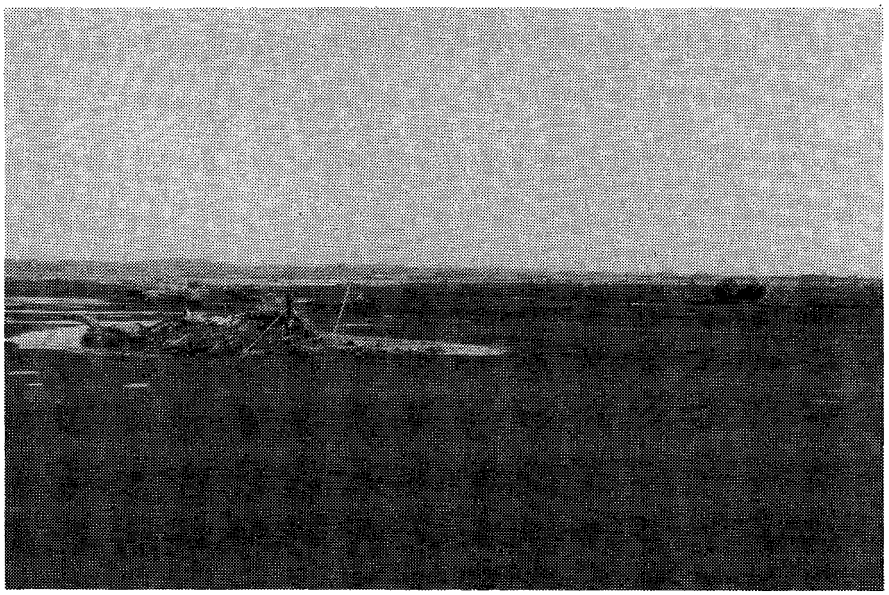


Severe bank erosion alongside the Mhlatuze river (photo by A. E. F. Heydorn 10 May 1977).

Deposition was also due to one less foreseeable event, i.e. the occurrence of five floods all in excess of 400 m^3/sec. over that period referred to (NRIO, pers. comm.) ([20]). These sediments have, by reducing the volume of the bay, increased the percentage of water exchanged on each tidal cycle to about 80% ([247]). While deposition continued during floods in February 1977 surveys by the NIWR became limited to observation of erosion and deposition patterns in the sanctuary area ([163]). The opinion was expressed that the influx of sediments "if continued at the present rate, will almost certainly terminate the sanctuary area's function as a nursery area" ([20, 247, 309]), as well as its suitability for certain forms of recreation ([88]). Pistorius (pers. comm.) has suggested that "we seem to be left with a choice between a functional sanctuary or sugar cane on the floodplain".

Fears have also been expressed that the Mhlatuze river is building a bank on its southern side, and isolating itself from the existing water area of the sanctuary. Thus inflow from the Mhlatuze may continue to become increasingly confined to a channel alongside the berm and become almost directly connected to the new mouth. Distinct flow channels have also developed opposite the Mtantatweni and a drainage canal on the western shore of the sanctuary area ([163]), (Ward, pers. comm.).

The process of delta formation at the new mouth of the Mhlatuze is already in an advanced stage and provides opportunity, from the point of view of ecological successions, for an unparalleled study.



Newly deposited Mhlatuze delta — 10 May 1977.

With the Mhlatuze diverted into the sanctuary area, the problem of siltation in the harbour hardly occurs — however some 800 000 m^3 of sand accrete against the south breakwater each year due to the net longshore transport of sand along the coast, (NRIO, pers. comm.). For the same reason erosion of the beaches in the lee of the north breakwater means that sand must be artificially resupplied to this point at some stage in the future.

Land ownership/use.
In the catchment: 53% of the catchment comprises Bantu areas, most of which are to become incorporated into KwaZulu. More specifically — the upper catchment is the centre of the wattle industry, with the factory of the Natal Tanning Extract Company, being centred at Melmouth. In the lower portion of the catchment agricultural activities, principally sugar cane, cotton, citrus and pineapples influence the area. A sugar mill, and the Ngoya Paper Mill are situated at Felixton; and there is another sugar mill and a cannery at Empangeni ([21]).

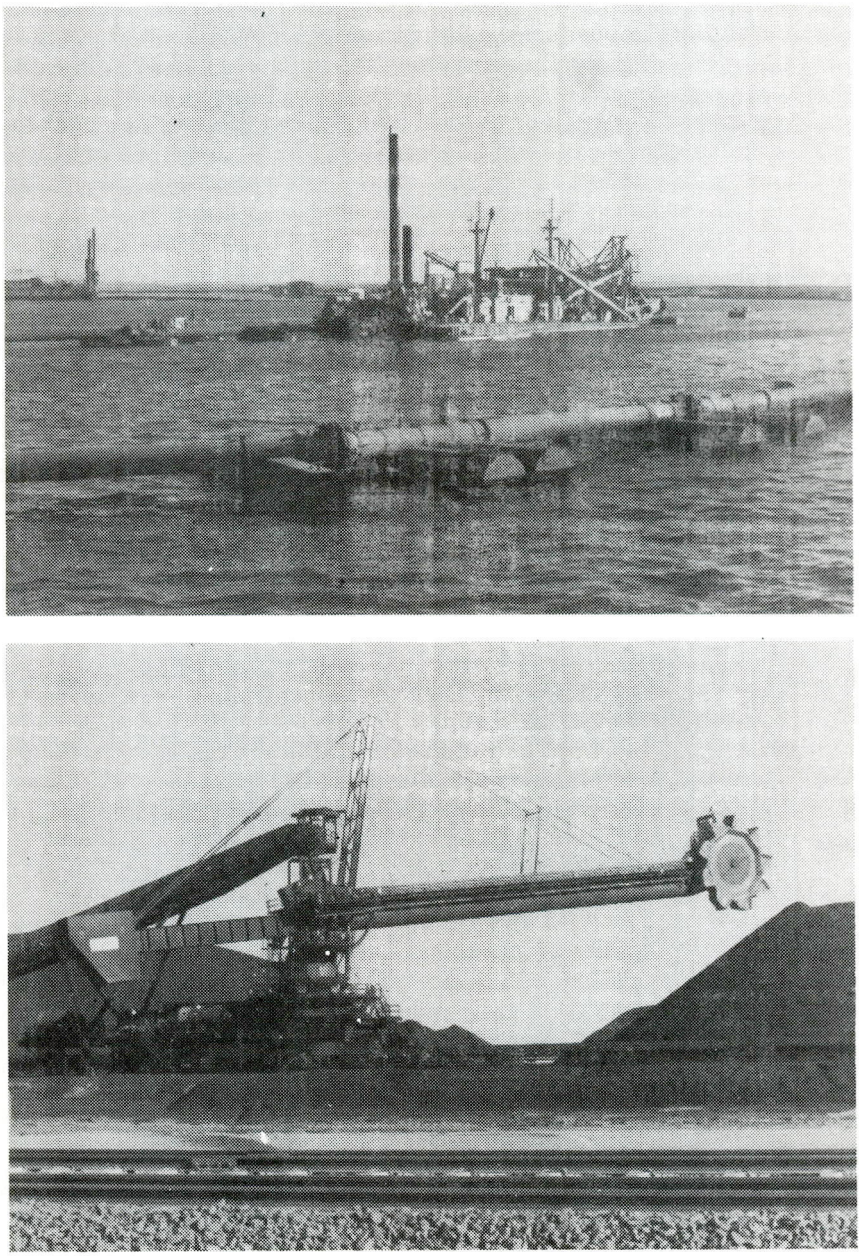
Around the bay:
Harbour — the harbour is becoming surrounded by industrial development (Alusaf producing aluminium electrical cable; and Triomf Fertilizers producing phosphoric acid) and the future city of Richards Bay, which is expected to have 21 500 ([88]) to 40 000 ([16]) Europeans living in it by 1980. By this time the importation and refining of crude oil ([210]) and the development of petro-chemical and cement industries is anticipated.

The harbour has been divided into a region for "dirty cargoes" in the south east ([10]) (i.e. the coal berths handling 20 ([16]) to 50 (Cox, pers. comm.) million tons of coal per annum by 1980) and a region for "clean cargoes" in the north west (such as containers).

Sanctuary — the land surrounding the sanctuary area is presently undeveloped except for sugar cane on the floodplain. The future Bantu township of Esikhaweni is to be centered upon Lake Cubhu immediately south of the sanctuary. It has also been proposed that part of the land in the vicinity of the southern shoreline be used for a fish farming venture (Hemens, pers. comm.).

Local authority.
Control of the harbour — South African Railways and Harbours.
Control north of the harbour — Richards Bay Town Board.
Control of the sanctuary —

Mouth	—	South African Railways and Harbours.
Water area	—	Natal Parks Board.
Peripheral area	—	Town Board.



A photograph of dredgers at work in the Richards Bay harbour, and of the coal terminal on the eastern shore.

Estuary uses.

Pre-harbour development. A popular holiday resort.

Post-harbour development.

Harbour	—	shipping, effluent disposal, recreation.
Sanctuary	—	conservation/recreation area ([88]).

Morphometry of the estuary

Area.

Pre-harbour development. Estimates vary from 2 750 ha ([311]) to 5 200 ha ([257])! Most estimates are in the vicinity of 3 000 ha ([20]) (2 890 ([152]); 2 990 ([144, 170]); 2 987 ([328]); 3 108 ([225])). Orme considers the original Holocene area of Richards Bay to have been 15 300 ha ([257]), this having been determined by the present day distribution of alluvium over the area.

Post-harbour development.

Harbour	—	±1 500 ha
Sanctuary	—	1 200 ha ([20, 88]) to 1 320 ha ([311]).

Axial length.
Pre-harbour development. 11 km.

Post-harbour development

Harbour	—	6,5 km
Sanctuary	—	6,0 km (note what was formerly the width of the system now becomes its length. Consequently the system has become orientated in a direction at right angles to its original one).

Shoreline length.
Pre-harbour development. ±37 km, including the periphery of islands such as Treasure Island, Pelican Island and Bird Island.

Post-harbour development. Although significantly large lengths of shoreline have been created as a result of the development, the environmental quality of the shoreline is no longer the same.

Harbour	±30 km, including the Msingazi canal, berm and islands.
Sanctuary	± 30 km, including the berm wall, borrow pit, island and delta areas.

Width.

		Maximum	Mouth
Pre-harbour development.		6,3 km ([328])	100 m ([225])
Post-harbour development.			
Harbour	—	3,75 km	750 m
Sanctuary	—	3,0 km	300 m

(Notice the greatly increased mouth size after harbour development).

Volume. Information is generally lacking.

Pre-harbour development. No record.

Post-harbour development. The National Mechanical Engineering Research Institute have modelled the sanctuary area and calculated exchange volumes ([100]).

Sanctuary		October 1975	May 1976 (values in $m^3 \times 10^6$)	June 1976
low tide	—	4,77	1,48	1,21
high tide	—	12,35	11,97	6,75

Bathymetry.
Pre-harbour development. The earliest depth survey of the bay was undertaken by Methven in 1902 ([88]). The depth of the bay was said to range from 0,25 m to 1,25 m ([170, 328]). More specific information ([225]), demonstrated channel depths of 4,5 m near the mouth, and that the major portion of the bay was very shallow, generally less than 1 m deep irrespective of season. A most significant feature of the bay was an extensive central 'mud-plain' of uniform depth, surrounded by a peripheral channel generally just over 1 m deep. This feature was indicative of sediment dispersal **by wind** rather than dispersal by **river flow** which is the case today in the sanctuary area.

Post-harbour development. Dredging involved the removal of 114 million cubic metres of material ([10, 14]) which, depending on its suitability, was either pumped to a reclamation area or out to sea through a series of pipes laid over the coastal dunes east of 'Spinach Point' (see Fig. **23**).

Harbour — 19 m deep access channels to each of the principal wharfs have been created to accommodate 150 000 ton ships. These will be increased to depths of 23 m in the future to accommodate 250 000 ton vessels ([17, 18]) although the costs of doing so have been estimated to be R40 million for each additional metre (NRIO, pers. comm.). Channel depths elsewhere are ±8 m deep. Estimates of harbour depths ([144, 156]) of 20 m to 30 m are therefore exaggerated. The dramatically increased depths of the harbour will naturally play and important part in bringing about radical changes in the physical, chemical and

biological characteristics of the area. Although shallow waters still remain at present and support life (such as flamingoes and prawns) — these areas will probably gradually become deepened as future development proceeds (as in the case of Durban Bay).

Sanctuary.
At high tide: In October 1975 depths ranged from 0,7 m to 1,3 m ([254]), and 65% of the area was deeper than 1,2 m ([168]). By May/June 1976 mean depths were 0,76 m and 43% of the area was less than 0,6 m deep ([168]). In the mouth however depths of 6 m have been recorded (Russell, pers. comm.).

At low tide: The sanctuary area is virtually inaccessible by boat. The radical changes in depths of the area can be seen from the data below:

Oct. 1975 — depths ranged from 0,24 m to 0,56 m ([254]).

March 1976 — substantial areas of the bottom started to become exposed, and depths of 0,1 m to 0,2 m were encountered ([168]).

May 1976 — 26% of the area was dry and the rest less than 0,25 m deep ([168]).

June 1976 — Mean depth 0,18 m ([168]).

April 1977 — More than half of the area was exposed at low spring tide ([163]).

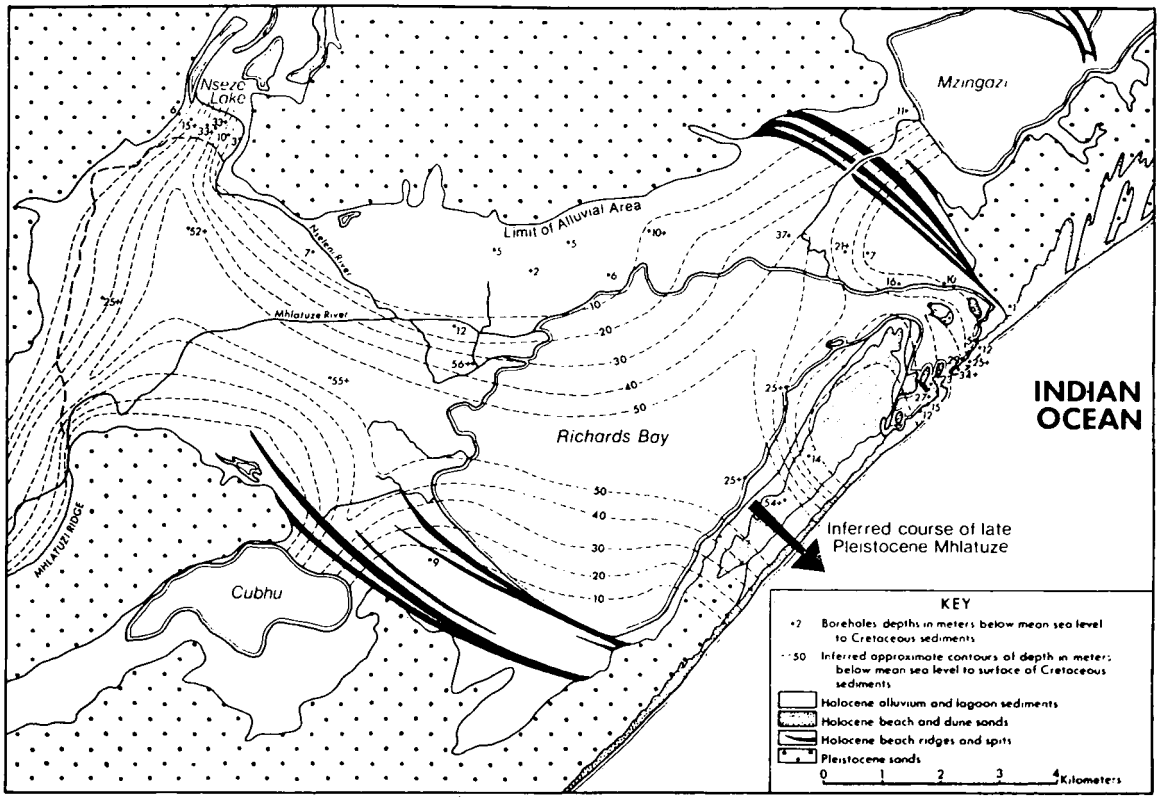


Fig. 26. Orme's interpretation of the original Holocene extent of Richards Bay, and inferred course of the late Pleistocene Mhlatuze ([257]).

Geomorphology

Geology.

(a) **The Catchment:** ([21, 188]) Varied, with Table Mountain Sandstone, Dolerite, Granite, Dwyka and Ecca rocks outcropping at regular intervals.

(b) **The Estuary:** Borehole data indicate cretaceous bedrock at 52 m to 55 m below the bay ([88, 257]). The position of the harbour mouth was governed by geological conditions ([97]) as surveys showed that an ancient silted up gorge 4,5 km long and 18 m to 23 m deep formed a natural entrance channel approaching the mouth at an angle of ±70° ([14, 16]). However it is interesting to note from the interpretations made by Orme ([257]), that, on sedimentological evidence, the inferred course of the late Pleistocene Mhlatuze was through the point in the dune where the new mouth has now been created (see Fig. **26**). Presumably a marine trench also occurs offshore at this point.

The bay system itself is enclosed by two Pleistocene barrier systems ([256]):

(i) a massive north extending barrier (emanating from Port Durnford) 8 km long, 2 km wide and some 60 m high;
(ii) a south west extending barrier complex which terminates on the northern headland of the present day harbour mouth.

Nature of bottom materials.

Pre-harbour development. According to Orme ([256]) the sediments which underlie the bay comprise a complex sequence of graded fluvial sands interspersed with silts and clays containing much organic debris. He also described the bay as lying "cradled in an extensive blanket of red clayey sands". However, earlier workers ([225, 328]) described the bottom of the estuary as consisting of deep, soft, fine mud, which changed to sandy mud in the channels and to clean shifting sand near the mouth, where wave action and currents prevented the settlement of silt.

The CSIR surveys of 1969/70 ([152, 155]) (see Table **5**) clearly demonstrated that throughout the bay (west of the line Spinach Point to Mzingaze river) sediments were homogeneous and consisted almost entirely of fine silt and clay. In general terms more than 90% of the sediment was less than 63 microns in size. The uniformity in size and quality of sediment over such a large area was an unusual and noteworthy feature. Mud (and interstitial water) from within mangroves showed that nitrogen and phosphorus values were greater than those from the bay, but the phosphorus present was in a relatively insoluble form ([155]). When compared to the quantities of nutrient provided by the sea and freshwater drainage, the proportion of nutrients coming from the mangrove swamp was considered insignificant.

Post-harbour development.

Harbour — from the limited data available after a survey in November 1976 ([254]), it is difficult to assess what the nature of the substrate in the harbour is like. In this survey emphasis was placed on heavy metal and pesticide detection and showed no exceptionally high concentrations anywhere.

Sanctuary — (see Table **5**). During dredging of the new mouth (October 1974) sediment phosphorus was higher than previously ([166]) as a result of the distribution of anaerobic dredged silt over the bay. Otherwise sediment parameters remained unchanged except where dredging operations brought about changes in particle size. Chlorinated pesticide residues were not detected in significant amounts, and heavy metal concentrations in the sediments were within normal limits ([85, 166]). Ranges are given below:

Mercury	=	,017 to ,029 micrograms/gram
Copper	=	8,3 to 12,0 micrograms/gram
Cadmium	=	,46 to ,76 micrograms/gram
Lead	=	20 to 32 micrograms/gram
Zinc	=	66 to 175 micrograms/gram
Iron	=	19 to 28,9 micrograms/gram.

However in October 1975 (while phosphorus levels remained high) 12% to 25% decreases in the nitrogen content and 33% to 50% decreases in chemically oxidisable materials of the sediment were apparent ([254]). Major changes in sediment characteristics appeared after the floods of 1976/77 in terms of particle size, and quantities of volatile and oxidisable materials ([163]). Instead of their former homogeneity, considerable variation in sediment quality now occurs. Such results represent the gross disruption of the highly productive 'central mud plain' depicted by Millard and Harrison ([225]). The only relatively unaffected area is on the southern shoreline of the sanctuary area.

Table 5. Sediment analyses from Richards Bay, pre- and post-harbour development.

	PRE-HARBOUR DEVELOPMENT				POST-HARBOUR DEVELOPMENT (Sanctuary area only)			
	Average from Stations 2-11 (west of line Spinach Point to Msingazi)				Stations 3-19, excluding 14	Stations 1-17	10 Stations*	
	1970				1974	1975	1976	1977
	Apr	May	Aug	Nov	Oct	Oct	Jun	Apr
Source of information	(152)	(155)	(155)	(155)	(166)	(254)	(168)	(163)
Solids (% dry weight)	51.1	50.9	51.1	51.0	50.1	49.7	46.1	Results unpublished to date.
Volatiles - (% dry weight volatile @ 600°C)	12.5	10.2	11.5	11.1	10.7	8.4	7.7	
Average particle size (microns)	41.0	-	-	-	-	-	-	
Oxygen absorbed (milligrams)	8.8	15.8	9.3	18.4	7.2	5.9	8.6	
Total nitrogen (micrograms)	-	-	-	-	-	-	610	
Kjedahl nitrogen (micrograms)	1423	1487	1386	1570	1456	1130	-	
Total phosphorus (micrograms)	160	102	81	76	248	168	166	
Organic carbon (milligrams)	17.2	-	-	-	-	-	-	
Iron (milligrams/gm dry weight)	48.8	55.1	48.4	56.0	-	53.5	-	
Sulphide (" " " ")	.43	.26	.06	.28	.08	.05	.91	
Humic acids (" " " ")	10.0	14.1	11.3	13.0	-	10.3	-	
Surface Area/cm^2 (cm^2)	-	-	-	-	11860	12960	-	
Remarks:	(A)				(B)			(C)

(A) = Note homogeneity especially in % solids and volatiles

(B) = Significant increase in phosphorus due to dredging activity

(C) = Many changes in quality reported

* = Certain station markers became lost after the floods of March 1976 and others displaced.

Sandbar characteristics.

Pre-harbour development. Prior to harbour construction the outer barriers of Richards Bay were composed of Holocene sands ([256]) which extended from both the north bank (as "the Crab's Claw") and from the south bank. The norm was for sandbar formation to be south extending ([349]). Both spits were highly unstable ([12, 225, 349]) (see Fig. **27**) because of variability in wind and wave activity, the opposing effects of south directed tidal currents and north directed littoral drift and because of changes in the velocity and direction of waters discharged from the bay. With wind and waves from the south, materials moved north east across the outlet, whereas when wind and waves came from the north east, a spit formed in a south west direction across the outlet. Floods and/or meanders undercutting at the inner edge of the spit, would breach it in various positions. Perennial inflow from several sources ensured the mouth remained open ([328]), although it was generally obstructed by a sandbar over which the depth was less than 1 m at low tide ([225]).

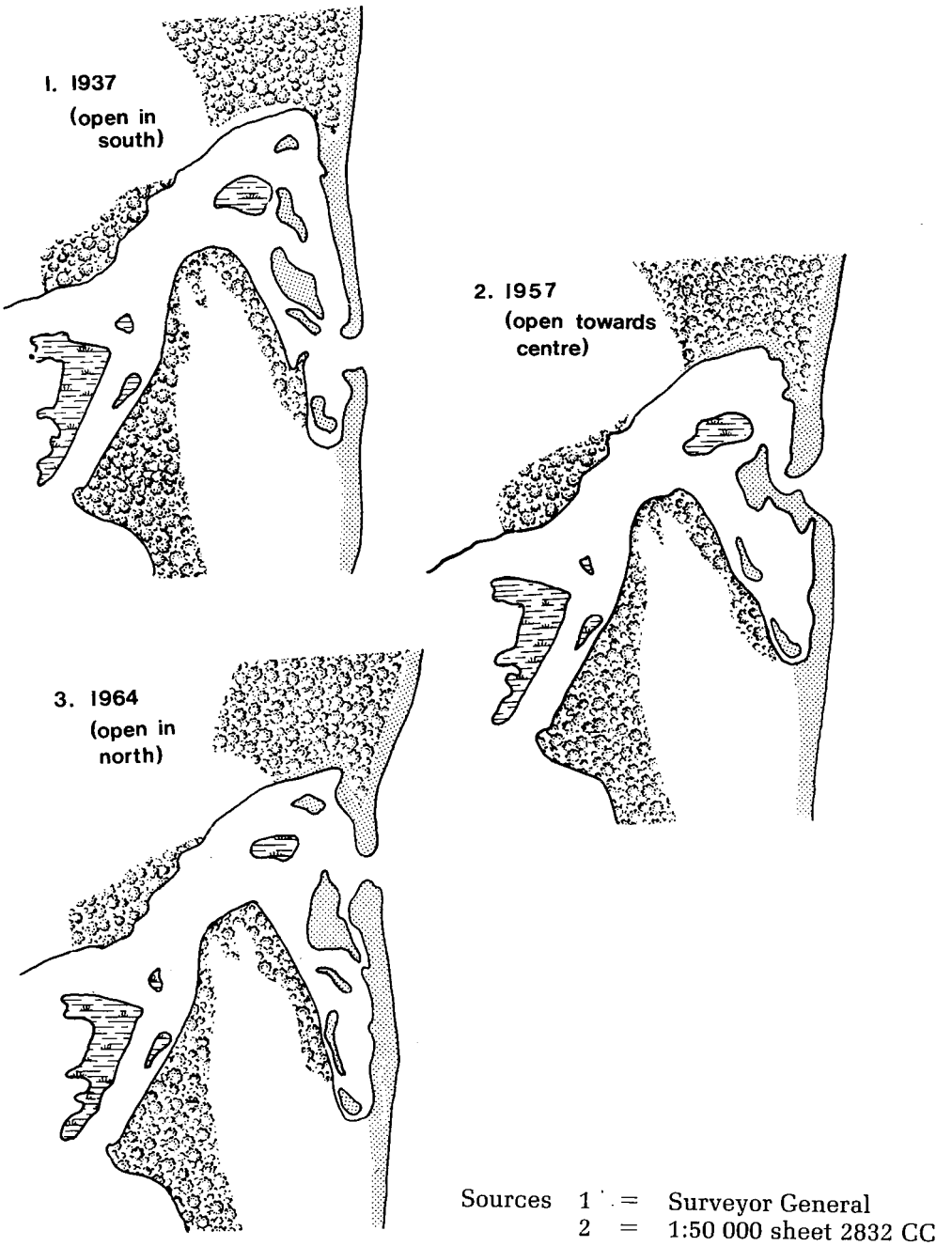


Fig. 27. Former changes in mouth position and sand banks — Richards Bay.

Post-harbour development.

Harbour — The old mouth has become extensively modified. Investigations of the harbour entrance (designed by the CSIR) began in 1968. The harbour entrance is now fixed and protected by a curved 1 400 m long southern breakwater and a straight 500 m long northern breakwater. On both sides of the entrance channel subsidiary headland works were built to counteract wave penetration ([10, 16]). (These structures are 270 m long on the north bank and 100 m long on the south bank.) 42 000 dolosse (of various sizes of up to 30 tons each) were used to build the breakwater system ([16]).

Sanctuary — To serve the sanctuary area and to obtain sand for construction of the berm, a new mouth was cut through the barrier dunes 5,5 km south of its original position. The cut was completed in August 1975 ([254]). Although designed for a cross sectional area of 300 m^2, after the flood discharge of the Mhlatuze in 1976, the cross sectional area of the mouth increased to 870 m^2 (NRIO, pers. comm.).

Present day expectations are that the cross sectional area of the new mouth should decrease (or "throttle down"), a process facilitated by storms at sea and sediment influx from either side of the mouth. In May 1978 however the sea was observed to have formed an additional entry point (into the borrow pit) just north of the existing mouth (Heydorn, pers. comm.)



Dredging of the new mouth, and creation of the berm in progress (photo by A. E. F. Heydorn, 18 March 1974).

At one stage, the new mouth was to be in the form of a concrete channel, 40 m wide and 2 m deep fitted with flood and tidal control systems ([170]).

Configuration of the adjacent shore. Lying north of Port Durnford, the coast trends north east and experiences nearshore circulation patterns similar to the Natal coast south of Port Durnford, but with a much reduced input of materials. Consequently parts of the adjacent coast are eroding into sea cliffs ([256]).

Currents. A vast amount of attention has been devoted by the CSIR ([349]) to studying the currents and wave conditions off Richards Bay. These results are available as 10 separate CSIR reports to which no detailed reference has been made in this review.

The offshore current is south directed, while the surf zone currents can be both north or south directed depending on circumstances at the time ([261]).

Physico-chemical characteristics (see Table 6).

Turbidity.

Pre-harbour development. High turbidities were characteristic of Richards Bay ([330]) and chiefly determined by the amount of wind ([152, 155]). During the summer periods of 1949-1951 Secchi values ranged from 0,55 m in the mouth to ±0,1 m in the bay ([225]). Light penetration would improve to 0,4 m in the bay during winter and, with the settlement of silt, would occasionally approach 1,0 m ([152]).

Post-harbour development.

Harbour — Although no Secchi disc readings for the harbour have been taken the water clarity has increased considerably following the deepening of the mouth and greater water exchange (van der Elst, pers. comm.).

Sanctuary — Secchi readings from 15 locations in the sanctuary area in October 1975 averaged 0,27 m ([167]).

Salinity.

Pre-harbour development. Average salinity values (for the period 1949-1951) ranged from 35,5‰ at the mouth of the bay to 20,8‰ within the bay and 14,3‰ in the river mouths ([225]). Similar salinity gradients were exhibited in 1971 ([144]). Salinities were higher in winter ([225]) or during drought years ([144]), lower in wetter years, and tidally influenced near the mouth. Whilst Millard and Harrison found salinities to be "remarkably constant" ([225]), Grindley found salinities "fluctuated very widely" ([144]) after major floods in May 1971. In August 1970 salinity over the whole bay was close to that of sea water ([155]). Vertical salinity gradients were detectable in November 1969 ([152]) (especially near the Mhlatuze river) when the bay had been relatively calm for a few days.

Post-harbour development.

Harbour — Salinities in the bay were unchanged ranging from 32,7‰ to 34,2‰ ([254]).

Sanctuary — In October/November 1974 results comparable to conditions in the undisturbed bay were attained (ranges from 30‰ to 34‰) these being high due to low flow from the Mhlatuze ([166]). Once the new mouth was opened rapid tidal changes in salinity became detectable ([254]).

Temperature.

Pre-harbour development. Ranges in 1970/71 were from 18°C in winter to 28°C in summer ([144]) — (a normal sub-tropical range). The average water temperatures in the bay were always higher than those of the sea in summer, and close to or below those of the sea in winter ([155, 225]). Naturally variations occurred, such as maxima in the shallows or over beds of *Zostera* ([152]), and minima in deeper water, river mouths and after rains. For example bay temperatures dropped from 30°C in January to 23,8°C in February after rains ([225]).

Post-harbour development.

Harbour — No record.
Sanctuary — No change from conditions pre-harbour development.

Oxygen.

Pre-harbour develoment. Oxygen saturation was high all over the bay, but there was appreciable differences between surface and bottom readings where depth were 1 m or more ([152]). Over beds of *Zostera* supersaturation occurred.

Post-harbour development.

Harbour — No record.
Sanctuary — No record.

Table 6. Physico-chemical characteristics.

RICHARDS BAY	MHLATUZE RIVER 12km above Estuary		PRE-HARBOUR DEVELOPMENT Bay					POST-HARBOUR DEVELOPMENT Sanctuary Area Only		
	(21)		(152)		(155)			(166)	(167)	
	(Dry Season)		Average from Stations 2-12					Average from Stations: 3-19	1-17	1-12
	1967	Jun 1968	Nov 1969	Feb 1970	May 1970	Aug 1970	Nov 1970	Oct 1974	Oct 1975	Feb 1976
Hydrogen ion concentration (pH)	6.68	6.15	8.03	8.1	8.0	8.0	7.8	8.2	-	-
Saturated pH value	7.4	-	-	-	-	-	-	-	-	-
Conductivity micromhos/cm	748	-	-	-	-	-	-	-	-	-
Suspended solids	-	-	-	-	-	-	-	262	-	51
Total dissolved solids ppm (calcd)	862	-	-	-	-	-	-	-	-	-
Dissolved oxygen mg/litre	Nil	1.4	7.13	7.5	7.2	7.3	7.3	-	-	-
% Saturation	0	16	92	88	97	97	103	-	-	-
Oxygen absorbed mg/litre	50.7	-	3.4	1.7	2.1	0.7	3.6	0.3	0.4	-
Biological oxygen demand mg/litre	-	40	-	-	-	-	-	-	-	-
Total Kjedahl nitrogen "	11.2	-	.26	.46	.22	.15	.33	.31	.19	.54
Soluble Kjedahl nitrogen "	-	-	-	-	-	-	-	-	-	.44
Soluble (unfiltered nitrogen) "	-	-	-	-	-	-	-	4.02	-	-
Ammonia "	-	-	.029	.069	.031	.038	-	.012	.03	.18
Nitrites "	-	-	.002	.007	.001	.003	-	-	-	-
Nitrates "	.05	-	.028	.187	.20	.19	.26	.28	.06	.12
Phosphates (Orthophosphate) "	.32	-	-	-	-	-	-	.128	.016	.02
Total phosphorus (soluble) "	-	-	.001	.028	.028	.019	.027	.035	.02	.03
Unfiltered phosphorus "	-	-	-	-	-	-	-	.16	-	-
Total alkalinity "	197	-	-	-	-	-	-	-	-	-
Total hardness "	254	-	-	-	-	-	-	-	-	-
Calcium "	53.6	-	-	-	-	-	-	-	-	-
Magnesium "	29.3	-	-	-	-	-	-	-	-	-
Sodium "	228	-	-	-	-	-	-	-	-	-
Potassium "	19	-	-	-	-	-	-	-	-	-
Sulphates "	7.6	-	-	-	-	-	-	-	-	-
Chlorides "	389	-	-	-	-	-	-	-	-	-
Silica "	-	-	-	-	-	-	-	1.2	1.14	-
Fluorides "	0.3	-	-	-	-	-	-	-	-	-
Free carbonic acid (as ppm (as ppm carbon dioxide)	80.5	-	-	-	-	-	-	-	-	-
Temperature °C	25.5	21.1	24.6	23.7	21.9	19.1	27.3	-	-	-
Turbidity (ppm silica scale)	-	39	-	-	-	-	-	-	-	-
Turbidity (APHA units)	-	-	57	113	14	100	-	-	-	-
Colour (APHA units)	-	5	-	-	-	-	-	-	-	-
Appearance	Foul									
Odour	Putrid									

Values underlined significant of disturbance.

Nutrients. [152]

Pre-harbour development. Nitrogen and phosphorus concentrations were relatively uniform all over the bay. In general Kjeldahl nitrogen varied between 100-400 micrograms/litre, nitrate between 150-300 micrograms/litre and total phosphorus between 10-50 micrograms/litre.

The bay was considered to be a nutrient trap and the waters extremely fertile as a result of retention within the bay. It was felt that mangroves partially contributed to the overall nutrient level, in particular to the availability of nitrogen.

Post-harbour development.

Harbour — Oxygen absorbed values were significantly higher than those recorded before development commenced (average 8,1 milligrams/litre — as opposed to 2,3 milligrams/litre.

Sanctuary — Whilst the new mouth was being cut (1974), concentrations of both nitrogen and phosphorus in the sanctuary were higher than normal because dredging operations sprayed silt from several metres below the mud surface into the bay [166]. Since then comparisons drawn between conditions in 1970 and 1975 [254] show decreases in both organic and inorganic soluble nitrogen compounds (especially in Kjedahl nitrogen). Soluble oxidisable material (oxygen absorbed) also decreased.

Pollution.

Pre-harbour development. The chemistry of the Mhlatuze river was studied in 1967/68 [21]. Sampling within 12 km of Richards Bay (at Felixton) showed the river to be in a very bad condition as a result of serious organic pollution. Foul, discoloured (black) water, with a putrid odour (smelling of molasses and sulphides) was characteristic. The river bed was described as being blanketed in cane or wood fibres actively evolving gas [21]. It is doubtful whether recovery took place before the water entered Richards Bay. This did prove to be the case [152, 155] but the materials were not considered to be harmful. Indeed, the suggestion was made that these materials may in fact contribute to the fertility of the area, although it was acknowledged that severe disturbance of such materials could result in periodic local mortalities of certain biota.

Post-harbour development.

Harbour — Once construction began attention was focused on the sanctuary area. However the present day water quality in the harbour is generally good with detectable pollution only near Alusaf, where average flouride levels in the Bhizolo canal are 10-20 milligrams/litre and fluctuate according to the tide [153]. In such areas harmful bioaccumulation is occurring in the hard tissues of the organisms frequenting them [149, 165]. Both Alusaf and Triomf generate a fluoride bearing effluent [154, 160, 161] but in 95% of the harbour, fluoride is undetectable. If fluoride bearing effluents are piped well into the harbour, there will be sufficient dilution of these effluents to ensure that pollutional hazards are avoided.

Trace heavy metals are also a potential pollutant in the Triomf effluent [150]. Flooding of the effluent holding ponds periodically brings down larger than desirable quantities of effluent into the harbour [149]. Layering due to density differences may confine the effluent to the bottom. A survey in November 1976 [151] showed mercury levels were relatively high throughout the bay (range from 0,23 to 1,92 micrograms/litre), whilst the levels of other metallic elements were considered normal, except near the Alusaf outfall.

Sanctuary — Organic pollution from Felixton still persists, the implications of which remain essentially the same as those already described. However with the massive exchange of water that now takes place at each turn of the tide, serious deterioration in water quality is not anticipated. Concentrations of mercury, copper, cadmium and lead in the water during November 1974 were within normal limits [166]:—

Mercury ranged from ,010 — ,378 micrograms/litre
Cadmium ranged from ,001 — ,025 micrograms/litre
Lead ranged from 0,53 — 3,94 micrograms/litre
Copper ranged from 0,25 — 3,08 micrograms/litre

Nevertheless the dumping of industrial waste in the vicinity of the borrow pit is a practice with considered pollution potential.

Public health aspects

Bacteriology.

Pre-harbour development. Although the lower Mhlatuze was reported to be heavily polluted in 1967/68 ([21]), and in November 1970 ([155]), the level of pathogenic organisms in the bay was reported to be low. This meant that where bacteriological results from the river were indicative of organic and faecal pollution (total plate counts of 750 000/ml; *Sphaerotilus* (sewage fungus) present, and confirmed *E. coli* counts of 10 000/100 ml), such pollution was neither widespread nor of serious proportions in the bay.

Post-harbour development. The level of pathogenic organisms in the bay was again reported to be low in November 1974 ([166]). With the present degree of tidal exchange, the waters of both the harbour and the sanctuary are considered to be comparatively unpolluted by sewage (Hemens, pers. comm.). Various small sewage treatment plants presently discharge a good quality effluent into the harbour and once a major sewage works is built (1980?) its effluent will probably be piped out to sea.

In general, little attention has been given to bacteriological studies because of the low values found previously. The possible importance of bacterial films, as a food source on the mud surface, has been emphasized ([168]).

Bilharzia. No attention has been given to this matter which is a serious omission in the light of the ever increasing population and degree of contact with water.

Public safety. The likelihood of shark and crocodile attacks in the area are aspects of public safety that have been drawn to the attention of the relevant authorities. Local attacks by both species have been known in the past (Heydorn, pers. comm.). Signboards to this effect have been prominently displayed in the recreational area (Cox, pers. comm.).

BIOTIC CHARACTERISTICS.

Flora.

The most significant plant communities identified in the vicinity of Richards Bay are or were as follows:

Aquatic vegetation.

Pre-harbour development. Richards Bay supported one of the last remaining extensive beds of *Zostera capensis* (eelgrass or seagrass) in Natal ([330]). These plants occurred below low tide level (although exposed at low springs) as two principal banks — one at Mermaids Folly and another on Flamingo bank near Pelican Island (see Fig. **23**) ([152, 225]). The *Zostera beds of* Richards Bay supported one of the richest and most diverse estuarine communities on the Natal coast.

Post-harbour development. The *Zostera* beds have become virtually eradicated through the process of harbour development. The hope has been expressed that *Zostera* will establish itself in the sanctuary area, even if encouraged by transplantation ([85, 336]). The plant has very specific requirements in terms of salinity, light penetration (turbidity) and substrate. Salinities should be high, the water clear, and substrate firm mud or muddy sand. For these reasons it was restricted to the vicinity of the former mouth of the bay and grew most luxuriantly in winter. Ward (pers. comm.) is of the opinion that conditions in certain parts of the sanctuary area are at present very favourable for the introduction of *Zostera*.

Algae.

Pre-harbour development. A list of the more important algae found in the bay in 1949-1951 is available ([225]). From the Mhlatuze river the presence of *Oscillatoria tenuis* ([21]) in 1967/68 confirmed the presence of organic pollution upstream.

The results from phytoplankton samples from the bay in 1970/71 ([144]) have never been reported on. The diatom flora of the system was studied by Cholnoky ([80]) and found to consist of a marine littoral community. Planktonic photosynthesis was reported to be continuous throughout the year in 1969 and to reach a maximum in summer ([85, 152, 155]) when rates of photosynthesis in the surface waters were estimated at ±138 mg to 210 mg oxygen/cubic metre/hour ([152]). This represented the production of ±2 600 kg of organic carbon per day. In winter production dropped to rates between 10 mg to 70 mg oxygen/cubic metre/hour (or 4,0 mg to 26 mg carbon/cubic metre/hour) ([155]).

Post-harbour development. In February 1976 the average rate of planktonic photosynthesis in the sanctuary area was 40 mg carbon/cubic metre/hour ([167]), but considerable variation according to locality became apparent since October 1975. Production is limited by the short residence time of the water mass. Extensive growths of filamentous algae on the floor of the sanctuary area were reported on in May 1978 by van der Elst (pers. comm.)

Papyrus swamps.

Pre-harbour development. On the floodplain and old Mhlatuze delta, papyrus swamps acted as a vast sponge absorbing flood waters and silt from the Mhlatuze.

Post-harbour development. These swamps have become by-passed (by canalization), reclaimed or drained to permit sugar cane farming ([88, 178]). Swamp communities (*Avicennia*, *Scirpus*, *Phragmites australis*, *et al*) are developing on the new Mhlatuze delta ([20, 88]). Papyrus on the south western shores of the sanctuary has been killed by the increased tidal range (Ward, pers. comm.).

Salt marshes.

Pre-harbour development. Salt marshes comprising *Juncus kraussi*, *Stenotaphrum*, *Arthrocnemum*, *Triglochin* and *Sporobolus*, occurred in association with *Phragmites australis* above water level. They were periodically subjected to partial inundation at high spring tides or after floods ([260]).

Post-harbour development. Salt marsh communities have been, or are in the process of being eliminated on the harbour side of the development. On the sanctuary side, salt tolerant *Phragmites* and *Juncus* communities tend to dominate this niche, but wetland communities are increasing their extent because of the increased water level and salinity regime (Ward, pers. comm.). Detritus emanating from such communities is an important organic food material for the sanctuary area ([168]).

Mangroves.

Pre-harbour development. Three species of mangroves (*Avicennia*, *Bruguiera* and *Rhizophora*) occurred on soft oozy mud just above tidal level and were fringed by *Hibiscus tiliaceus* and *Achrostichum aureum* at slightly higher elevations ([88, 225]). Cooper ([91]) listed only two species and gave their extent in 1968 as 40 ha. *Avicennia* dominated Pelican Island and Treasure Island in the 1950's and did not apparently occur in what is the sanctuary area today ([225]).

Post-harbour development. Most of the mangroves on the harbour side of the development have been killed or eradicated. Those that remain (*Rhizophora mucronata*) are becoming sanded up (van der Elst, pers. comm.) and threatened with extinction. They are one of the last red mangrove communities in Natal.

On the sanctuary side mangroves are flourishing and increasing their influence ([20]). They support a very characteristic fauna and contribute locally to nutrient levels on the edges of the bay ([155]). Accreted mud has been washed away by the increased tidal range revealing the "knee root" system of *Bruguiera* ([30]). The *Bruguiera* community in the sanctuary presently represents the last, truly flourishing community surviving in Natal ([88]). Transplantation of *Rhizophora* is being undertaken experimentally (Ward, pers. comm.). *Avicennia* does now occur on the southern edge of the sanctuary and on the Mhlatuze delta ([336]). During the process of canalizing the Mhlatuze some of this community became killed by the deposition of spoil by dredgers (Ward, pers. comm.).

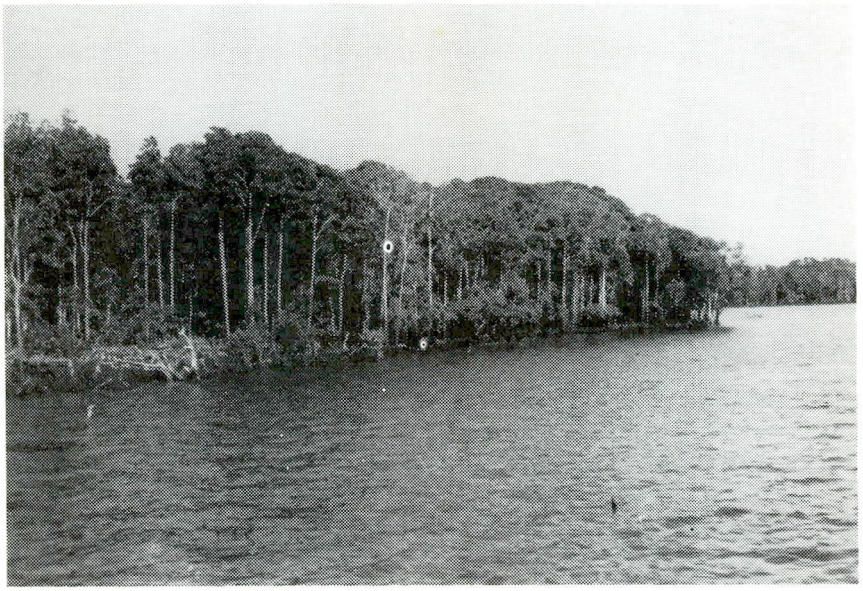
Swamp forests.

Pre-harbour development. Freshwater swamp forest communities (*Barringtonia*/*Ficus*/*Hibiscus* associations) occurred in low lying areas near the outlet to Lake Cubhu and on the lee side of the barrier dunes ([88, 260]).

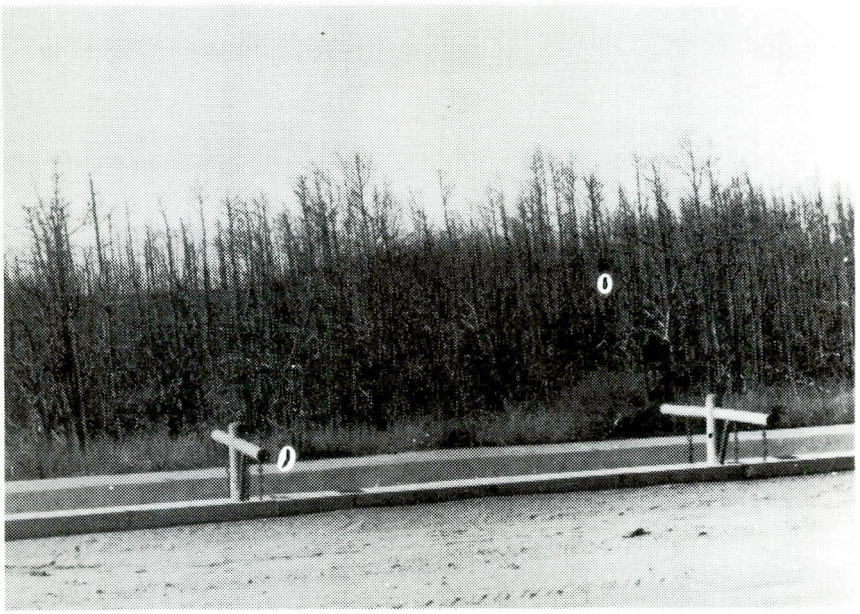
Post-harbour development. With the increased tidal range swamp forest communities have been killed on the edge of the sanctuary area. One of these was of particular interest because of the presence of *Phoenix* palms within the swamp (Ward, pers. comm.).

Dune forests.

Pre-harbour development. The eastern shore of the bay was characterized by climax forest communities on the barrier dune complex ([260, 321]).



One of the finest stands of Bruguiera gymnorrhiza (Black mangrove) remaining in Natal occur in the Richards Bay sanctuary area.



Most of the mangroves on the harbour side of the development have been killed.

Post-harbour development. A well preserved remnant of this climax dune forest remains on the eastern side of the sanctuary area.

On the harbour side of the development virtually no dune forest remains but instead, *Casuarina* plantations dominate the dunes. On steep slopes, sand stabilization has been successfully undertaken using the creeper *Ipomoea*.

Grass savannah. Savannah communities overlook the sanctuary from higher land near Lake Cubhu ([88]). Lala palms are interspersed amongst the community.

Fauna

Richards Bay once represented "an almost classical nursery and feeding ground for many marine organisms" ([170]), and most evidence pointed to its important role in the maintenance of certain fish and invertebrate populations along the Natal coast ([155]). Millard and Harrison listed a total of 183 species from the whole estuary, excluding birds ([225]). They described the

Zostera beds as providing food for "a teeming population of shrimps, prawns and small fish, which in turn encouraged the entry of larger angling fish." They considered Richards Bay as a system which could be profitably compared with the ideal estuary postulated by Day (i.e. Knysna) ([119]).

The marked association and diversity of the fauna within the *Zostera* beds can be seen from the manner in which the species were distributed in the system ([152, 225]). These beds became the focal point or epicentre of the entire bay.

Of the 183 species 35 could be found near the mouth, 153 in the middle reaches (where *Zostera* was established), 48 in the upper reaches, and 11 near the head of the estuary (in the river mouths). A marked decrease in the diversity of the fauna was apparent west of Spinach Point, i.e. in the area which is the sanctuary area today. However it must be emphasized that in terms of biomass the southern area of the bay was of paramount importance. Here species such as mullet (Mugilidae), prawns (*P. indicus* and *Acetes*) and crabs (*Uca* and *Sesarma* in the mangrove fringe) were abundant. By 1970 the nursery value of Richards Bay had become more important than ever before, because of the degradation by that time of systems such as St. Lucia (to the north) and Durban Bay (to the south). The prospects of harbour development therefore had particularly serious implications. The fundamental fallacy in expecting the sanctuary area to act as a nursery comparable to the original bay was that right from the start the sanctuary area basically lacked several essential qualities, in terms of substrate conditions, water clarity and plant communities. Although the new mouth and hopes of re-establishing *Zostera* altered these facts, the recent massive invasion of silt and the exchange volumes which have developed have reduced any such potential significantly.

Plankton.

Pre-harbour development. A survey of the plankton of Richards Bay was carried out in 1970 by the Port Elizabeth Museum ([144]). Two distinct communities were found — a diverse neritic marine community in the tidally influenced areas east of Spinach Point; and a copepod dominated estuarine community west of this point (*Pseudodiaptomus* sp. and *Acartia*). In terms of biomass the 'lagoon' community was much higher (with estimates of up to 344 mg/cubic metre being quoted ([144])). Hemens *et al* pointed out that utilization of the plankton appeared to take place only after it has sunk to the bottom ([155]).

Post-harbour development. Connell has continued to study the zooplankton of Richards Bay in the post-development phase. Although rich in 1974 (with total numbers of 82 000 animals in a 50 m haul, and settled volumes of 9,0 ml ([166])) and dominated by a calanoid copepod *Acrocalanus similis* (instead of *Pseudodiaptomus*) as well as *Acartia*, the zooplankton community of the sanctuary area has basically collapsed, since large exchange volumes have developed. Although diverse as a result of neritic marine forms being brought in on the tide, the standing crop of plankton has decreased markedly. By October 1975 total numbers in a 50 m haul were down to 5 500 (settled volume 1,9 ml) and by June 1976 down to 9 650 and mean settled volume of 1,05 ml ([247]).

In the harbour in November 1976 ([254]) far richer communities, still dominated by *Acrocalanus*, occurred (total numbers of 59 000 and settled volume of 3,5 ml), and it was concluded that the backwaters of the harbour had been only slightly affected by the development. However, tidal exchange was ([144]) and still is ([254]) the most important factor controlling zooplankton in the Richards Bay system.

Benthos.

Pre-harbour development. The bottom fauna was examined very thoroughly in 1970 ([152, 155]) to a depth of 10 cm within the sediments. Amongst the larger components, the small crab *Tylodiplax blephariskios* was very numerous and widespread all over the bay. The shrimp *Palaemon pacificus* dominated the *Zostera* beds and was said to occur "in millions" by Millard and Harrison ([225]) in 1949 to 1951; (a situation confirmed in 1969/70 ([152])). With respect to prawn life the system was dominated by *Peneaus indicus*. *Metapenaeus monoceros* (common in 1969 ([152])) and *P. monodon* (common in 1949 to 1951 ([225])) were also very conspicuous. Prawns were the basis of a small bait fishery (worth ±R50 000 per year) ([330]). The Mhlatuze delta appeared to provide conditions favoured by penaeid prawns. Joubert and Davies ([203]) refer to the prawn stocks of Richards Bay decreasing in 1964 due to the effects of pollution (presumably from Felixton) and considered it unlikely that prawns would remain in the area once harbour development commenced.

Of the some 15 conspicuous interstitial species, the polychaete worm *Mediomastus* was abundant ([155]). The southern area of the bay also supported molluscs such as *Solen*, *Tellina* and *Nassa*.

Post-harbour development. Surveys in 1974 ([166]) in the sanctuary area showed benthic results essentially similar to those already described. Some changes in composition were apparent in October 1975 ([247]) in the form of a polychaete (*Ancistrosyllis*?) and oligochaetes near the Mhlatuze, (the latter almost certainly a reflection of organic pollution in the Mhaltuze, having been collected there in 1967/68 ([21])). *Tylodiplax* was still common — the total biomass being estimated at 80 000 kg. After the silt influx of 1976 their numbers diminished drastically ([168, 254]). By 1978 however they were once again very conspicuous (pers. obs.). In the mangroves crabs of the genus *Uca* and *Sesarma* are also flourishing. Molluscs, however, still remain conspicuously absent.

From the harbour a survey in November 1976 ([254]) showed very limited meiofaunal populations, only a single specimen of *Tylodiplax* and the absence of *Nassa*. Several new benthic components were present. Such results indicate that the benthos has been highly disturbed. However Penaeid prawns still abound in back waters of the harbour area, from where they are netted by the Natal Parks Board.

Fish.

Pre-harbour development. Of the 183 animal species in the system in 1949 to 1951 ([225]), 74 of them were fish and virtually all of these were to be found in the vicinity of the *Zostera* beds near the old mouth.

However, during the period June 1969 to May 1970 Wallace ([330]) and Hemens *et al* ([152, 155]) re-examined the system and after 51 nights of gill netting revealed the presence of only 48 species — and only 34 of the original 74. In other words 40 species appeared to have disappeared and 14 were newcomers to the system. This surprising result is probably attributable to differences in sampling methods. Wallace's results from netting in Richards Bay during 1971 to 1972 ([328, 329]) have not been published.

Post-harbour development. Since 1975 van der Elst has netted in the sanctuary area, in order to assess the extent to which teleost fish use the system. Publication of his results ([307, 309, 310, 312]) is in preparation. The maximum number of species found at any one time is 33, a high proportion of which were juveniles. During the course of five surveys over the period 1975 to 1977, 58 species have been recorded from the sanctuary area. Although diverse in this respect ([20]), what is significant is that:

(a) *Zostera* associated species (such as *Lutjanus* (snapper), *Rhabdosargus* spp. (stumpnose or bream) and *Pelates* (trumpeter) are conspicuously absent ([88]).
(b) Furthermore the composition of the fish fauna (with 24 newcomers) is entirely different to the original one described by either Millard and Harrison in 1949 to 1952 ([225]), or Wallace ([330]) in 1969 to 1970.

The illegal netting of fish in the sanctuary area by Africans is increasing and considered to be ecologically damaging.

Experimental netting in the harbour has only recently been recommenced (May 1978). Having been deepened, the harbour now appears to support a marine fish fauna as opposed to an estuarine fauna, an indication of which is the predominance of sharks.

Birds.

Pre-harbour development. No information is available on the bird life at Richards Bay prior to harbour development.

Post-harbour development. During the course of 9 counts over the period November 1976 to October 1977 Nicholls (pers. comm.) has shown 75 estuarine associated bird species to be present at Richards Bay. 11 of these are provisionally listed in "The Red Data Book" ([279]) as species requiring conservation (see Table 7).

In addition to these, another 121 species have been listed by the Natal Bird Club ([29, 88]) as present in the general surrounds of the estuary. Realizing these potentials, much of the nature orientated plans of the Natal Parks Board for land-use in the vicinity of the sanctuary area have revolved around bird watching ([88]).

In the light of the shallow, silted characteristics of the sanctuary area and the gradual tendency towards the development of swamp communities on the newly deposited Mhlatuze delta, the prospects of the sanctuary area becoming an important bird sanctuary in the future, are good ([20, 88]). Bird life, in particular estuarine associated species, can capitalize on a situation such as that which has developed, and with the right management techniques, the sanctuary area could become a valuable asset in this regard. In addition, because the birdlife

Table 7. Conservative estimates of the maximum number of estuarine associated birds (at any one time) at Richards Bay during the period Nov. 1976 to Oct. 1977.

Pink-back Pelican *	700	Mongolian Plover	1
White Pelican *		White-fronted Plover	100 +
Cape Cormorant	120	Kittlitz's Plover	100 +
Reed Cormorant	30	Three banded Plover	3
White breasted Cormorant	200	Grey Plover	50 +
Darter	7	Blacksmith Plover	4
Grey Heron	35	Great Sandplover	50 +
Blacknecked Heron	9	Broadbilled Sandpiper	2
Purple Heron	4	Curlew Sandpiper	10 000 +
Goliath Heron *	3	Wood Sandpiper	50 +
Squacco Heron	1	Terek Sandpiper	500 +
Black Heron	25	Marsh Sandpiper	50 +
Great White Egret	25	Little Stint	10 000 +
Little Egret	150	Sanderling	6
Hamerkop	1	Ruff	1 000 +
Wood Stork *	13	Greenshank	50 +
Woollynecked Stork *	3	Bar-tailed Godwit	1
Sacred Ibis	40	Whimbrel	100 +
Glossy Ibis	1	Curlew	1
Spoonbill	110	Avocet	375
Greater Flamingo *	1 200	Stilt	16
Lesser Flamingo *		Red-winged Pratincole *	35
Spurwing Goose	50	Grey-headed Gull	2 000 +
Egyptian Goose	25	Kelp Gull	60
Cape Shoveler	2	Caspian Tern *	80
Yellowbill Duck	250	Common Tern	2 000 +
Redbilled Teal	150	Arctic Tern	
Cape Teal	3	Sandwich Tern	30
Hottentot Teal	100 +	Lesser Crested Tern	12
White-faced Whistling Duck	30	Swift Tern	25
Ethiopian Snipe	1	Little Tern	2 000 +
Water Dikkop	2	White-winged Black Tern	2 000 +
Marsh Harrier	2	Whiskered Tern	7
Fish Eagle *	2	Kingfisher (Pied)	8
Osprey	1	Marsh Warbler	2
Palm Nut Vulture *	2	Brown-throated Golden Weaver	1
Turnstone	50 +	Cape Reed Warbler	10 +
Ringed Plover	10 000 +	Gannet	3

* Species provisionally included in South African Red Data Book[279], as species requiring conservation.

which presently feeds in the harbour, will become displaced, the sanctuary area should play an increasingly important role in providing for them. Its function as a roosting area is already apparent. The newly killed swamp forest should in all likelihood be well utilized for breeding purposes by species such as egrets, herons and pink-backed pelicans.

It happens all too often that birds are excluded during the course of estuarine surveys and in the case of the Richards Bay sanctuary area, far greater attention should be paid to this aspect than is being done presently. However, being a large and difficult area to survey, the logistics of doing so must be carefully considered.

Mammals. Hippopotami were said to be encountered in Richards Bay in the pre-development era ([144, 151]). Hippo tracks in the sanctuary area have been recently observed (Ward, pers. comm.) and are probably the result of exploratory ventures by individuals from nearby Lake Nsese ([88]).

Reptiles. Crocodiles occur in the lower reaches of the Mhlatuze and are encountered in the sanctuary area.

SYNTHESIS

Our present day state of knowledge of the Richards Bay system is good. Research investigations should continue to ensure that it remains this way. Particular attention should be focused on the harbour area to assess the present day utilization thereof by marine organisms, and in the sanctuary area to assess among other things the utilization thereof by bird life. In many respects it is a pity that biological sampling by the NIWR in the sanctuary area ceased after June 1976 because the area was so unstable. Monitoring of changes during such a period are always valuable, because a break in the continuity of research can never be repaired. Monitoring of the changes occurring in the plant communities around the bay is essential.

The present day environmental condition of the system is essentially poor because the whole system is in a state of instability. This applies both on the harbour side whilst construction continues and on the sanctuary whilst the future input of silt threatens to remain an unknown factor. There will always be a danger that when 'equilibrium' is reached, the harbour will probably gradually deteriorate into "a Durban Bay type situation", whilst the sanctuary area will probably continue to be subjected to various adverse ailments originating in the Mhlatuze catchment. The prospects of preventing this are however exciting. For this reason, the conservation/recreation plan proposed by Coke ([88]) is applauded. The opportunity for incorporating such ideas into a rapidly developing city very seldom presents itself.

Nevertheless it is difficult to accurately assess the present day natural resource value of the Richards Bay system ([20]). The resource value of the harbour is unknown. The principal value of the sanctuary area appears at present to be its birdlife. However, resource values are completely dependent upon:

(a) the continued co-existence of a diverse interdependent flora and fauna and
(b) the effectiveness of future management plans.

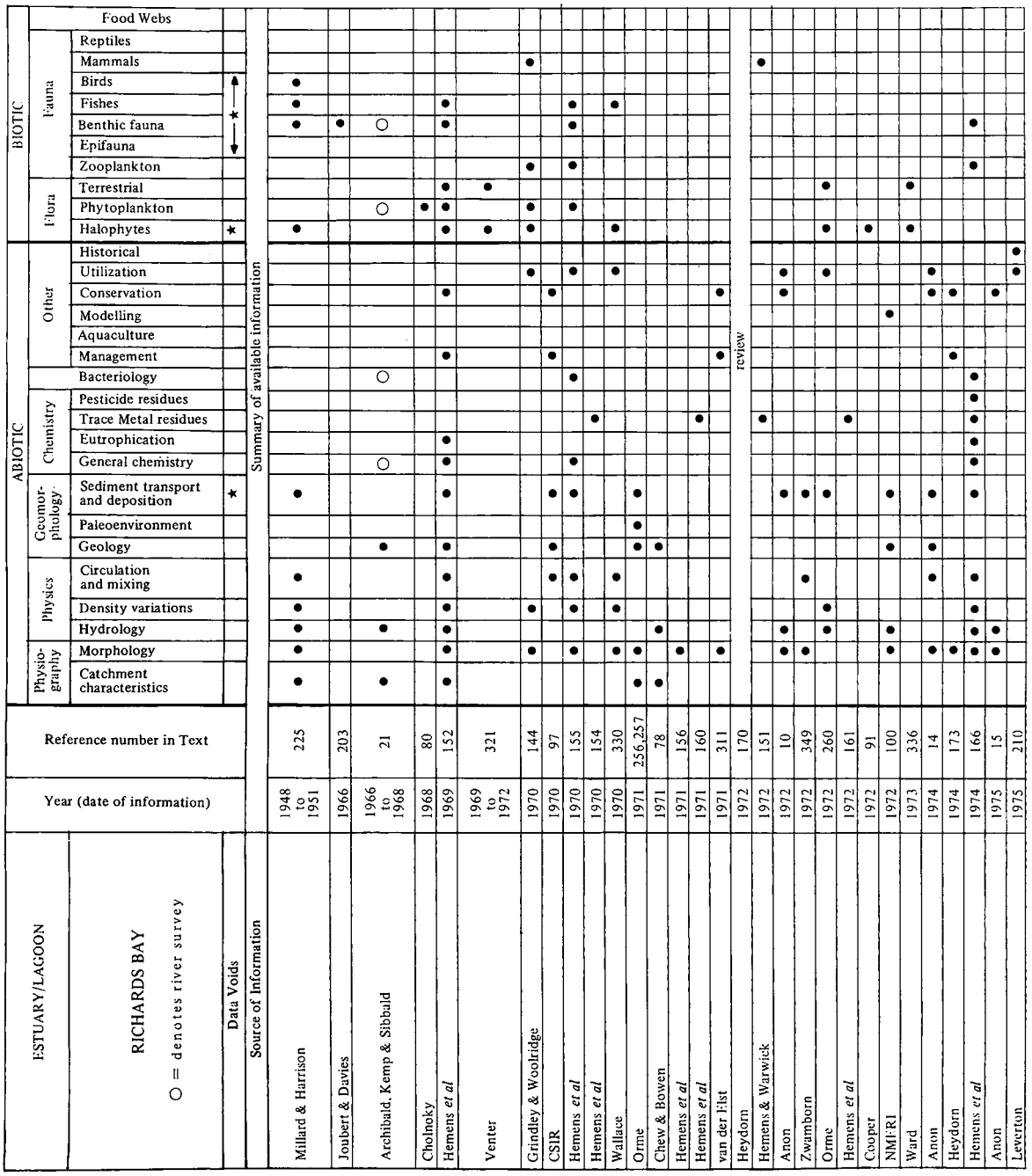
Problems apparent at Richards Bay may be summarized as follows:

In harbour	—	(i)	elimination of shallow areas and nutritive substrates;
		(ii)	elimination of marginal vegetation;
		(iii)	a potential for pollution from industry and ships.
In sanctuary	—	(i)	chronic siltation (the only solution to which is to decanalize);
		(ii)	a potential for pollution from the Mhlatuze, from the future Bantu township of Esikhaweni and to a lesser degree from the harbour.

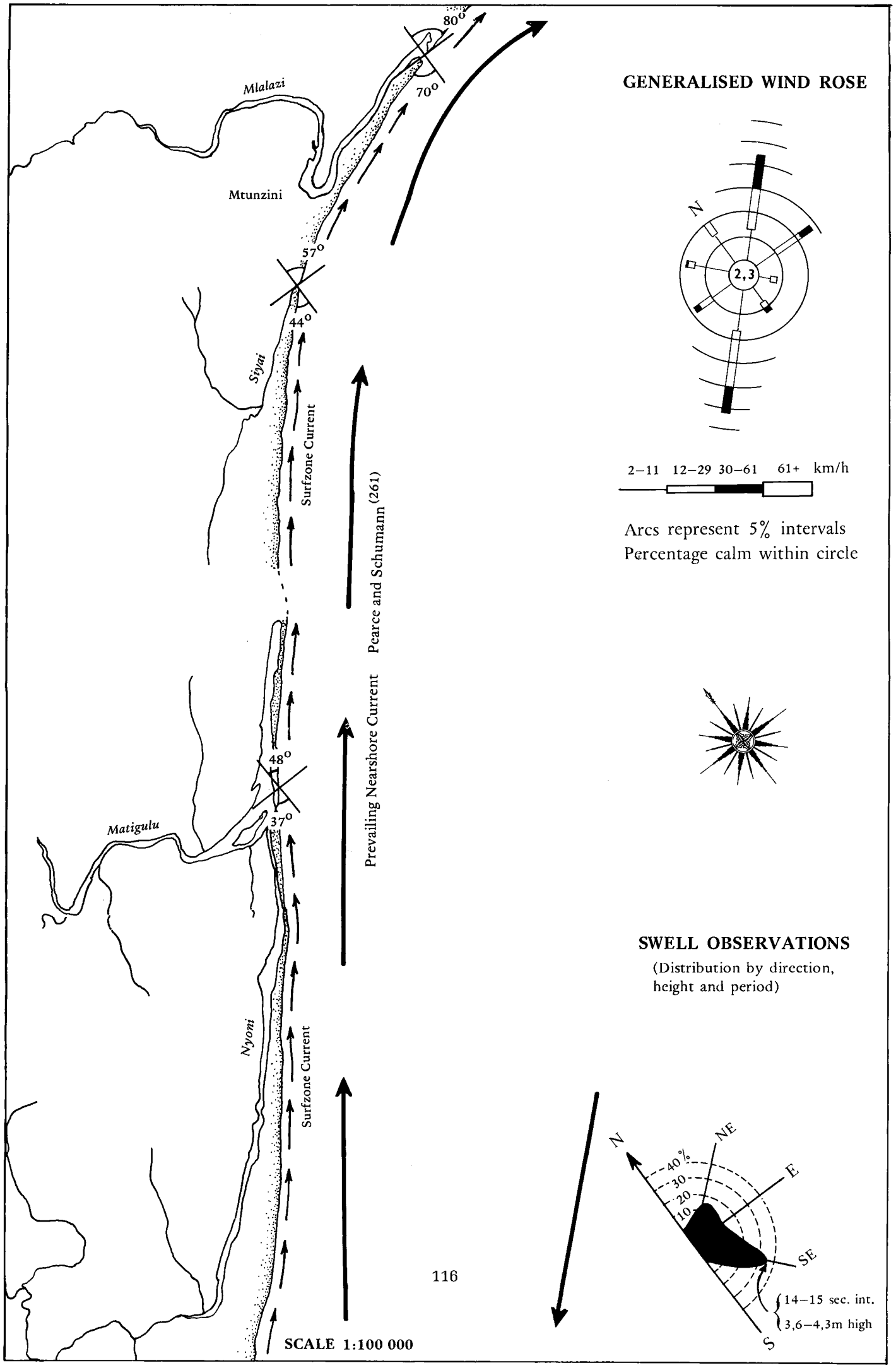
In addition a lesson has been learnt and that is that in a system as sensitive as an estuary, conditions cannot simply be artificially reproduced; that estuarine systems do not take kindly to modification; and to state that "the ecosystem would remain substantially unchanged" ([152]) was being very optimistic, if not unrealistic. To date virtually every engineering action has inevitably had adverse ecological connotations (river diversions and canalization, alterations in depth, tidal ranges and exchange rates, alterations in the nature of the substrate and the shoreline, effluent release, dredging and peripheral development).

Although division of the bay into two was considered to be "enlightened planning" ([328]) as well as a "lucid example of multidisciplinary planning" ([311]), in retrospect the sub-division of the bay has proved to be more in the interests of the future harbour than the future 'estuary'.

If undertaken in a manner with the latter in mind, the prospects of having left the Mhlatuze where it was, of having left the old mouth and the well established *Zostera* beds where they were, and to have built the harbour where the sanctuary area is today are thought provoking.



ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																								BIOTIC												
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other											Flora			Fauna										
RICHARDS BAY (continued)			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	Food Webs
Data Voids										★												★				←	★	→				
Source of Information			Summary of available information																																			
van der Elst	1975	307								●																	●	●										
Wallace	1975	328,329		●	●	●				●												●						●										
Hemens *et al*	1975	167		●		●				●	●											●					●	●										
Oliff *et al*	1975	247			●		●			●															●		●											
Anon	1976	16		●				●		●										●	●	●																
van der Elst	1976	309,310				●				●												●					●	●										●
Cloete & Oliff	1976	85	review																																		
Bennett	1976	29																											●								
Hemens *et al*	1976	168		●	●					●				●													●										
Hemens *et al*	1976	149,153 & 165											●																									
Heydorn	1976	178								●						●								●														
Oliff *et al*	1976	254		●	●					●	●	●	●	●									●		●		●										
Nicholls	1976 to 1978	pers. comm.																											●								
van der Elst	1977	312		●		●				●												●					●	●										●
Hemens *et al*	1977	163		●	●					●																											
Hemens & Sibbald	1977	149,150											●									●															
Berjak *et al*	1977	30																				●															
Heydorn	1978	179			●					●						●								●													
Anon	1978	20		●			●			●																		●	●								
Coke	1978	88	●	●	●			●	●							●			●	●	●	●		●				●	●	●							
Aerial photos (Scogings)		No.																																		
1:10 000 Job No. 250	1976	177 to 183		●						●												●		●													
1:25 000 Job No. 251	1976	408 to 412		●						●														●													



GENERALISED WIND ROSE

2–11 12–29 30–61 61+ km/h

Arcs represent 5% intervals
Percentage calm within circle

SWELL OBSERVATIONS

(Distribution by direction, height and period)

MLALAZI

Synonyms
Umlalazi ([182, 333]).

Zulu meaning
"The place of the whetstone" . . . because of the whetstones (used for sharpening spears) which were obtainable there ([289]).

Location
28°57'S; 31°48'E.

Accessibility
The Mlalazi estuary is easily accessible by road and lies below the village of Mtunzini, 140 km north east of Durban and ±35 km south of Richards Bay. There is a railway siding at Mtunzini and an airstrip for light aircraft on the floodplain of the estuary.

Bridges
A railway bridge traverses the middle of the estuary 7 km from the mouth; and the national road bridge crosses the head of the estuary 10,5 km from the mouth.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. Although given as 130 km² by Hill ([182]), the catchment area is between 420 km² ([78, 158, 232, 257]) to 507 km² ([223]) in extent.

River length. 40 km ([21, 158, 232]) to 68 km ([78]).

Mean annual run-off. 131 x 10^6 m³ ([78]) to 139 x 10^6 m³ ([223]).

Flow. Flow is guaged at Eshowe, at a point representative of run-off from only 18 km² of the catchment. These records are of little value to any understanding of the estuary. The probable average total flow from the catchment is given as 1,9 m³/sec. in ([232]).

Flood history. 1:100 year floods have been estimated to discharge 1 500 m³/sec. ([232]) and produce flood levels of 4,5 m to 5,0 m above mean sea level. This order of flooding is confirmed by the memories of local inhabitants ([232]). In May 1971 the water reached road level at the national road bridge ([158]).

Level fluctuations. Unless the mouth has been temporarily deepened by floods, the low neap tide level is lower than low spring tide ([182]). This is because the volume of water which enters the estuary on a high spring tide does not have time to escape before the next tide starts rising in the sea. The actual exchange volumes are unknown. At the tearoom (i.e. on the big bend) the tidal range was shown to be 0,85 m on 9 February 1963 ([182]). Hemens *et al* describe the tide as being "quite effective" even at the railway bridge (Station 5) ([158]).

Dams.
Existing: Eshowe dam near the headwaters of the river.

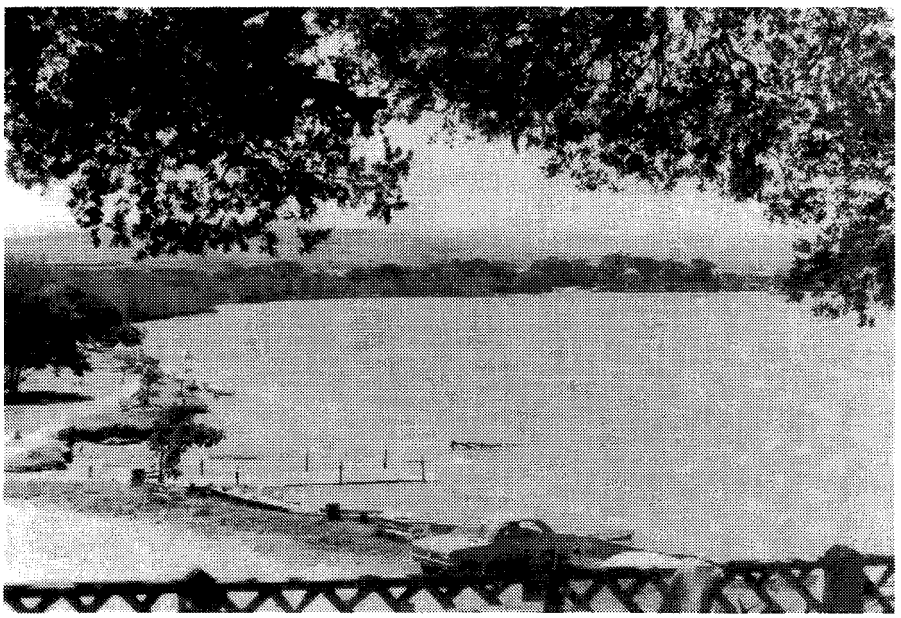
Proposed: A dam site has been located at Obanjeni, ±30 km above the estuary ([78]).

Siltation. Although no quantitative information on silt loads is available, reports of siltation arising from bank erosion because of sugar farmers ploughing up to the water's edge, date back to 1948 ([301]). In 1960, Ward ([333]) drew attention to the same problem, as well as "increased artificial drainage and the destruction of riparian trees and other vegetation including reeds . . .". Hill ([182]) also noted in 1963 that the river turned muddy as cultivated areas were encountered and where drainage furrows had been cut through adjacent sugar cane lands. Precipitation of silt occurs in the estuary due to the salinity of the water. At one stage (1960) uninformed sources considered the spread of mangroves to be the cause of silting ([333]). Dredging by the Reclamation Unit of Provincial Building Services was underway by 1965 ([158]) and spoil was deposited in the *Phragmites* swamp opposite Station 7 (see Fig. **28**). It has not been possible to establish when dredging ceased or why it was being done.

Land ownership/use. 72% of the catchment is Bantu influenced and destined to remain so as KwaZulu. The northern bank of the estuary is to become the KwaZulu National Botanic Gardens (Cooper, pers. comm.). The coastal plain is used principally for the production of sugar cane.

Above the estuary is the township of Mtunzini with a present day population of ±560, which increases to ±1 350 during the tourist season.

Although sugar cane farms converge upon the upper reaches of the estuary, much of the surrounds are in the hands of the Natal Parks Board and administered as a nature reserve. Tearoom/boat hire facilities have been developed alongside the estuary. There is no Admiralty Reserve.



A view of the Mlalazi estuary from the tearoom. Notice the mangrove development on the southern bank.

Local authority. The southern and eastern banks are controlled by the Mtunzini Town Board and Natal Parks Board; and the northern and western banks by the Department of Bantu Administration.

Estuary uses. Boating and angling are principal uses. Picnicking occurs in the public open space provided alongside the estuary. Having distinct potential as a resort, the development of a marina has been given serious consideration in the past ([232]).

The estuary is also of educational value, having been selected as a research site and for student excursions by the Department of Biological Sciences at the University of Natal (Forbes, pers. comm.).

Morphometry of the estuary (see Fig. **28**).

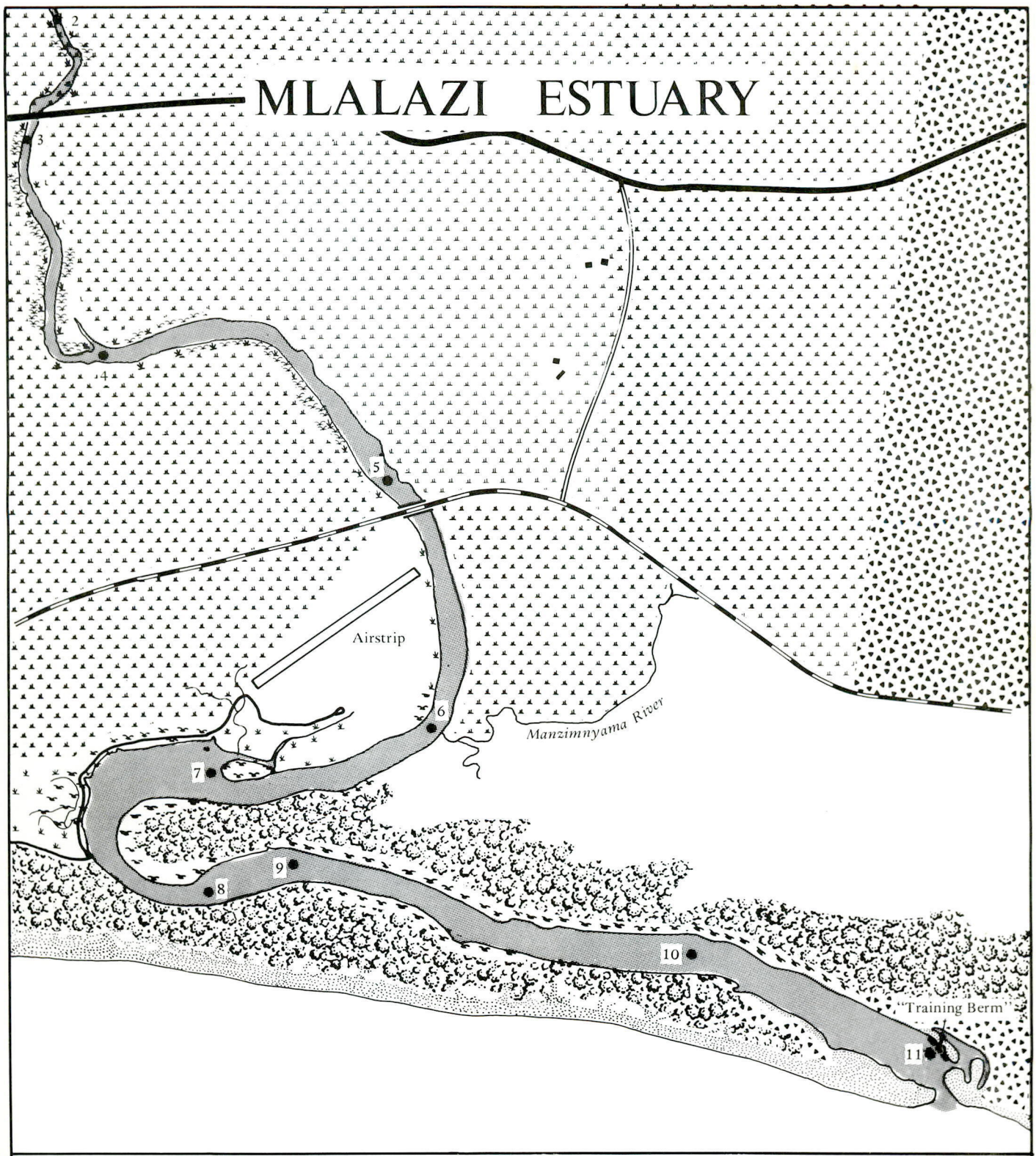
Area. 126 ha to 132 ha ([328]).

Axial length. Hill considered "Balcombe's Rocks" (7 km from the mouth, although he says 8 km) as the head of the estuary ([182]). However, Archibald *et al* ([21]) found the water at the national road bridge (Station V2) to be "clearly estuarine" in 1967/68. Hemens *et al* also consider the estuary to extend up to and slightly above this point ([158]). Its total axial length is therefore ±11 km.

Shoreline length. 23,7 km.

Width.
Maximum: 270 m.
Mouth: 50 m to 150 m (varying with tide and season).
Floodplain: In places up to 1 km wide.

Bathymetry. In places greater than 3 m ([158, 182]) at high tide.



Station Numbers after Hemens et al 1972[158]

Coastal Dune Forest

Exotic Plantation

Reed Swamp

Mangroves

Barringtonia

Cane

1km = 4

500 0 500 1000 1500 2000 metres

Fig. 28

1=1
2=12
3=20.5

4= 29
5= 37.5

Geomorphology

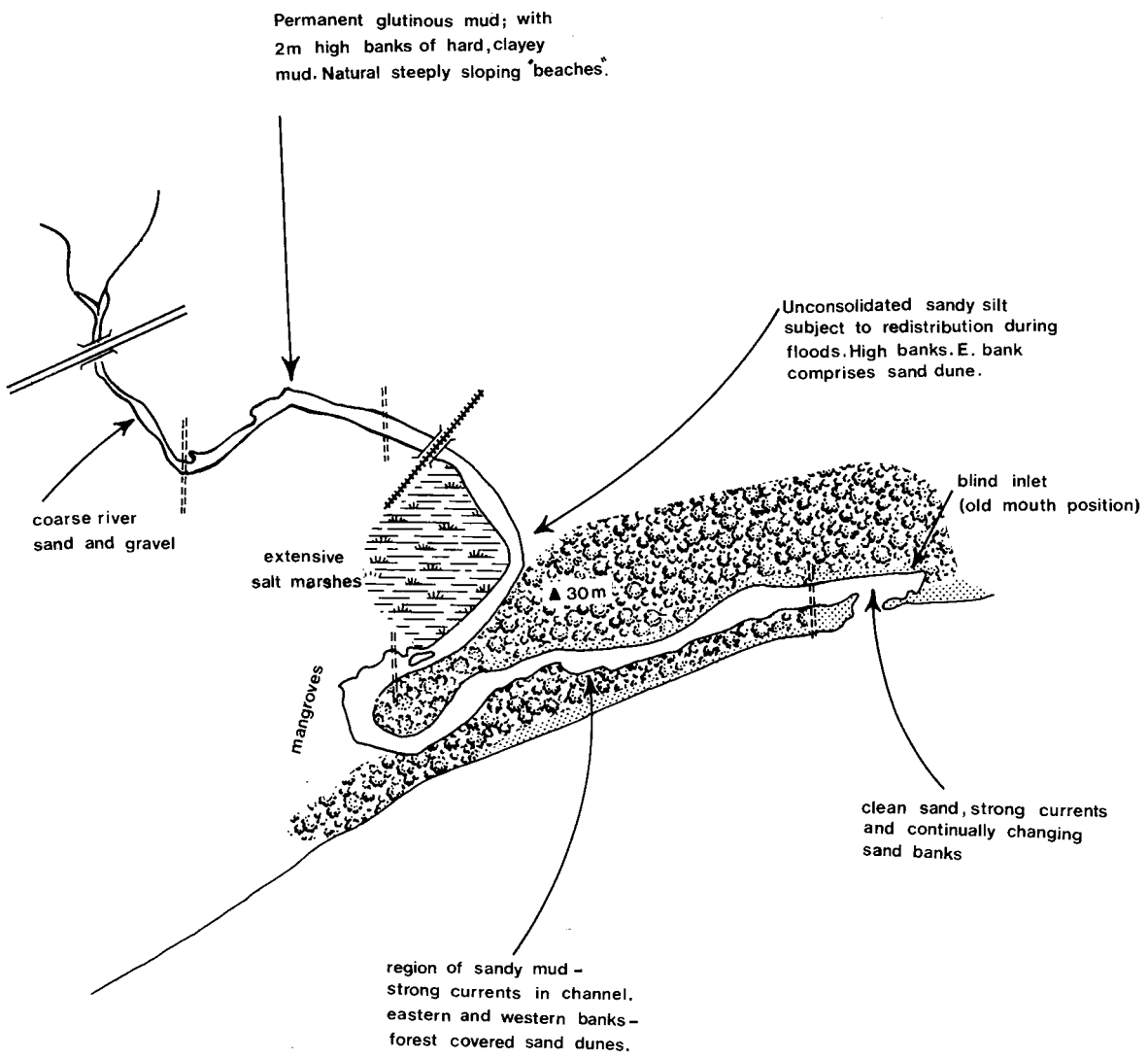
Geology ([78])

In the catchment, Table Mountain Sandstone and Archaean Granite dominate the region. In the vicinity of the estuary, formations of Ecca and cretaceous deposits (sandstone and shale) occur, which are said to be unconsolidated Miocene beds (calcareous sandstone) ([158]).

Nature of bottom materials (see Fig. **29**)

Rocky outcrops occur as low reefs, 200 m above the railway bridge at "Balcombe's Rocks". Soft mud occurs wherever there is little or no current action, in permanently submerged or inter-tidal areas. Where currents occur the substratum becomes sandy. Near the upper tide levels and above, the mud becomes sunbaked and dried out, although underwater, some hard clay beds do also occur ([182]).

Fig. 19. Nature of the bottom materials — Mlalazi estuary.



Particle size and chemical analyses of the sediments were undertaken by Hemens *et al* in 1971 (158). At certain places, fine organic sediments were located which were anaerobic and contained high sulphide concentrations. Although very variable according to the nature of the substrate, the average values obtained between Stations 2 to 11 on 27 May 1971 were:

Dry weight (%)	=	65,7
Dry weight volatile @ 600°C (%)	=	5,6
Oxygen absorbed mg/g dry weight	=	5,3
Kjeldahl nitrogen µg/g	=	837
Total phosphorus µg/g	=	80,3
Humic acids mg/g	=	9,5
Iron mg/g	=	12,3
Sulphide mg/g	=	0,68

Additional data is available from an exploratory survey a year earlier (158). On this occasion, the organic and iron content were greater because sampling had not been preceded by floods.

Information on the granulometric nature of the bottom materials in the Mlalazi mangrove swamp has become available since studies in 1976 on the distribution of fiddler crabs by Chrystal (81).

Sandbar characteristics. In response to the supply of material from the Tugela and strong, unidirectional wave attack (256, 257) the estuary lies deflected behind a 3,5 km long north extending sandbar. The greater part of the sandbar is colonized by dune forest and forms a stable peninsula.

An aerial photo of the mouth in 1937 (182) shows it to be almost 1 km north of its present position. The remnant of this channel is a blind inlet north of the present mouth.

Hill mentions that granite boulders were laid down in the mouth region in 1962, at the foot of the dunes on the west bank, to prevent erosion into the estuary. By the addition of sand bags and dolosse (158) this structure became built, to act as a "training berm" to direct the floodwaters away from the dunes. It was partially destroyed by floods in May 1971 (158). The idea originated from Ward in 1960, because of concern about the deposition of sand into the mouth of the estuary due to dune slumping (333).

The Mlalazi mouth has been permanently open since 1952 (158, 182, 333). Local enquiries revealed that until 1952 mouth closure was a regular event (182). A list of dates when the mouth was known to be closed is available. As far back as 1912 farmers used to open the mouth when necessary, to prevent the flooding of sugar cane (333). They would wait until the level of the blocked lagoon rose to the top of the pillars of the old road bridge before attempting to do so. With any level lower than this, it was apparently a "waste of time" (333). At this level the water in the lagoon must have become very fresh and have covered a considerably larger area than it does today. The reason why the mouth should suddenly open and have remained so for the past 25 years is inexplicable.

Configuration of the adjacent shore.

At the Mlalazi estuary, the angle of the shore begins to assume a totally different relationship to the estuary mouth and the estuary begins to receive protection from north east storms by the "bulge" in the coast at Port Durnford. Wave attack from the south east becomes directed from an angle which approximates 90°, directly into the mouth.

Surf zone currents. No record.

Physico-chemical characteristics (158, 182) (see Table 8)

In 1963 Hill undertook detailed studies of salinity, temperature and water transparency changes in the estuary (182). In May 1971 Hemens *et al* studied a wider spectrum of chemical characteristics within the estuary, but shortly after heavy floods. The water quality of the river was comprehensively studied by the NIWR team in 1967/68 (21, 205) and found to be contaminated in the lower reaches of the river. Station V2 at the national road bridge was considered to be **clearly estuarine** (even in the wet season) due to the relatively high conductivity, total dissolved solids, sodium and chloride values (21).

Thermal properties (182). Due to insolation of the shallower estuarine waters, there is a gradual increase in temperature from the mouth (because of the influence of sea temperatures) to the head of the estuary. On 1 November 1973 (at a high spring tide) a transition from 23°C to 27,3°C occurred over this distance. The mean surface temperature in July was 16,7°C

Table 8. Physico-chemical characteristics.

MLALAZI	(21) National Road Bridge			(158) Average of Station 2-11
	Winter 1967	Summer 1968	Winter 1969	9 June 1971
Hydrogen ion concentration (pH)	7.35	6.97	-	-
Saturated pH value	8.20	8.50	-	-
Conductivity micromhos/cm	3 404	2 019	7 560	-
Total dissolved solids ppm (calculated)	2 070	1 256	-	-
Dissolved oxygen mg/litre	4.60	5.80	-	-
% Saturation	50	69	82	-
Oxygen absorbed mg/litre	3.50	-	-	1.50
Biological oxygen demand mg/litre	-	-	2.10	-
Kjedahl nitrogen mg/litre	2.20	-	-	.096
Ammonia "	-	-	-	.002
Nitrites "	-	-	-	.002
Nitrates "	0.18	0.21	-	.256
Phosphates "	-	0.09	-	-
Total phosphorus "	-	-	-	.011
Total alkalinity "	69.9	53.5	-	-
Total hardness "	403	229	-	-
Calcium "	29.3	18.1	-	-
Magnesium "	80.4	44.7	-	-
Sodium "	635	450	-	-
Potassium "	23.5	12.0	-	-
Sulphates "	161	81	-	-
Chlorides "	1 082	600	-	-
Fluorides "	0.3	-	-	-
Free carbonic acid (as ppm carbon dioxide)	-	11.20	-	-
Temperature ^{o}C	19.5	24.9	-	-

* values underlined significant of disturbance

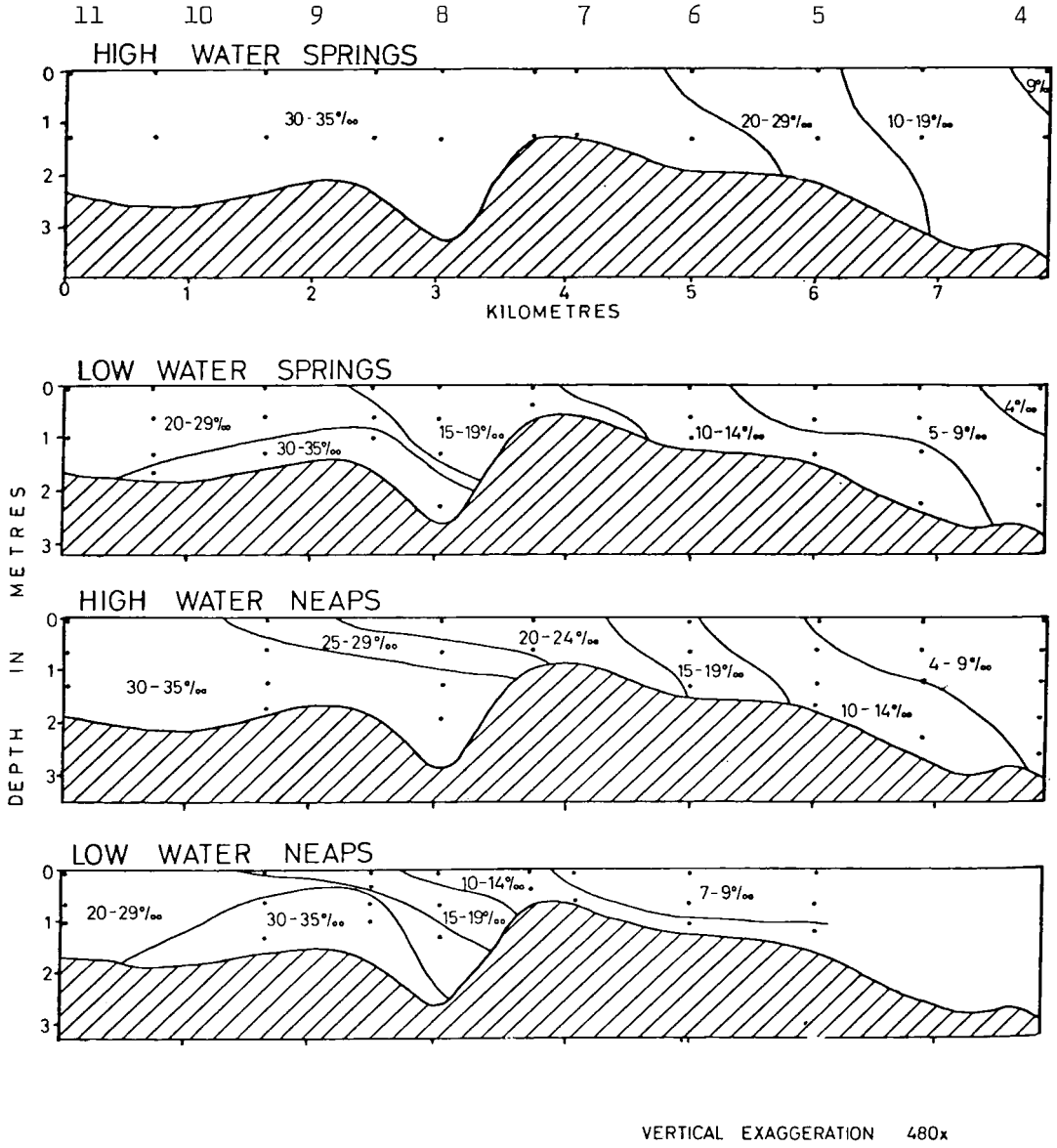


Fig. 30. Longitudinal sections of the Mlalazi Estuary at various tides showing distribution of masses of water of different salinities (after Hill ([182])).

(minimum 15°C); and in November was 25,9°C (maximum 27,9°C). Deeper down colder water (associated with its greater salinity) was encountered. For example on 8 November 1963, the temperature at the surface was 26,7°C, but at 1 m was 23°C. Insolation causes temperatures in pools in the mangrove swamp to rise as high as 35°C and also accounts for the fact that water around the margins of the estuary can be warmer than that in the centre.

Transparency ([182]). In 1963 average Secchi values ranged from 95 cm at the mouth (near source of clean sea water) to 60 cm at the head of the estuary (where silt from the river was in suspension). After heavy rains Secchi readings throughout can be reduced to 5 cm. Strong winds can also reduce transparency by the resuspension of bottom muds. Transparency is maximal two hours **after** peak high tide, because during the incoming tide the sea water has remained on the floor of the estuary and only becomes gradually mixed with the surface layers.

Salinity ([158, 182]). Vertical salinity gradients occur even after reasonably severe floods (e.g. 25 October 1963) ([182]). Salinity layering was confirmed by Hemens *et al* but the flushing effect of the floods of May 1971 produced less pronounced stratification along the whole estuary ([158]).

The outgoing surface water leaves the estuary more rapidly than the bottom water. In Fig. **30** the distribution of water masses of differing salinity along longitudinal sections through the estuary are shown. Reversed horizontal salinity gradients were apparent at low water. The smallest changes in salinity occur at either end of the estuary, and it is interesting to note that salinity **variation** was greatest at the surface ([182]). As the 'salt water wedge' retreats on the outgoing tide, pockets of more saline water are left in the deeper parts of the estuary ([158]).

Nutrients ([158]). Nitrogen and phosphorus concentrations lie well within 'normal' ranges, decreasing as the estuary mouth is approached.

Public health aspects

Bacteriology. There was some indication of faecal contamination in the upper reaches of the estuary in 1971 ([158]), but at levels which were not considered to be excessive (*E. coli* levels below 500/100 ml). However, since *Salmonellae* and *Staphylococci* were isolated at several stations on both the high tide and the low tide (see Table **9**), the estuary cannot be considered as clean. Below Station 8 the estuary was of far better bacteriological quality.

Table 9. Bacteriology of the Mlalazi estuary.

Date	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml	Total Coliforms per 100 ml	*Salmonella* per 250 ml
	6 days @ 20°C	Confirmed		
1969*	5,5			
27.5.71** (high tide)	3,1	24	1 027	+
9.6.71** (low tide)	5,2	125	1 270	+

* From Archibald *et al* ([21]) at Station V2 (National road bridge).
** Average result from Stations 2 to 10 ([158]).
\+ Significant of disturbance.

Bilharzia. Both vector species, *Biomphalaria* and *Physopsis* have been located in the catchment by Jackson (State Department of Health, pers. comm.) on 20 October 1970. However, the markedly saline nature of the estuary makes transmission in the Mlalazi estuary unlikely.

BIOTIC CHARACTERISTICS

Flora.

The estuary is surrounded by luxuriant climax dune forest on both its western and eastern sides. Mtunzini is also well known for a colony of *Raphia* palms that have become established below the township.

Near the mouth of the estuary *Casuarina* forests have become established through the efforts of the Department of Lands in the 1950's to control drift sand. In the middle reaches of the estuary, the banks are lined by mangroves, dominated by *Avicennia marina* ([217, 333]). Mangroves (presently estimated to be 10 ha in extent ([91]) first became established in the estuary in the 1940's ([333]). They began to spread as more and more fine silt became deposited over what were previously sandy banks in the lower part of the estuary ([333]). The fact that the mouth remained open from 1952, facilitated the process, because this meant that these alluvial banks now became subjected to the unrestricted, fluctuating water levels of a tidal regime. Prior to this, periods of static water levels (while the mouth was closed) inhibited the establishment of a thriving mangrove community ([182, 217]). Their establishment has been beneficial in that the mangroves supply detritus to the estuary and support a typically mangrove associated fauna. In addition, the banks became protected from erosion and, by effectually narrowing the width of the estuary, they have increased current speeds and scour in the channel ([182, 333]). However, Hill also suggests that their establishment in the shallows has been at the expense of *Zostera* ([182]).

The beds of *Zostera* present in 1963 had certainly become reduced to a few patches by 1971 ([158]), although Hemens *et al* suggest that recent flooding, or earlier dredging operations could have been responsible for this situation. Behind the mangrove community are salt marshes comprising *Juncus*, *Arthrocnemum* and *Phragmites*. Due to the general raising of the shoreline by the deposition of spoil in these areas, very little tidal flooding occurs ([158]). It is interesting to note that Orme's colour infra-red imagery also revealed that both mangroves and reedswamp alongside the Mlalazi were experiencing considerable stress ([260]).

In the upper reaches of the estuary *Barringtonia racemosa* replaces the mangroves on muddy shores, as does *Hibiscus tiliaceus* in certain places. The reed *Phragmites communis* grows along the very edges of the water on a narrow "beach" area. Severe sugar cane encroachment becomes apparent in the upper reaches of the estuary.



An impression of the mangrove community alongside the Mlalazi estuary. The taller trees are Avicennia (the white mangrove) whilst the understorey are Bruguiera (the black mangrove).

Fauna.

The fauna is distributed to a large extent by the nature of the substratum ([158, 182, 217]) and after his survey in 1963, Hill ([182]) presented a list of the 156 animals found in the system, together with information on their distribution within the estuary. This was a particularly diverse fauna and a situation mainly attributable to the existence of intertidal flats, mangroves, *Zostera* and a wide variety of other substrata.

Lower trophic levels. The mudflats were rich in mud prawns (*Upogebia*), polychaetes (*Dendronereis*) and razor shells (*Solen*). Swimming prawns were common and molluscs (*Cerithidea*) associated with the mangroves, were abundant. Marsh crabs (*Sesarma*) and fiddler crabs (*Uca*) were very common above tide levels. Barnacles (*Balanus*) were found in dense populations on rocks at the railway bridge, and even logs, embedded in mud, supported a characteristic fauna of polychaetes, molluscs and crustacea. Barnard ([27]) drew attention to the presence of the lamellibranch *Martesia striata* in the Mlalazi estuary.

Grindley (pers. comm.) took zooplankton samples from Mlalazi (in 1967) but has not analysed them yet.

By 1971 Hemens *et al* [158] considered the estuary to be only moderately productive. Only 27 invertebrate species were found to be present, whereas in 1963 Hill [182] had recorded 95 invertebrate species. In the interim, *Zostera* had disappeared, dredging has been taking place and floods had occurred recently. However, the high catch rates of *Penaeus indicus* in February 1977 by IFCOR, immediately offshore (de Freitas, pers. comm.) are suggestive of a nearby source of such animals in vast numbers (particularly as the petasma of the male prawns was unfused). Despite the lack of such animals in 1971 [158] it is reasonable to suggest that the Mlalazi could have been the source from which these animals came.

In 1976 a study of the distribution of fiddler crabs (*Uca* spp.) was undertaken by Chrystal in the Mlalazi mangrove swamps [81].

Higher trophic levels.

Fish: 58 species of fish were recorded by Hill in 1963 [182]; and only 15 species in 1971 [158]. Attention has been drawn to the presence of the Zambezi shark, *Carcharhinus leucas*, in the estuary [158]. Over shallow mud banks juvenile fish of numerous species were abundant [182].

Birds. 50 species of estuarine associated birds have been recorded on or around the Mlalazi estuary, by Sinclair (pers. comm.) during the course of six surveys over the period 27 May 1972 to 14 July 1975. None were present in high numbers, although the numbers of Swift Terns, the presence of Red-winged Pratincoles and a breeding pair of Fish Eagles were considered noteworthy. Associated with the *Raphia* palms at Mtunzini, is a breeding pair of the rare Palm-nut Vulture.

SYNTHESIS

Our general state of knowledge of the Mlalazi estuary is fair, but requires updating — largely to ascertain whether the Mlalazi estuary still is the productive system which it was in 1963 [182]. Whilst surveys in 1971 have indicated that this is not the case, there are other indications (such as the IFCOR catches of prawns — see under Fauna) that it may be so. The system warrants further biological study, as well as hydrological study, to try and understand what it is that keeps the mouth of the Mlalazi open, particularly as the proposal to build a dam on the Mlalazi river could affect this condition.

In its present environmental condition, the Mlalazi estuary has several outstanding estuarine characteristics such as its open mouth, nutritive substrates and a flourishing mangrove community. Consequently it has distinct conservation potential. As in most estuarine systems in Natal, excessive siltation threatens the system, and cane encroachment into its upper reaches is a problem. Other problems relate to past interference with wetland communities alongside the system and the likelihood of resort development.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other						Flora			Fauna							Food Webs
MLALAZI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Historical		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids					★		★			★																←	★	→				
Source of Information	Summary of available information																																
Towner Coston	1948	301								●																							
Ward	1960	333								●							●						●		●				●				
MacNae	1963	217																					●				●						
Hill	1963	182		●		●	●	●		●													●		●	●	●	●					
Barnard	1964	27																									●						
Kemp & Sibbald	1966	205	●								○																						
Archibald *et al*	1967	21	●								●					●																	
Cooper	1968	91																					●										
Midgley & Pitman	1969	223			●																												
Moreland Technical Eng.	1970	232			●																●												
Chew & Bowen	1970	78	●		●			●																									
Hemens *et al*	1971	158	●	●		●	●	●		●	●					●									●								
Orme	1971	260		●																			●		●								
Orme	1971	256,257						●		●																							
Cloete & Oliff	1971	85	Summary of Hemens *et al* [158]																														
Sinclair	1975	pers. comm.																											●				
Wallace	1975	328		●																								●					
Chrystal	1976	81								●																	●						
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 250	1976	166 to 170		●						●													●		●								
1:25 000 Job No. 251	1976	426 to 427	●	●																													

2.1.4.2 **SIYAI**

Synonyms

Siyana (1:50 000 map No. 2831 DD)
Siyani ([256, 257])
Siyaya (1:250 000 Topo No. 2830 ([232])).
Siaya (Garland, pers. comm.).

Adoption of the name Siyai is recommended as this is the most commonly used local name for the lagoon.

Zulu meaning

The name means "we go" signifying the reply from Shaka's impis after he instructed them to destroy a particular tribe in the vicinity of the Siyai (Garland, pers. comm.).

Location

28°58'S; 31°45'45"E.

Accessibility

The Siyai lies on the coast just east of Mtunzini. Consequently by road it is 140 km north east of Durban. Access to the western bank of the Siyai is through the farm "Twinstreams", owned by Mr I. F. Garland.

Bridges

There are no bridges across the lagoon.



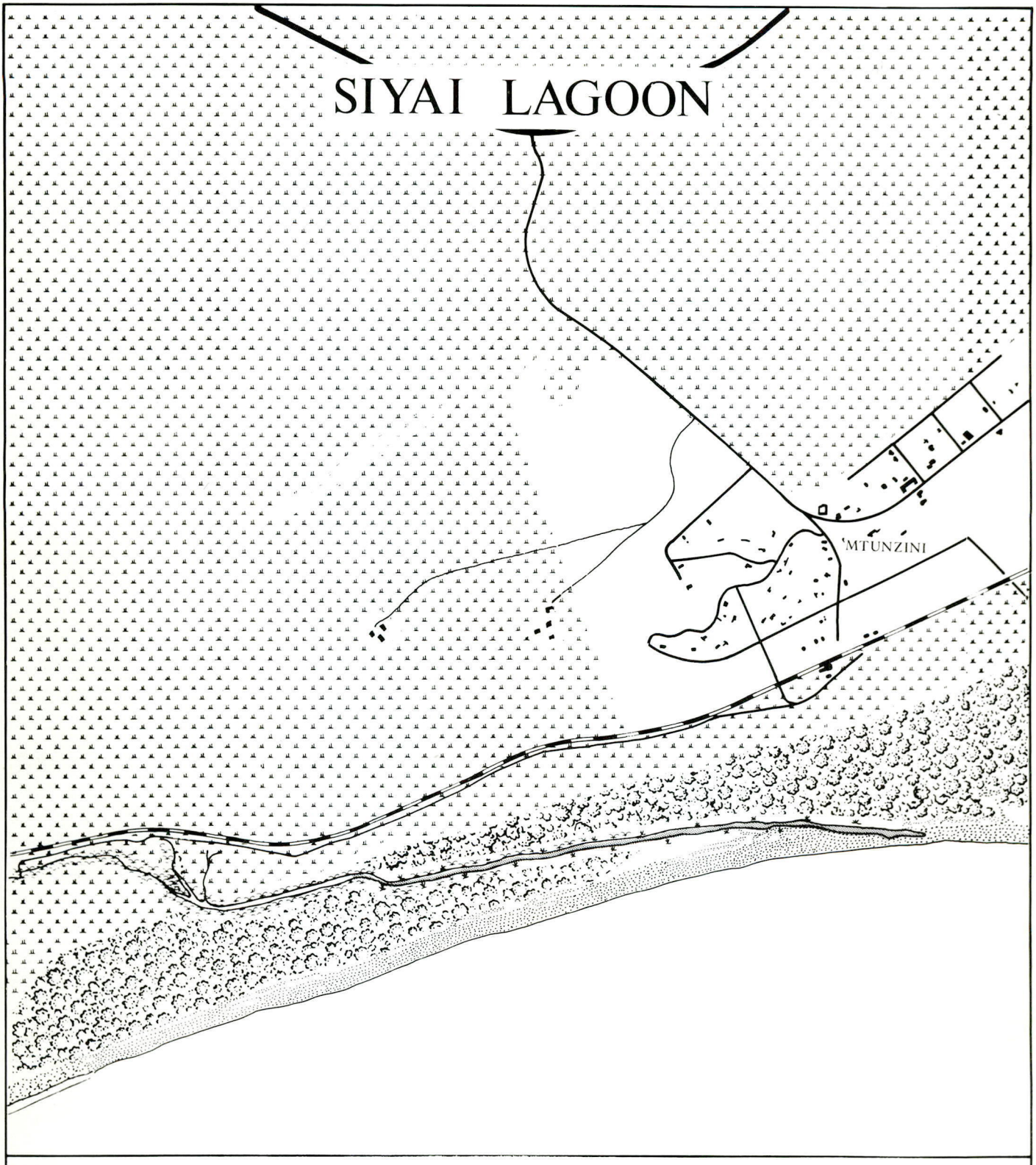
Gum tree stumps have been thrown into the bed of the Siyai river to reduce water velocities.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 18 km^2.

River length. 8 km.



Coastal Dune Forest

Barringtonia/Swamp Forest

Reed Swamp

Cane

500 0 500 1000 1500 2000 metres

Fig. 31

Mean annual run-off. No record.

Flow. No record.

Flood history. Flooding in the Siyai has in recent years become exceedingly violent (Garland, pers. comm.). Among other things, this is as a result of swamp destruction upstream, the installation of drainage schemes and graded contours and the re-shaping of the hill slopes. Garland has attempted to decrease water velocities during flood periods by constructing barriers of gum tree stumps across the stream bed.

Dams. Existing or proposed — nil.

Siltation. The Siyai used to be a deep, clear stream until sugar cane farmers (from ±1946) began to reshape the terrain, plough downhill of steep slopes, plant onto the river banks and remove sponge and swamp vegetation. The consequent erosion, largely in the form of sand, has in a relatively recent period of time (15 to 20 years) reduced the Siyai to a "shadow of its former self" (Garland, pers. comm.). Depths have become dramatically reduced and changes in channel positions occurring as bed levels have gradually become raised.

Land ownership/use. Although the entire Siyai catchment is used for the cultivation of sugar cane, the lagoon is surrounded by undisturbed indigenous forests.

Local authority.
Lower reaches — Natal Parks Board
Upper reaches — Mr I. F. Garland.

Estuary uses. Being situated adjacent to a good beach, the lagoon used to be favourite picnic place prior to it becoming infilled by silt. The "Mlalazi marina" development was to be interconnected by a canal to the Siyai ([232]).

Morphometry of the lagoon (see Fig. **31**)

Area.	±8 ha	to the "brack water limits" described by Garland (pers. comm.)
Axial length.	2,5 km	
Shoreline length.	5,2 km	

Width.
Maximum: 45 m.
Channel: No record.
Floodplain: 60 m to 100 m wide.

Bathymetry. No measurements in the actual lagoon have ever been made, but in the river above, pools originally 1,5 m to 2 m deep have become reduced through siltation to ±0,25 m today (Garland, pers. comm.).

Geomorphology.
Geology. Rocks outcrop in several places across the stream above the lagoon, forming cascades and small waterfalls. No information as to the identity of these rocks is available.

Nature of bottom materials. The bottom materials presently comprise coarse fluvial sands and mud. 15-20 years ago the bottom of the lagoon was said to be composed of clean sand of marine origin (Garland, pers comm.).

Sandbar characteristics. Heavy material inputs (from the Tugela) and strong unidirectional energy flows (waves) have diverted the mouth of the Siyai north east and parallel to the shore for 2,5 km ([256, 257]). The mouth is still shifting steadily northwards (Garland, pers. comm.). It is generally closed and opens only for very brief periods (of up to a week) after floods. The bar is topped by the high spring tides.

The lagoon is never breached artificially due to the lack of agricultural encroachment around it.

Configuration of the adjacent shore. No record. Zwamborn (pers. comm., 17 October 1977) has indicated that this section of beach is remarkably flat and safe for bathing. It is likely to become utilized for this purpose in the future.

Surf zone currents. No record.

Physico-chemical characteristics

No record. Salinities are probably maintained by "bar topping" on the spring tides.

Cropland pollution problems could arise from fertilizers, herbicides (used to eradicate weeds) and "Temik" (used to eradicate nematodes) all of which are applied annually to the land by sugar farmers (Garland, pers. comm.).

Public health aspects.

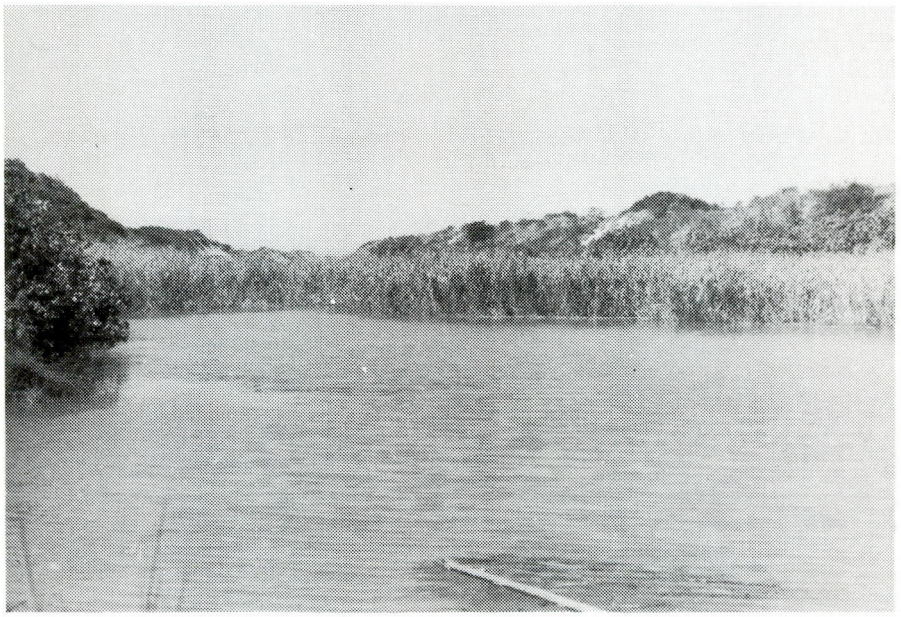
Bacteriology. No record. Farm employees do use the stream for bathing and the washing of clothes. Consequently the danger of faecal pollution exists.

Bilharzia. On 30 January 1970 a survey by Jackson (pers. comm.) failed to reveal the presence of any of the vestor snails species. However the stream warrants thorough re-examination before being accepted as "bilharzia free".

BIOTIC CHARACTERISTICS

Flora

Since shallowing, the Siyai lagoon has become dominated by reeds (*Phragmites*) which have encroached into the lagoon from the edges. Also encroaching are *Barringtonia* and *Hibiscus*, both as a result of sand deposition within the river and alongside the banks.



A view of what remains of the Siyai lagoon. Notice the reeds which have encroached into the water-body as a result of siltation.

The west bank comprises coastal dune forest in a very good state of preservation due to the conservation awareness of Mr Garland. Within this forest, 259 species of trees occur. Where small streams enter the system, patches of swamp forest have developed (*Ficus hippotami, Bridelia, Voacanga, et al*) and the growth of *Raphia* palms is encouraged. Star grass, *Setaria*, *Cyperus* and various other sedges have been planted as stream bank binders.

On the sandbar and dunes to seaward of the lagoon, dune pioneer species such as *Scaevola*, *Passerina* and *Chrysanthemoides* occur.

Patches of submerged aquatic vegetation in the form of *Potamogeton pectinatus* were found in the lagoon in October 1977 (pers. obs.).

Fauna

The sandprawn, *Callianassa*, occurs and the mollusc *Neritina natalensis* was found by Jackson in the Siyai lagoon on 31 January 1970 (pers. comm.). *Macrobrachium* and a particularly large penaeid prawn (*P. monodon*?) used to frequent the lagoon (Garland, pers. comm.). A list of fish caught in the Siyai in 1950, after a survey by Campbell *et al* is available from Mr Garland. 16 species were present (excluding barbel and eels). Although no more

recent information is available, there seems little doubt that utilization of the lagoon by many estuarine species has ceased. From the recollections of Mr Garland, it is interesting to note the distance to which certain estuarine species (such as mullet and prawns) used to move above the lagoon. From such observations it becomes clear that the limits of sea water penetration may not necessarily constitute a boundary to certain estuarine organisms. This is an important point as deterioration of the river upstream could be as important as deterioration of the lagoon itself to such species.

From the information supplied by Mr Garland, 22 species of birds are normally associated with the lagoon. Amongst these Pell's Fishing Owl, the Palm Nut Vulture, Little Bittern, White-backed Night Heron and Peter's Finfoot are noteworthy due to their relative scarcity elsewhere. A list of the tree frogs in the area, many of which are associated with various plant communities alongside the lagoon, is also available from Mr Garland.

Hippo and crocodiles occasionally by-pass the lagoon whilst moving **along the beach** between the Matigulu and similarly large expanses of water, further north (Garland, pers. comm.).

SYNTHESIS

The general state of knowledge of the Siyai lagoon is very poor. In view of the great success achieved by Mr Garland in bank stabilization, and the re-establishment of riverine/swamp communities, the possibility of restoring an 18 km^2 catchment exists. This would be dependent on the co-operation of every farmer upstream of the Siyai lagoon and the assistance of the Sugar Association. The reponse of the lagoon system to land use changes in the catchment should be monitored. The Siyai could become Natal's case example of catchment restoration.

Although degraded, and changing rapidly, in their present environmental condition the lagoon surrounds warrant stringent protection because of the flora and fauna found in the area.

There are several sugar associated problems apparent in the Siyai lagoon. These include siltation, excessive run-off, swamp destruction, cane encroachment, reed encroachment and possible pollution by a variety of agricultural chemicals.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other						Flora			Fauna							Food Webs
SIYAI			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids					★					★				★								←			★						→	
Source of Information	Summary of available information																																
Moreland Technical Eng.	1970	232																		●													
Orme	1971	256,257								●																							
Garland	1977	pers. comm.	●		●					●												●		●			●	●	●	●		
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 250	1976	163		●						●													●										
1:25 000 Job No. 251	1976	428	●																														

2.1.4.3 **MATIGULU**

Synonyms
Amatikulu ([162]); (e)Matikulu ([289]).

Zulu meaning
Various suggestions have been made ([289]):

(a) The name has been derived from the word "makulu" (big) and "amate" (spit).
(b) It means "the place of the great water".
(c) It is called after the Amatungula fruit which flourished on the river banks.
(d) It is called after Chief Magulu whose name has been given to a nearby hill in which he took refuge and was killed.

Location.
29°04'S; 31°38'E.

Accessibility.
By road, the Matigulu estuary is 105 km north east of Durban and 56 km south of Richards Bay. Although the national road is only 10,5 km away from the estuary, it is generally considered to be inaccessible due to the rough, often muddy tracks which lead to it through cane farms and a Bantu Reserve. Gingindlovu, the nearest town of any size is 13 km distant.

Bridges
There are no bridges across the estuary.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 850 km^2 ([257]); 878 km^2 ([223]); 900 km^2 ([21, 162, 205]).

River length. 84 km ([162, 205]) to 108 km ([78]).

Mean annual run-off. 132 x 10^6 m^3 ([78]) to 186 x 10^6 m^3 ([223]).

Flow. The probable average annual flow has been given as 0.7 m^3/sec. ([21]) to 4,2 m^3/sec. ([205]).

Flood history. No record.

Level fluctuations. From the automatic tide guage recorder, belonging to the Prawn Research Unit, a range of 1,3 m is evident in the estuary on a spring tide. A range of 25 cm during a neap tide in March 1972 was recorded by Hemens *et al* ([162]). Considerable alteration of the tidal prism must have taken place when the Nyoni was captured. With changes in the mouth position occurring, further alteration of the tidal prism can be anticipated.

Dams.
Existing: Nil.

Proposed: A dam site on the Matigulu river 16 km above the head of the estuary (with hydro-electric power, urban and irrigation potential) has been located ([78]). The construction of such a dam could result in a change of flow relationships downstream, which could close the estuary mouth (see under sandbar characteristics).

Siltation. No record, but from aerial photographs, patterns of deposition within the estuary and changes in depth over the past few years (see under Bathymetry), siltation of severe proportions is apparent.

Land ownership/use. Although there are two sugar mills in the catchment (at Amatikulu and Entumeni), there are no adverse effects detectable in the estuary, presumably due to the tidal exchange. Much of the catchment is used for sugar cane farming and 56% of the catchment area is Bantu influenced.

North of the estuary is a Bantu reserve (No. 8) and south of the estuary, the Amatikulu leper location. The entire estuary is destined to become incorporated into KwaZulu. The leper

location was closed in March 1977 (Hooey, pers. comm.). Undoubtedly its presence accounts for the fine state of the forests on the south bank of the Matigulu.

Local authority. Bantu Administration.

Estuary uses. Indirect use is being made of the estuary by the Prawn Research Unit (a mariculture venture by the Fisheries Development Corporation, established in 1970). Water from the estuary is pumped through the artificial ponds. When conditions are favourable, live prawns are collected from the estuary.



F.D.C.'s Prawn Research Unit alongside the Matigulu estuary.

Morphometry of the estuary (see Fig. **32**)

Area. 122 ha ([328]).

Axial length. Hemens *et al* ([162]) suggest that salt water influences diminish upstream of Station 9. The axial length of the estuary, (with the mouth in its old position) is therefore 7,5 km.

Shoreline length. 16,5 km.

Width.
Maximum: 240 m
Mouth: 100 m (May 1976)
Floodplain: 550 m.

Bathymetry. From measurements made in March 1972 ([162]) with the mouth in its old position, the maximum depth was 7 m at Station 8. Transverse depth profiles were drawn at several stations. Today, with the mouth in its present position, the depth at Station 2 is estimated to be 1,5 m (Champion, pers. comm.), compared to 3,4 m at this locality in 1972 ([162]).

MATIGULU ESTUARY

Casuarina

Gums

1

2

Casuarina

Prawn Research Unit

3

4

7

9

8

NYOM

Station Numbers after Hemens et al 1972[162]

Coastal Dune Forest

Coastal Riverine Forest

Coastal Dune Pioneer

Exotic Plantations

Cane

Grassland

500 0 500 1000 1500 2000 metres

Fig. 32

Table 10. Sediment analysis. Sampled 23/24 March 1972 (after Hemens *et al* ([162])).

Matigulu Estuary	Station Numbers - see Fig. 32						
	1	2	3	4	7	8	9
Particle size (%)							
> 1 000 microns	1.7	0.4	0.6	43.2	45.1	1.6	4.8
1 000 to 500	22.9	8.8	5.0	36.8	40.3	6.3	32.8
500 to 250	62.6	5.0	36.2	18.4	12.7	20.7	50.6
250 to 125	12.7	36.8	54.8	1.2	0.4	6.8	9.0
125 to 63	0.1	25.4	2.8	0.2	0.2	3.4	1.1
< 63	0.0	22.9	0.6	0.2	1.3	61.2	1.7
Dry weight (%)	78.0	56.3	79.1	83.3	80.8	52.8	79.5
Volatile @ 600°C (% dry weight)	1.3	5.9	0.3	0.3	0.4	7.5	0.5
Oxygen absorbed (mg/g dry weight)	0.04	5.68	0.15	0.10	0.09	15.78	0.42
Kjeldahl-nitrogen (µg/g)	59	1039	26	51	6	1639	59
Total phosphorus (µg/g)	28	131	20	5	6	185	17
Sulphide (mg/g)	0.0	0.3	0.0	0.0	0.0	1.12	0.01

Geomorphology

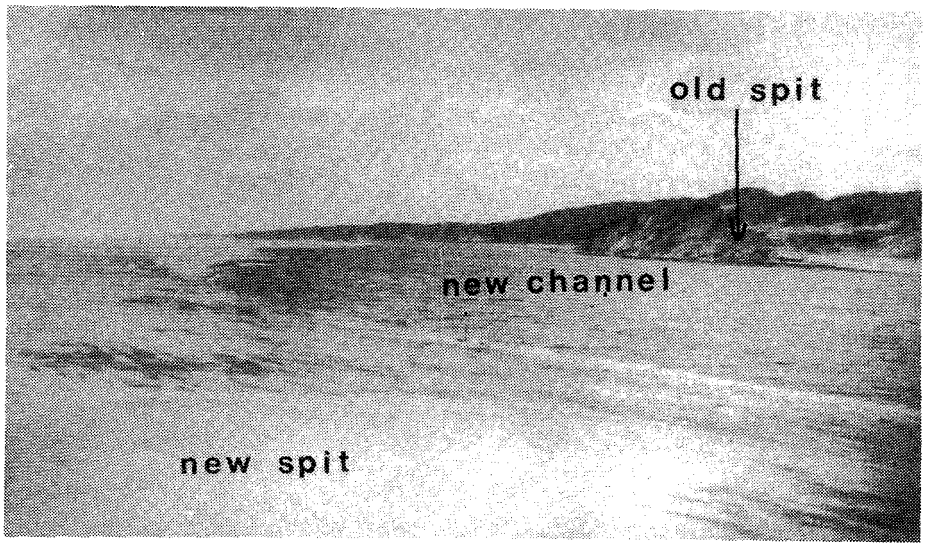
Geology. ([21, 78]). There are outcrops of Archaean granites, Table Mountain Sandstone, Ecca and Dwyka rocks in the catchment. Cretaceous deposits are said to underlie the estuary. According to the Department of Geological Survey, clayey red and grey sands surround the estuary, and sandstone formations and undifferentiated basement rocks outcrop at places on the western bank (du Preez, pers. comm.).

Nature of bottom materials. Table **10**, reproduced from ([162]) are the only results available on the nature of the bottom materials in the Matigulu estuary. In 1972 these were said to be governed by the shape of the channel and water velocity changes. Consequently where the channel was wide and shallow, the bottom materials were sand or gravelly sand; and where the channel was deeper (and velocities less) fine sediments containing substantial amounts of nutrient and organic material, were deposited. Sulphide was present at a depth of 7 m from sediments in the vicinity of Station 8. Extensive sandbanks have recently begun to form in the centre of the estuary as a result of the gross changes occurring there, in terms of mouth movements. These are becoming tidal mud flats upon which mangrove colonization may, in the future, be successful.

Sandbar characteristics (see Fig. **33**). The Matigulu sandbar is a massive north extending barrier laid down in response to wave attack from the south east ([256, 257]) and consists to a large extent, of sand supplied by the Tugela, 20 km to the south. Prior to the floods of 1976, with the mouth in an extreme northerly position, the bar was 4,5 km long and one of the most impressive in Natal. Certain sections of it have been stabilized by *Casuarina*. With the capture of the Nyoni river after the floods in May 1971 ([162]), the mouth became a common feature serving both the Matigulu and Nyoni. In March 1976 however, floods broke through the Matigulu sandbar at a point on the coast where the estuary becomes deflected through 90° to the north. This according to Orme ([257]) is not an unusual occurrence. The mouth is gradually shifting back towards the north, but this movement is being resisted by now vegetatively stable portions of the bar (see Fig. **33**). What is of particular interest, is that a new spit and estuary channel are therefore forming to the seaward side of the old Matigulu spit.

It is clear therefore that the Matigulu mouth and sandbar are dynamic, unstable features of the estuary. Movement of the mouth is of concern to the Prawn Research Unit because it was purposely located alongside the main estuary channel to the sea. Since the mouth has assumed a new position the Unit has become situated alongside a backwater of the estuary. One of the most important consequences of this is that the water from the estuary (which is used to supply the holding ponds and tanks) becomes too fresh at certain times. Although this situation has improved with the mouth moving north and consequently closer to the Prawn Research Unit, if a new spit continues to be laid down in front of the old one, the Unit shall probably be cut off completely from the sea, in the near future.

The mouth is very seldom closed, but Champion (pers. comm.) says that present flows are just able to maintain this situation. For this reason dam construction above the estuary is viewed with concern.



A new spit and estuary channel are forming on the seaward side of the old Matigulu spit. Such events epitomize the dynamical forces operative in an estuary.

Fig. 33. Variation in mouth position — Matigulu estuary.

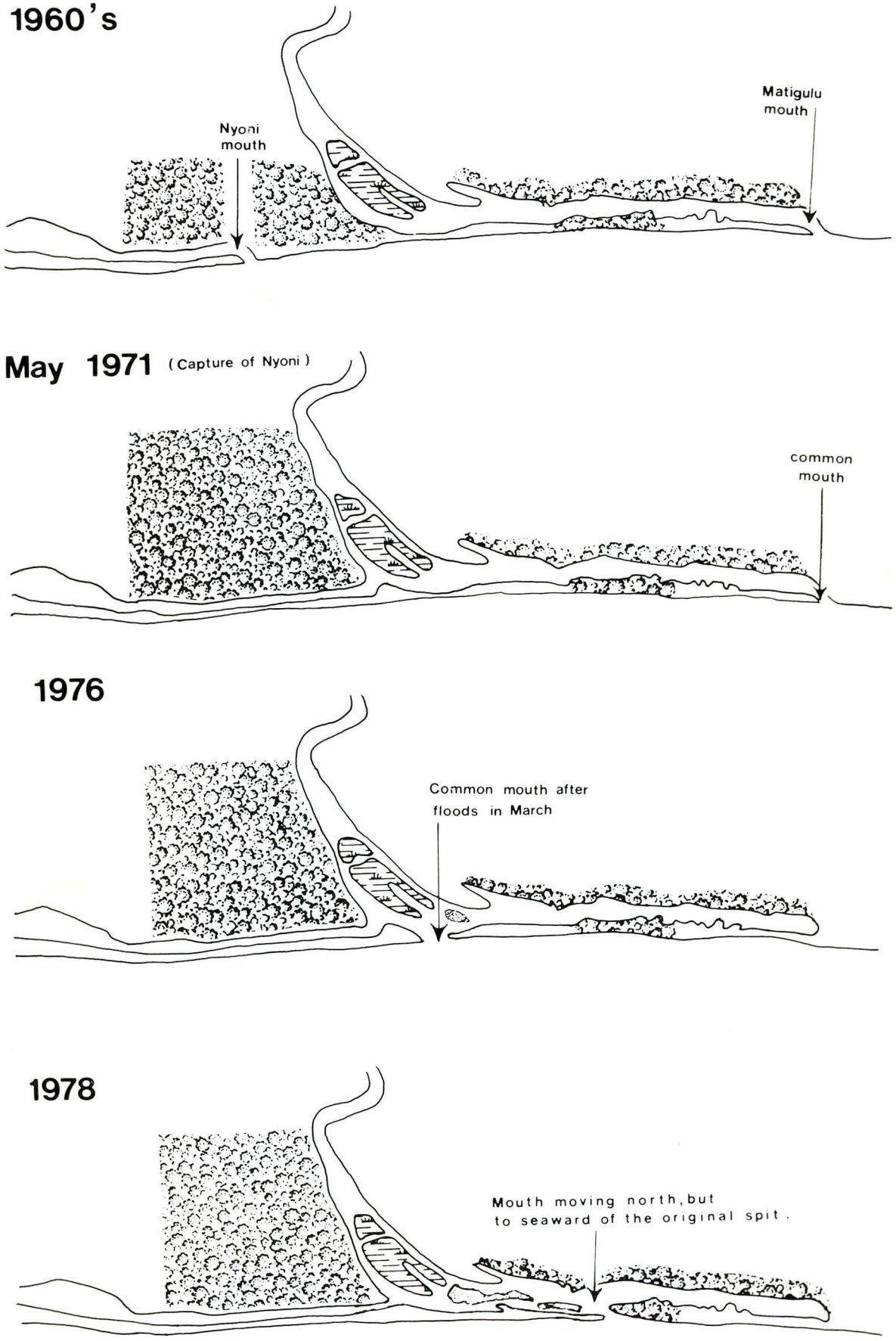


Table 11. Physico-chemical characteristics.

MATIGULU	9km ABOVE ESTUARY (21) Values recorded from Station U4			IN ESTUARY (162) Average of values recorded from Stations 1-4; 7 & 9	Prawn Research Unit (pers. comm.) Values recorded opposite Prawn Research Unit			
					Average		Range	
	1967 Winter	1968 Summer	1969 Winter	23 March 1972 Summer	8.11.1975 - 13.4.1977 Summer	Winter	Maximum	Minimum
Hydrogen ion concentration (pH)	7.55	7.27	-	7.36	7.94	7.99	8.4	7.1
Saturated pH value	8.3	9.0	-	-	-	-	-	-
Conductivity micromhos/cm	359	236	372	-	-	-	-	-
Total dissolved solids ppm (calculated)	211	137	-	-	-	-	-	-
Dissolved oxygen mg/litre	7.9	7.7	-	6.66	5.6	5.06	7.3	2.81
% Saturation	89	93	101	83.5	-	-	-	-
Oxygen absorbed mg/litre	1.2	-	-	6.8	-	-	-	-
Biological oxygen demand mg/litre	-	-	1.0	-	-	-	-	-
Kjedahl nitrogen mg/litre	2.0	-	-	.643	-	-	-	-
Ammonia "	-	-	-	.036	-	-	-	-
Ammonium "	-	-	-	-	.042	.038	.191	.035
Nitrites "	-	-	-	.004	.036	.035	.121	.034
Nitrates "	.08	0.24	-	.403	.095*	-	-	-
Phosphates "	.14	.08	-	-	-	-	-	-
Total phosphorus "	-	-	-	.026	-	-	-	-
Total alkalinity "	88.9	39.1	-	-	-	-	-	-
Total hardness "	82.2	48.8	-	-	-	-	-	-
Calcium "	13.4	6.6	-	-	-	-	-	-
Magnesium "	11.8	7.8	-	-	-	-	-	-
Sodium "	48.3	24.0	-	-	-	-	-	-
Potassium "	4.7	1.8	-	-	-	-	-	-
Sulphates "	8.1	8.2	-	-	-	-	-	-
Chlorides "	71.8	47.2	-	-	-	-	-	-
Fluorides "	0.2	-	-	-	-	-	-	-
Free carbonic acid (as ppm carbon dioxide)	4.9	4.1	-	-	-	-	-	-
Temperature °C	18.0	24.9	-	26.3	23.5	17.5	30.0	14.0
Colour (APHA units)	-	-	-	45	-	-	-	-
Salinity °/oo	-	-	-	0.25	21.76	25.9	32.6	1.2

* Average over period 9 Dec 1975 to 6 Mar 1976

Physico-chemical characteristics (see Table **11**).

Water in the Matigulu estuary is considered to be of good quality and free of industrial pollution. Daily records of temperature, pH, salinity, dissolved oxygen and nitrogen are maintained by the Prawn Research Unit. The greatest spectrum of chemical characteristics were evaluated in the river 9 km above the estuary in 1967/68 ([21]).

Thermal properties. In mid winter, temperatures in the estuary fall to 14°C (minimum) and rise in summer to 30°C (maximum) (Andrews, pers. comm.). Temperature layering may occur in portions of the estuary which are deeper than 2,5 m, if such areas still occur.

Transparency. The water in the estuary is generally very turbid (Champion, pers. comm.) but no transparency measurements have ever been made.

Oxygen. Satisfactory levels of oxygen are generally maintained throughout the estuary, although values tend to decrease in summer during periods of high river flow, to a minimum of 2,8 ppm (Andrews, pers. comm.).

Salinity. During the March 1972 survey ([162]), the river was flowing strongly, and neap tides were in operation. Consequently salinities were very low (0,25‰). Only near the mouth (Station 2) was a subsurface intrusion of sea water detectable. From the records of the Prawn Research Unit, it is clear that salinities in the estuary may at times be as high as 32,6‰ (average ±24‰) and fall in the wet season to 1,2‰. At certain times the Tugela river is said to influence the salinity of the surf zone opposite the Matigulu mouth (Champion, pers. comm.). This means that the sea water coming into the estuary would itself be diluted to some extent by the Tugela.

Nutrients. Information on the levels of various forms of nitrogen in the water are available. The nitrite results from the Prawn Research Unit are considerably higher than those revealed by Hemens *et al* in March 1972 ([162]) (see Table **11**).

Public health aspects.

Bacteriology. (see Table **12**). In March 1972 after a period of high river flow the bacterial quality of the water in the Matigulu estuary indicated fairly heavy contamination by domestic sewage, i.e. an average of 4 665 confirmed *E. coli*/100 ml, and pathogenic organisms (*Salmonella*) present at all stations except at the mouth ([162]).

Table 12. Bacteriology of the Matigulu river 9 km above the estuary ([21]).

Date	Total Plate Count/ml x 10^3	*E. coli* I per 100 ml	Total Coliforms per 100 ml	*Salmonella* per 250 ml
	6 days @ 20°C	Confirmed		
26 Sept. 1967	—	365	—	
20 Feb. 1968	—	568	3 000	—
1969	10,5	—	—	—
March 1972*	—	**4 665**	12 825	+
Aug. 1972	—	220	9 650	—

* Average bacterial quality in estuary ([162]).
\+ and values in bold are significant of disturbance.

Sources of pollution were not determined, but were suspected to be above the national road bridge. This situation contrasted to bacteriological sampling at the national road bridge both five months later (August 1972) and several years earlier (1967 to 1968) ([21]) when appreciably lower levels of pollution were revealed.

Bilharzia. Although there was no evidence of vector snails in March 1972 ([162]), Hemens *et al* pointed out that it cannot be assumed that they are absent, since suitable habitats may exist further upstream.

BIOTIC CHARACTERISTICS

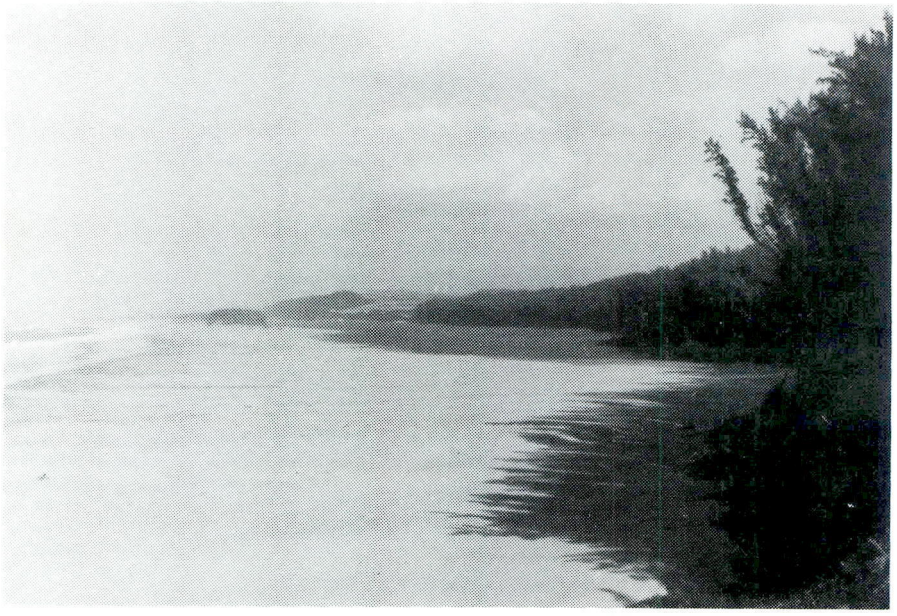
Flora

With the mouth of the Matigulu being closed very seldom, it is strange that no mangroves have developed in the Matigulu system. Attempts to establish them in the estuary by the Natal Parks Board have failed ([182]), although one specimen does exist (Emmerson, pers. comm.). No-one knows which species were tried or whereabouts in the estuary they were planted. The lack of a suitable substrate is the most probable reason and yet, the presence of penaeid prawns and certain fish (such as *Periophthalmus*) are indicators that suitable substrates do exist. In recent years tidal flats have formed which should be well suited to mangrove colonization. Although *Zostera* was reported to be absent in 1972 ([162]) a few patches do apparently occur (Champion, pers. comm.).

The topography of the land does not really lend itself to the development of wetland communities, although several large low lying islands in the centre of the estuary are covered in halophilous grass and herb communities.

The northern bank comprises grass covered hills, some sugar cane and cultivated lands; whilst the southern bank is heavily forested by indigenous coastal forest ([260]). The head of the

estuary is fringed by *Barringtonia* and *Hibiscus*, and on the southern bank some *Phragmites* occurs. Near the old mouth *Casuarina* dominates the edges of the estuary on both banks and immediately behind the *Casuarina* (on the west bank) is a gum plantation. *Ipomoea pes-caprae* (a creeper) features on the sandbar, as a stabilizing agent ([162]).



The original mouth position of the Matigulu estuary (pre 1971). Notice the Casuarina forests alongside the western bank.

The algology of the river was studied in 1967 ([21]). The presence of water hyacinth in the estuary (in April 1978) suggests that these plants are being transported down the river from some nutrient rich sources upstream (pers. obs.).

Fauna.

Lower trophic levels.

Zooplankton: Grindley (pers. comm.) took samples from the estuary in 1968, but has not as yet analysed them.

Benthos: The March 1972 survey by Hemens *et al* revealed a poorly developed community of 14 benthic species all of which were low in numerical abundance ([162]).
Ceratonereis (a Polychaete) and chironomid larvae were the main components. The distribution and abundance of the benthos was governed by the same factors as those governing the nature of the bottom materials (water velocity and channel shape). Thus sandy sediments were sparsely inhabited, and where black and sulphurous in the deeper part of the estuary, were virtually lacking in any life. Where currents or turbulence accounted for less severe oxygen depletion, conditions improved. Despite this, penaeid prawns are commonly taken in deeper parts of the estuary. Five species have been collected from the estuary by the Prawn Research Unit — the commonest being *Metapenaeus monoceros*, *Penaeus indicus* and *P. monodon*. Crabs (*Varuna* and *Scylla*) are also present, and spectacular migrations of megalopa larvae into the estuary occur periodically (Andrews, pers. comm.). Marginal sandbars are inhabited by the ghost crab (*Ocypode*). Hill spent some time collecting *Scylla* from the estuary in January 1977 (Champion, pers. comm.).

Fauna from marginal vegetation: The marginal vegetation itself is limited, but best developed upstream of Station 7. In this niche, ±20 species of animals were taken in March 1972 between Stations 4 and 7 ([162]).

Higher trophic levels.

Fish: For an estuary in which invertebrate food organisms are considered to be lacking ([162]) marginal vegetation limited, *Zostera* sparse and benthos poor, the numbers and

diversity of fish (comprising 26 species) are surprising. Of the 13 species encountered in March 1972 ([162]), juvenile mullet were the most common, but "glassies" (*Ambassis*), "slimies" (*Leiognathus*) and small grunter (*Pomadasys*) were also numerous. Much the same results were obtained by Wallace ([328]). Besides these published records, regular seining in the estuary by the Prawn Research Unit has revealed an additional 13 species (Andrews, pers. comm.). Amongst these, sea pike (*Sphyraena*) and the mud-skipper (*Periophthalmus*) are noteworthy — particularly the latter in the absence of mud banks and mangroves. Skates and eels are known to enter the estuary, as well as predatory species such as sharks, salmon, garrick and kingfish.

Birdlife: At least 17 of the 87 species of birds seen in the vicinity of the Matigulu estuary on 18 June 1978 by Nichols and Newman (pers. comm.) were estuary associated. These results also confirm that the birdlife reported in the forest cover on the south bank by Hemens *et al* ([162]) is indeed varied. In April 1978, eleven Woolly-necked storks were sighted on the estuary by Cooper (pers. comm.).

Crocodiles: Crocodiles do occasionally venture into the Matigulu estuary from the Nyoni river (Andrews, pers. comm.).

SYNTHESIS

In conclusion our state of knowledge regarding the Matigulu estuary can be regarded as fair. At this stage, with no foreseeable development threatening the system, and the Prawn Research Unit maintaining a "listening watch" on the system, only certain investigations seem warranted. These should include trying to ensure adequate water quality for the Prawn Research Unit in view of the mouth movements and sandbar formation which are occurring. Another attempt to establish mangroves should be undertaken.

From a scenic and amenity viewpoint, the estuary compares very favourably with others in Natal. Despite this, there is reason to recommend that the estuary system as a whole should be conserved.

The forests to the south of the Matigulu estuary have considerable potential and from what can be established, there is a significant degree of utilization of the estuary by various forms of marine life dependent upon spending part of their life cycles in estuaries.

A number of problems are apparent, the most serious of these being siltation and the prospects of dam construction upstream.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC											
			Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other						Flora		Fauna								Food Webs
MATIGULU ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids					★		★			★												★										
Source of Information	Summary of available information																															
Hill	1963	182		●																		●										
Kemp & Sibbald	1966	205									○																					
Archibald *et al*	1967 to 1968	21									○				○								○									
Midgley & Pitman	1969	223	●		●																											
Chew & Bowen	1971	78	●		●																											
Orme	1971	257,260	●		●					●													●									
Hemens *et al*	1972	162		●	●	●	●				●				●		●					●	●		●	●	●					
Cloete & Oliff	1972	85	Summary of Hemens *et al* [162]																													
Wallace	1975	328		●																							●					
FDC Prawn Research Unit (Champion *et al*)	1975 to 1977	pers. comm.			●	●	●			●	●						●			●						●	●	●		●		
du Preez	1977	pers. comm.						●																								
Cooper, Nichols & Newman	1978	pers. comm.																										●				
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 250	1976	153 to 158		●						●													●									
1:25 000 Job No. 251	1976	437 to 439	●	●						●													●									

2.1.4.4 **NYONI**

Synonyms
Inyoni

Zulu meaning
"The bird".

Location
29°08'S; 31°36'E.

Accessibility
The Nyoni estuary is virtually inaccessible since no roads (with the exception of one barely passable track) lead anywhere near it. It is best approached by boat from the Matigulu estuary. Consequently the distances from various places would be the same as those quoted for the Matigulu (see 2.1.4.3).

Bridges
There are no bridges across the estuary.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 114 km^2 ([223])

River length. ±25 km

Mean annual run-off. 21,6 x 10^6 m^3 ([223])

Flow. Said to be "low" ([162]).

Flood history. No record.

Dams. Existing or proposed — nil.

Siltation. No record. From aerial photography the estuary appears to be seriously silted. Areas of erosion in the Nyoni catchment are shown from remote sensing imagery by Orme ([260]) but a great deal of sand (originating from the Tugela) is probably transported by wind over the sandbar into the estuary (pers. obs.).

Land ownership/use. 75% of the catchment is Bantu influenced and lies within Bantu reserves which are destined to become part of KwaZulu.
The estuary surrounds are undisturbed although, until closed down in March 1977, the Amatikulu leper location was located to the west of the estuary but high above it.

Local authority. Bantu Administration.

Estuary uses. Nil.

Morphometry of the estuary (see Fig. **34**).
Area. ±70 ha.

Axial length. ±7 km

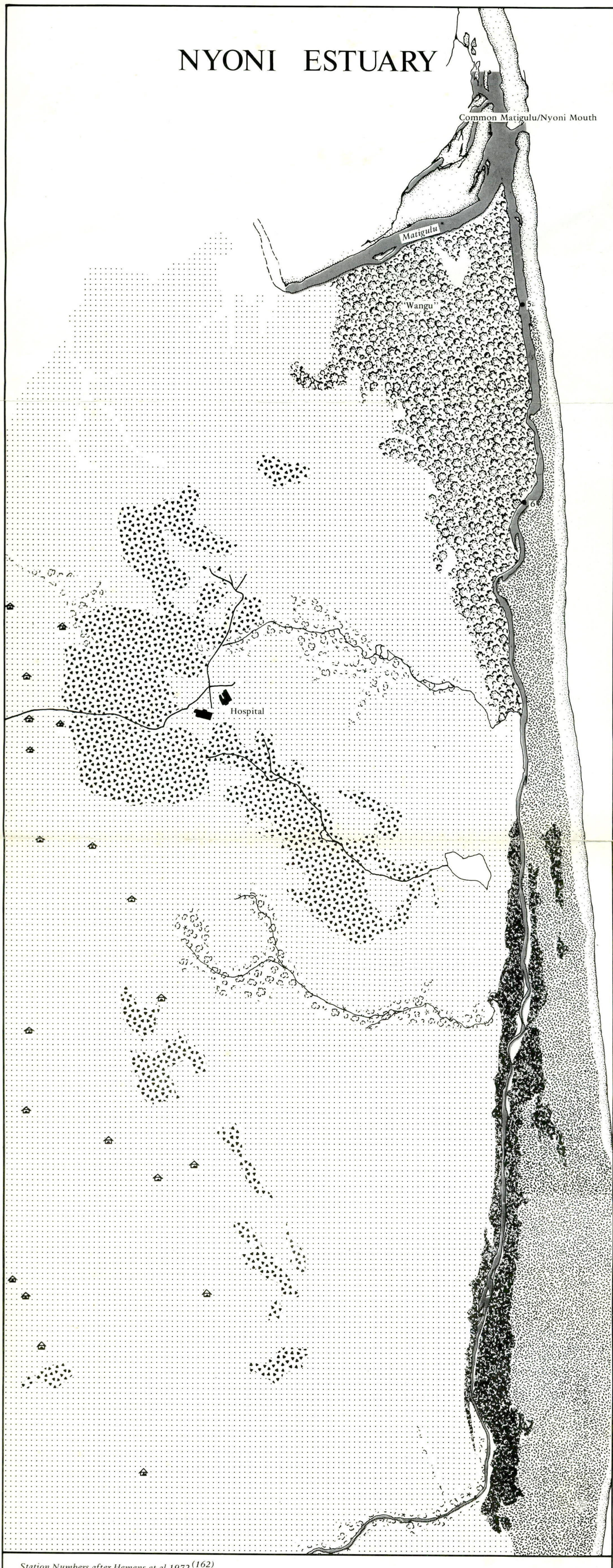
Shoreline length. ±15 km.

} the precise limits of the estuary have yet to be accurately determined.

Width.
Maximum: 110 m
Channel: Exhibits considerable variations in width but up to 50 m.
Floodplain: 270 m.

Bathymetry. Maximum depths of 1 m were recorded in March 1972 ([162]) and in April 1978 (pers. obs.).

NYONI ESTUARY



Station Numbers after Hemens et al 1972 (162)

Coastal Dune Forest

Coastal Riverine Forest

Coastal Dune Pioneer

Exotic Plantations

Swamp Forest

Grassland

500 0 500 1000 1500 2000 metres

Fig. 34

Geomorphology.

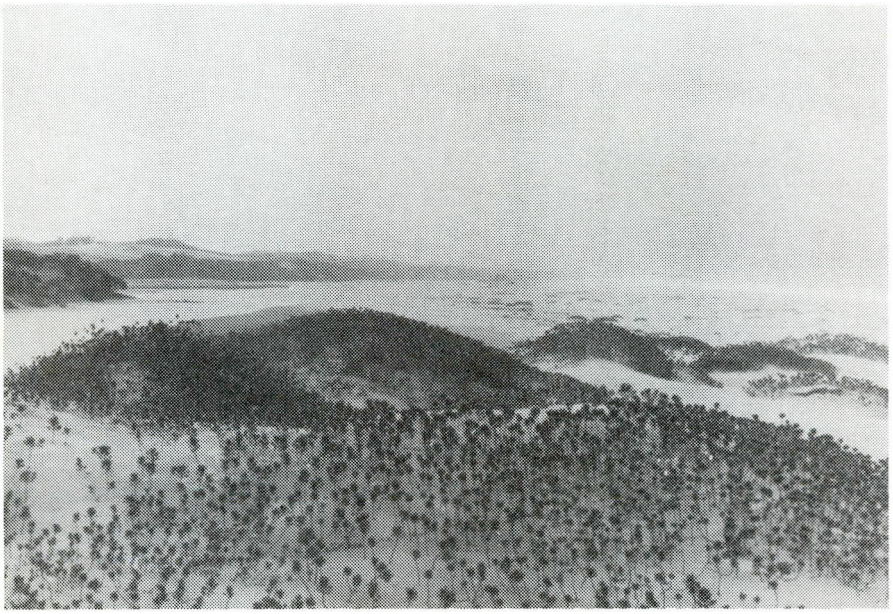
Geology. Bedrock of the Karoo System occurs in the catchment ([260]) but cretaceous deposits underlie the estuary. A succession of beach ridges (wave cut?) are a conspicuous feature of the terrain on the hill-slopes west of the estuary.

Nature of bottom materials (see Table **13**). Although lacking in fine materials and consequently deficient in organic materials and nutrients in 1972 ([162]), this did not appear to be the case in April 1978 (pers. obs.).

Sandbar characteristics. The Nyoni spit is the most impressive sandbar in Natal. It is north directed (under unidirectional wave attack from the south east) and some 8 km to 10 km in length ([257]). The Nyoni spit is composed of sediments from the Tugela ([256, 257]) that are being transported northwards along the coast. Prior to 1971 the Nyoni had its own separate mouth to the sea which probably used to close — as shown on the 1:50 000 map (2931 BA). Under these circumstances the system would have tended to assume the characteristics of a lagoon.

Table 13. Sediment analysis March 1972 (after Hemens *et al* ([162])).

Nyoni Estuary	Station	
	5	6
Particle size (%)		
> 1 000 microns	3,3	2,3
1 000 to 500	25,4	22,9
500 to 250	57,2	64,3
250 to 125	13,3	9,1
125 to 63	0,5	0,4
< 63 to 0	0,3	1,0
Dry weight (%)	79,7	80,2
Volatile @ 600°C (% dry weight)	1,4	0,9
Oxygen absorbed (mg/g dry weight)	0,39	0,21
Kjeldahl nitrogen (µg/g)	70	80
Total phosphorus (µg/g)	28	48
Sulphide (mg/g)	0,0	0,0



A view of the Nyoni/Matigulu junction, and of the massive sand spit. (18 April 1978).

However after floods in May 1971, the river was captured by the Matigulu ([162]). Although the Nyoni still tends to become isolated from the Matigulu by sandbar formation, at times of low flow, the system presently shares a common mouth with that of the Matigulu. Whether it will ever re-establish a separate mouth in the future is uncertain.

Configuration of the adjacent shore. No record.

Surf zone currents. North directed ([257]).

Physico-chemical characteristics (see Table **14**)

The only information available on the water chemistry of the Nyoni estuary is that collected by Hemens *et al* in March 1972 ([162]). At the time of sampling, the water quality was good, but salinities were abnormally low due to recent rainfall. Oxygen absorbed values (12,3 mg/litre) were high and attributed to the leaching of organic materials from marginal vegetation alongside the river above the estuary. During the survey period, marked depletion of oxygen was observed in stretches of the estuary where the water was static.

Table 14. Physico-chemical characteristics*

NYONI	March 1972
Hydrogen ion concentration (pH)	7,1
Salinity ‰ (g/litre)	0,35
Dissolved oxygen mg/litre	4,4
% Saturation	54
Oxygen absorbed mg/litre	**12,3**
Kjedahl nitrogen mg/litre	,830
Ammonia mg/litre	,056
Nitrites mg/litre	,002
Nitrates mg/litre	,088
Phosphates mg/litre	,013
Temperature °C	26,7
Colour (APHA units)	80

* Average results from Stations 5 and 6 ([162]).

Values in bold significant of disturbance.

Nitrogen and phosphorus values were low, being much lower than those in the Matigulu, despite the two bodies of water being interconnected at the time.

Public health aspects

Bacteriology. Only two samples from the Nyoni estuary have been examined bacteriologically, these being taken in March 1972 ([162]). The results (see Table **15**) showed marked faecal contamination and pathogenic organisms as being present. Similar results were obtained from the Matigulu and it is likely that contamination of the Nyoni was evident simply because of the two estuaries being confluent at the time.

Table 15. Bacteriology of Nyoni estuary*

Date	*E. coli* I/100 ml Confirmed	Total Coliforms per 100 ml	*Salmonella* per 250 ml
22 March 1972	**5 780**	12 550	+

* Average results from Stations 5 and 6 ([162]).
+ and values in bold are significant of disturbance.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora. Extensive swamp forest communities occur in the upper reaches of the Nyoni, although probably beyond the "estuary limits". These comprise very fine stands of *Barringtonia* and *Lygodium* ferns (Cooper, pers. comm.). Another important component of the Nyoni system is the luxuriant coastal dune forest of "Wangu", which sweeps upwards from its western bank. In the estuary itself, wetland communities are generally lacking. On the sandbar a variety of dune pioneer species (*Scaevola*; *Ipomoea* and *Digitaria*) occur and an interesting transition from such forms of plants to dune forest can be observed on the 'beach ridges' already described (see under Geology). In April 1978, the presence of dead water hyacinth in the estuary suggested that somewhere in the Nyoni catchment the plant was flourishing.

Fauna

Benthos. In March 1972, eight species were represented, amongst which the ostracod *Limnocythere* was the most abundant.

Fauna of marginal vegetation. No record, although in March 1972 *Metapenaeus monoceros* (Speckled prawn) was taken in a seine net from the Nyoni estuary. Burrows of the ghost crab (*Ocypode*) were obvious along the edge of the 'strand line' in the estuary in April 1978 (pers. obs.).

Fish. Small mesh seining undertaken in March 1972, revealed six species as present. Shoals of small mullet were very much in evidence in the shallows of the estuary in April 1978 (pers. obs.).

Birds. No record, but presumed to be mainly forest associated species. Dwarf geese occur according to Zaloumis (pers. comm.).

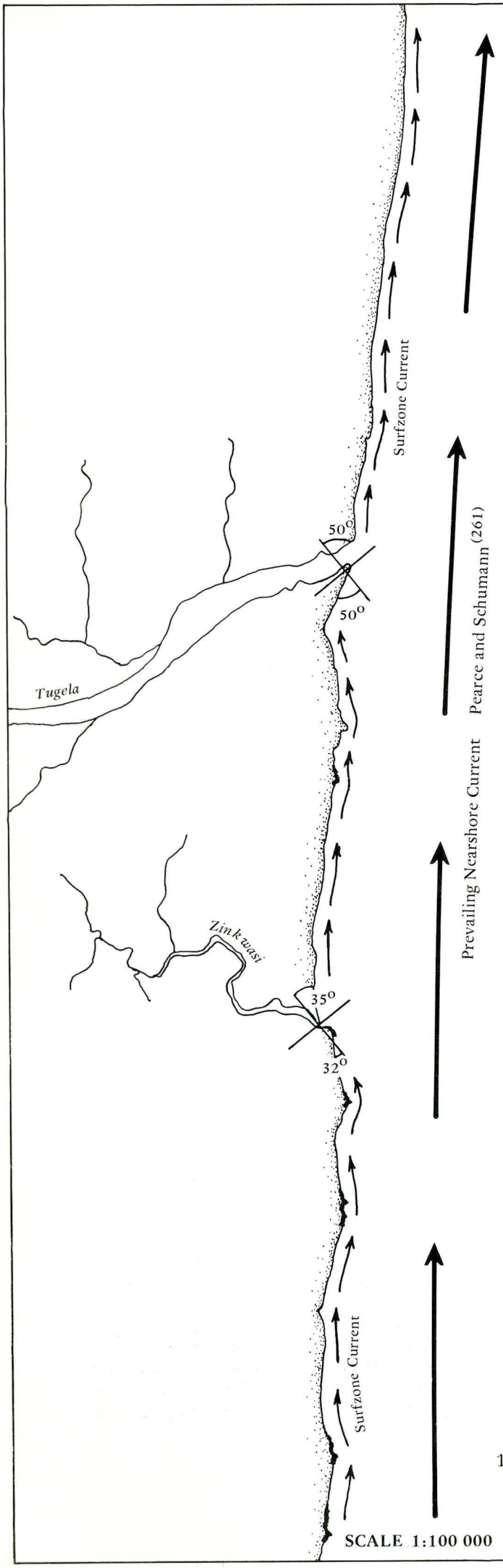
Reptiles. Crocodiles are present and probably represent one of the most southerly populations in Natal at present. They are indicators of the undisturbed nature of the estuary.

SYNTHESIS

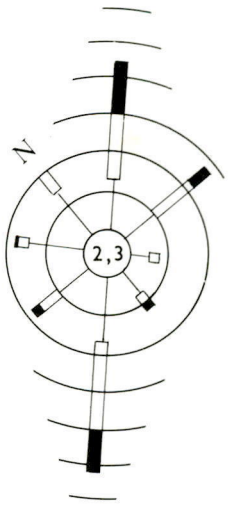
Being another system which has received little attention in Natal, our state of knowledge of the Nyoni estuary is regarded as poor. To supplement an otherwise very superficial understanding, periodic biological investigations are most certainly warranted, because in its present environmental condition the terrain in the vicinity of the Nyoni estuary, is almost undisturbed, and consequently likely to maintain a flora and fauna which is worthy of protection.

The only problem apparent is that of wind blown sand which appears to be infilling the estuary.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other						Flora		Fauna								Food Webs
NYONI			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																						◄	★				★	►			
Source of Information	Summary of available information																																
Midgley and Pitman	1969	223	●		●																												
Orme	1971	256								●																							
Orme	1971	257								●																							
Orme	1972	260	●					●			●													●									
Hemens *et al*	1972	162		●			●			●	●				●									●			●	●	●			●	
Cloete & Oliff	1976	85	Summary of Hemens *et al* [162]																														
Cooper	1978	pers. comm.																						●									
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 250	1976	150-153		●						●														●									
1:25 000 Job No. 251	1976	440-445	●	●						●																							



GENERALISED WIND ROSE



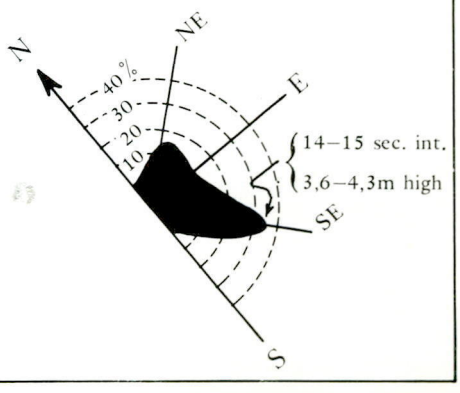
2–11 12–29 30–61 61+ km/h

Arcs represent 5% intervals
Percentage calm within circle



SWELL OBSERVATIONS

(Distribution by direction, height and period)



SCALE 1:100 000

2.1.5.1 **TUGELA**

Synonyms
Tukela (from map in Natal Archives dated 1850).

Zulu meaning
(1) "a river that acts with frightening suddenness . . ." [289];
(2) a name derived from the verb "tuku" which means to astonish or to be startled [289];
(3) "the fearsome one" [271].

All meanings presumably refer to the flood characteristics of the system.

Location
29°13'S; 30°30'E.

Accessibility
The Tugela river mouth lies midway between Durban and Richards Bay. It is 10 km distant from the national road and 104 km from Durban. It is most easily approached via the settlement of Tugela Mouth on the northern bank.

Bridges.
There are no bridges across the estuary.

ABIOTIC CHARACTERISTICS
Catchment characteristics
The Tugela is the largest river system in Natal.

Area. 28 000 km² [257]; 29 008 km² [41, 271]; 29 100 km² [223].

River length. Estimates vary from 290 km [271] to 520 km [41]. There are eight major tributaries.

Mean annual run-off. 5 071 x 10^6 m^3 [223]. It is said to be "a generous river yielding an average of 145 000 m^3 (,145 x 10^6 m^3) per year from each square kilometre of the catchment [271]".

Flow. The average annual flow is said to be from 184 m^3/sec. [41] to 226 m^3/sec. [223, 257]. The average winter discharge is given as 73,6 m^3/sec. and average summer discharge as 481 m^3/sec. [257].

Flood history. The Tugela is said to have "terrible peak flood" characteristics [271], so that during the rainy season "it is not uncommon to see walls of muddy water 0,9 m to 1,5 m high advancing downstream, bearing trees, animals and detritus . . . As the speed of the current increases 2 to 5 fold, wholesale movement of the river bed results, and the river often changes course within its bed" [41].

Dams.
Existing: Several very small dams exist in the catchment (Chelmsford, Amcor, Windsor, Wagen Drift) [41].

Proposed: Much attention has been paid to hydro-electric power production from the Tugela and four possible dam sites have been located with potential outputs of 450-550 megawatts [197, 271, 318] (e.g. Kranskop, Mandini Weir).

Siltation. With the amounts of silt transported to the coast by the Tugela, the bed level of the estuary shelves sharply upwards, the primary consequence of which is minimal sea water penetration. For the period 1955 to 1958 the mean annual silt load of the Tugela was considered to be 10,5 x 10^6 tons per year [223, 257]. The mean annual concentration of suspended sediment by weight in the Tugela is 0,23%. During the rainy season sediment plumes may extend 3 km to 5 km offshore, and 15 km alongshore [257, 260]. Orme compares the "mechanical denudation" of the Tugela watershed (by erosion) at a rate of 375 tons/km²/year for the Tugela with other systems in the world (e.g. Zambezi at 75 tons/km²/year; the Missisippi at 154-230 tons/km²/year; the Colorado at 271 tons/km²/year and the Indus at 420 tons/km²/year) [257]. As a result of such denudation the Tugela is important as the principal

system supplying sand to the beaches of northern Natal. One must recall that this is a very important function, and that such sediments will be intercepted if large dams are built on the Tugela. This would result in an imbalance in the nearshore sediment budget (an example of which can be seen from the Aswan Dam on the Nile) ([278]). This in turn will render the North Coast vulnerable to severe erosion, as it is exposed to very strong wave driven currents.

Land ownership/use. 30% of the catchment is Bantu influenced and is to remain so in the future as KwaZulu. Being the largest river system in Natal, the catchment of the Tugela includes Estcourt, Ladysmith, Dundee, Newcastle and many other towns. Newcastle is predicted to become a "third Iscor" ([271]) at its present rate of industrial development.

The biggest pulp and paper mill in Africa, SAPPI, is situated immediately above the estuary. It consequently represents a potential source of pollution to the estuary. The estuary is surrounded by flat alluvial land or rolling hills, all used for the cultivation of sugar cane. In many cases these come right up to the edge of the river.

On the north bank are gum plantations and the settlement of "Tugela Mouth", comprising 40 to 50 houses, with a camping site on the edge of the estuary. On the south bank is a smaller settlement of fishermen's shacks (±10 in number) ([266]).

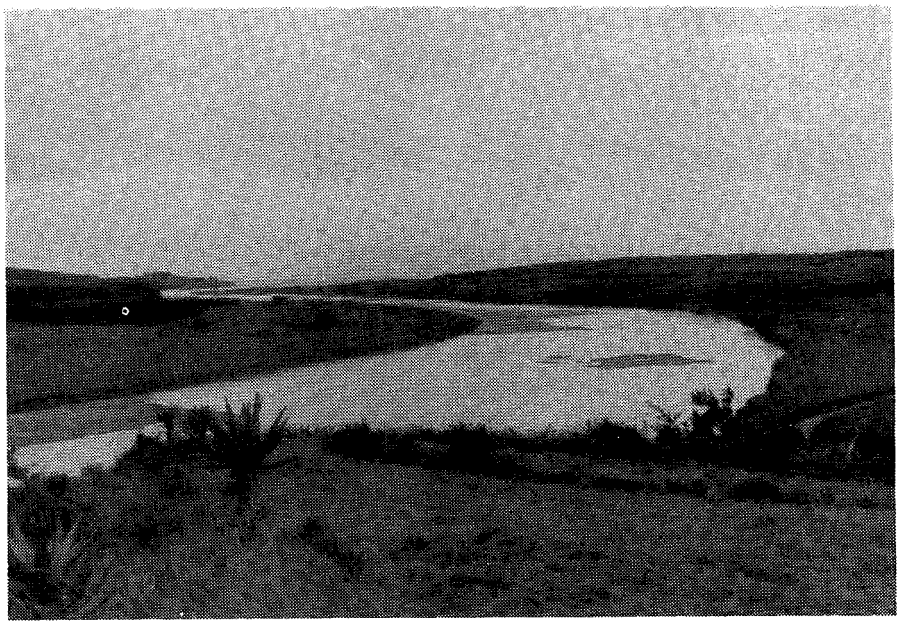
The area alongside the bank is zoned as 'Government Reserve' and the Tugela has been earmarked as a proposed site for a future nuclear power station (NTRPC, pers. comm.).

Local authority. Local Health Committee of Tugela Mouth.

Estuary uses. The estuary is not used for any specific purpose. Just above the estuary are features of historical interest which were of particular significance in the Zulu war (1878). These are Fort Tenedos, Fort Pearson and the Ultimatum Tree.

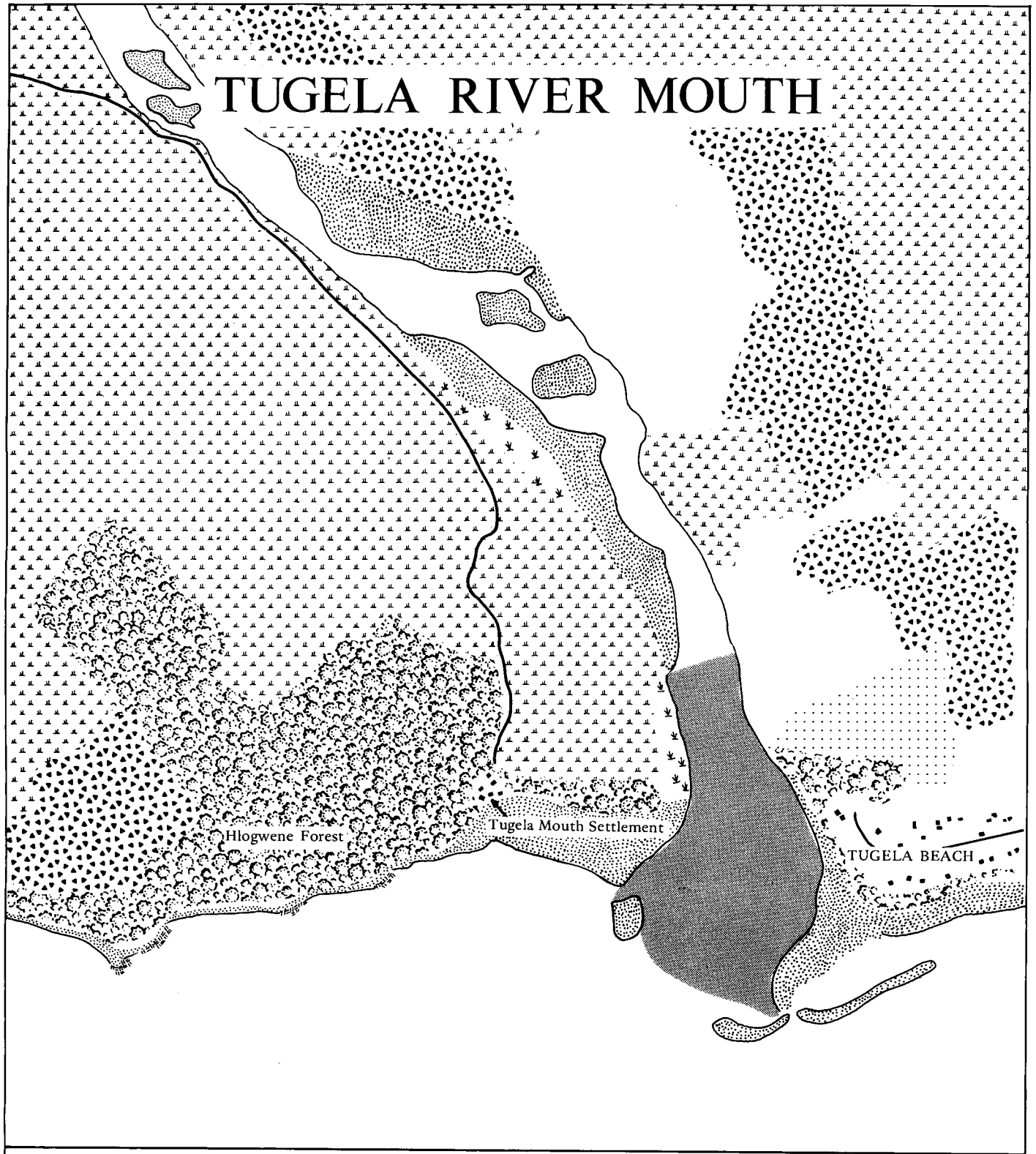
Morphometry of the estuary (see Fig. **35**).

Area. ±55 ha during low flow periods. Changes in river flow cause considerable changes in morphometry of the estuary. The estuary very often extends out to sea and becomes unconfined by banks.



A view of the Tugela river mouth from Fort Pearson provides an impression of the former extent of the estuary. Note the encroachment of sugar cane.

Axial length. 800 m during low flow periods and is said to "hardly exist" during floods ([41]). For this reason the estuary is classified as a river mouth. Descriptions of the Tugela lagoon in 1910 (Mercury Pictorial dated 1 September) are interesting in that the lagoon was said to "extend for miles" up river.



Coastal Dune Forest

Cane

Exotic Plantations

Grassland

500 0 500 1000 1500 2000 metres

Fig. 35

Shoreline length. ±2 km.

Width.
Maximum: 330 m during normal flow periods.
Channel: During normal flow periods ±50 m wide. During floods up to 1 km wide.
Floodplain: Although Brand ([41]) considers there to be no "floodplain zone" on the lower Tugela, Orme ([257]) refers to the Tugela floodplain as being 1 500 m wide at the mouth, and that 700 m of this is "blocked" by a stable sand spit.

Bathymetry. Orme considers the Tugela estuary to be "comparatively deep" ([257]), however actual measurements are not available.

Geomorphology.
Geology. The geology of the catchment is very varied, including Basaltic lava of the Drakensberg, Stormberg and Beaufort beds, old granites and gneisses, beds of Table Mountain Sandstone and rocks of Dwyka and Ecca series.
"The estuary is cut into Dwyka tillites and Ecca shales of the Karroo system . . ." ([257]).

Nature of the bottom materials. "Thick grey to brown silty sand is typical of the debris presently being discharged by the Tugela into its estuary . . ." ([257]). At the surface these sands may be covered by a brown clayey sand. 6 km above the mouth, bedrock was overlain by 51,8 m of alluvium.

Sandbar characteristics. The Tugela sandbar is generally a north extending structure, but is composed of a 700 m stable component (carrying coastal dune forest) on the floodplain and a 700 m unstable component (lacking vegetation), across the mouth. The latter is periodically destroyed by flood discharges ([257]). Consequently, as shown in Fig. **36**, the norm is for the bar to confine the estuary mouth to a 50 m channel on the northern bank. During floods the bar is swept out to sea and the mouth then becomes situated on the southern bank. Under such conditions an offshore bar forms which directs the Tugela floodwaters into the sea in a southerly direction. With the perennial flow of the Tugela, the mouth is never closed.

Fig. 36. Variation in the mouth position of the Tugela river mouth.

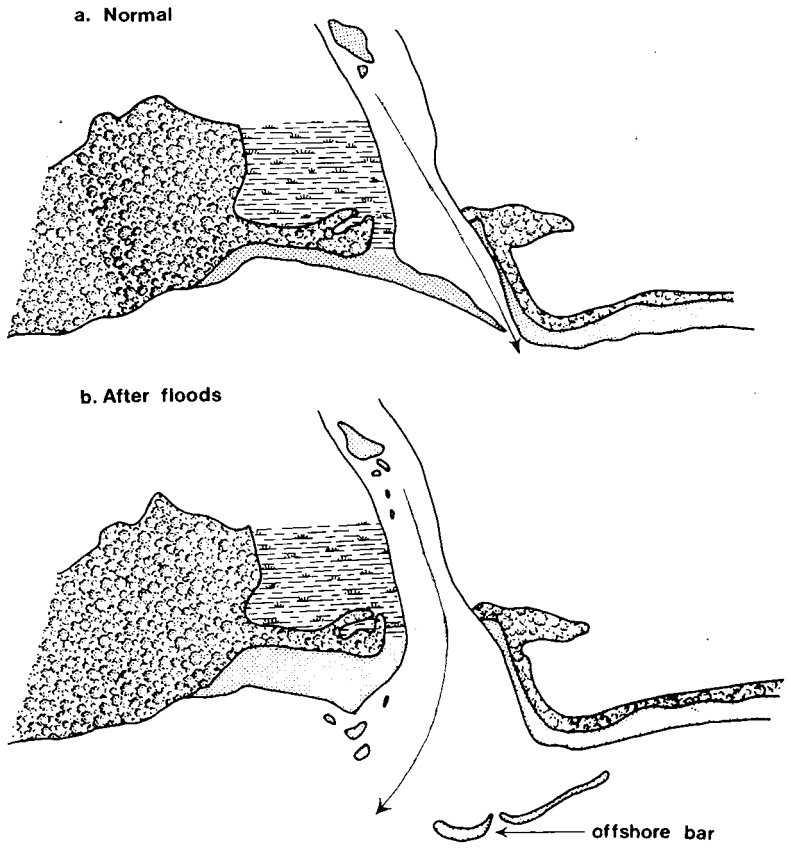


Table 16. Physico-chemical characteristics ([41]).

Locality: Tugela River Distance above estuary: 10km	Average results for period 1953 to 1955	24 May 1965	14 Sep 1965	22 Sep 1965
Hydrogen ion concentration (pH)	7.93	7.92	7.9	8.41
Conductivity micromhos/cm	175	225	253	166
Total dissolved solids ppm (calculated)	125	-	-	-
Dissolved oxygen mg/litre	-	9.0	7.8	7.8
% Saturation	-	101	95	98
Oxygen absorbed mg/litre	2.8	-	-	-
Biological oxygen demand mg/litre	-	1.3	>7.8	3.3
Ammonia mg/litre	0.2	-	-	-
Nitrites "	.005	-	-	-
Nitrates "	.08	-	-	-
Total alkalinity "	91.9	-	-	-
Total hardness "	82.4	-	-	-
Calcium "	16.8	-	-	-
Magnesium "	9.7	-	-	-
Sodium "	15.6	-	-	-
Potassium "	1.3	-	-	-
Sulphates "	13.5	-	-	-
Chlorides "	8.5	-	-	-
Temperature °C	-	21.0	25.0	26.5
Appearance	-	Dirty	Dirty	Turbid

Values underlined significant of disturbance.

Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

There is no information available on the physico-chemical characteristics of the Tugela estuary. The average analytical results of water samples taken 10 km above the estuary by Oliff during the period 1953 to 1955 are shown in Table **16** ([41]), and provide some indication of conditions likely to be found. Included in this table are the results of Brand's survey in 1965. He concluded that organic pollution from the SAPPI paper mill at Mandini (confirmed by Grindley ([137])) resulted in the lower reaches of the Tugela system being classified as "verging on public nuisance levels" ([41]). This situation is to be remedied at some stage in the future by the installation of very costly treatment facilities.

Above Mandini the Tugela system is generally of good quality. However drainage from coal fields in the upper reaches of the system (Mooi River) constitutes a major problem. This is in the form of acidic drainage from the iron sulphides in the mine dumps and poses a problem to which there appears to be no satisfactory solution. However, due to the neutralizing effect of the calcareous soils associated with Ecca rocks in the catchment, the situation is not as serious as it could be. Fortunately these difficulties are encountered sufficiently far above the estuary not to influence it.

Public health aspects

Bacteriology. There is no information available on the bacteriology of the Tugela estuary. However in 1965, samples taken 10 km above the estuary ([41]) (see Table **17**), revealed organic and faecal pollution in the lower reaches of the Tugela system. The source of such pollution is almost certainly from African compounds at Mandini, factory effluents and the effluent from the Mandini sewage works.

Table 17. Bacteriology Tugela river (10 km above estuary).

Date	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml	*Salmonella* per 500 ml
	5 days @ 32°C	Confirmed membrane count	
24 June 1965	**285**	220	+
14 September 1965	**398**	20	+
22 September 1965	**228**	450	—

+ and values in bold significant of disturbance

Bilharzia. The nature of the Tugela estuary is such that it probably is bilharzia free. *Biomphalaria* were taken from the Incandu river near Newcastle in August 1959 ([41]).

BIOTIC CHARACTERISTICS

Flora

Of prime botanical importance around the Tugela estuary is the 200 ha expanse of the Hlogwane Forest (Cooper, pers. comm.) which is a remnant of indigenous coastal dune forest in a very fine state of preservation. It is also known as the Seula Bush and extends southwards in a narrow strip to the northern bank of the Zinkwasi lagoon.

Besides this, due to the encroachment of sugar cane onto the estuary surrounds (and eucalyptus plantations on the northern bank), the flora of the Tugela estuary has little of resource or ecological value. This is confirmed by Orme after having reported on the results of a survey of the Tugela floodplain using colour infra-red imagery techniques ([280]).

Fauna

There is no information available on the fauna of the Tugela estuary. Grindley took zooplankton samples from the estuary in the late 1960's but found the estuary to be barren in this regard (pers. comm.). Faunal analyses from the station nearest to the estuary in the NIWR river survey ([41]) are not available. In the early 1900's the Tugela lagoon was regarded as one of the few 'unspoilt' fishing resorts on the Natal coast and mention of fish kraals in the lagoon was made (Mercury Pictorial, September 22, 1910).

Because of the large sandbar and exposed sand banks/islands in the middle of the estuary, the Tugela is a fairly important site for estuarine dependent birds. Over the last few years Nicholls has observed 19 estuarine dependent species (pers. comm.) and considers the Tugela estuary to be an important tern roosting site. The numbers of Little terns (up to 600) and Swift terns on the estuary are particularly noteworthy.

SYNTHESIS

Our state of knowledge of the Tugela estuary, or river mouth, is exceedingly poor. As the estuary is virtually "non-existent", the only research that seems vital is that which would enable one to assess the consequences of damming the Tugela, paying regard to the consequences of intercepting sediments which are being supplied to the coast.

In its present environmental condition the Tugela estuary is degraded, the only element of natural value remaining being the Hlogwene Forest on the southern bank. This forest, plus the continuation thereof to the Zinkwasi lagoon, should be preserved.

Several problems on the Tugela are apparent, these being sugar cane encroachment, excessive siltation and organic pollution. Future ones such as thermal pollution and nuclear waste disposal may result should a nuclear power station be built.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text.	ABIOTIC																				BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other							Flora		Fauna							Food Webs
TUGELA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids										★																					
Source of Information	Summary of available information																														
Pistorius	1962	266																	●												
Brand	1965	41	●	●	●		●	●				○			○																
Midgley & Pitman	1969	223	●		●																										
Grindley	1970	317										●																			
Robertson	1970	271	●		●																										
van Robbroeck *et al*	1970	317			●																										
Orme	1971	257,260	●					●		●													●								
James	1973	197	●		●																										
Godbold	1974	135			●					●																					
Nicholls	1976 to 1977	pers. comm.																									●				
Cooper	1977	pers. comm.																					●								
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 250	1976	133-139		●						●													●								
1:25 000 Job No. 251	1976	449	●	●						●																					

2.1.5.2. **ZINKWASI**

Synonyms
Sinquasi; Sinkwazi ([43]); Zinkwazi ([266]).

Zulu meaning
isiNkwazi is said to mean "the place of the Fish eagle" ([289]).

Location
29°16'S; 31°27'E.

Accessibility
By road the Zinkwasi lagoon is ±90 km north east of Durban. The main national road is 7,8 km away. Secondary roads lead down to the edge of the lagoon at several places on the southern bank.
There is a railway siding at Darnall, 8,3 km distant.

Bridges
There is a road bridge across the upper reaches of the lagoon, 2,5 km from the mouth.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 70 km^2 to 76 km^2 ([257]).

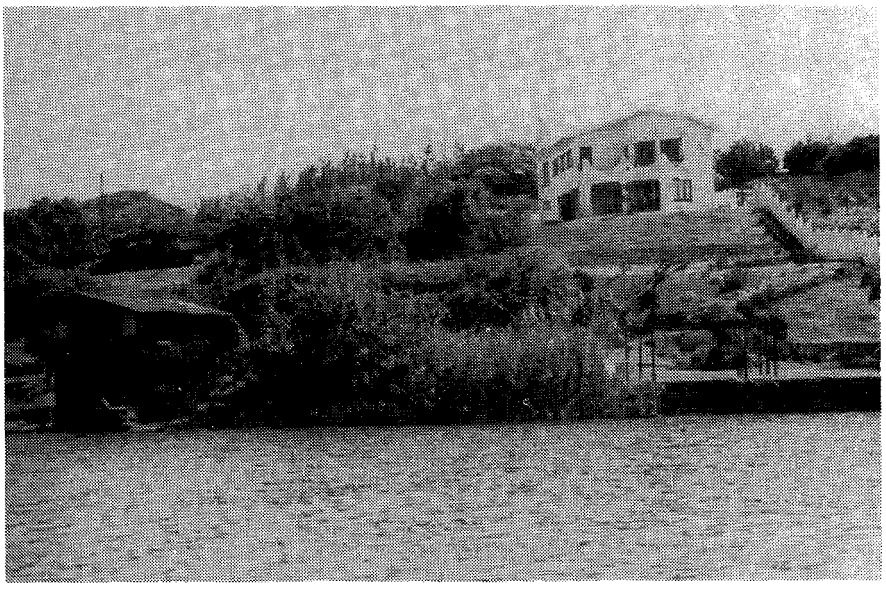
River length. 20 km ([43]) to 24 km ([78]).

Mean annual run-off. 14,3 x 10^6 m^3 ([78]).

Flow. Considered to be "low" as nothing greater than 0,42 m^3/sec. was observed in 1964 ([43]).

Flood history. Reliable information on this subject is lacking.

Dams. No dams exist, nor are any proposed because the water of the river is too mineralized ([43]) (Rouillard, pers. comm.).

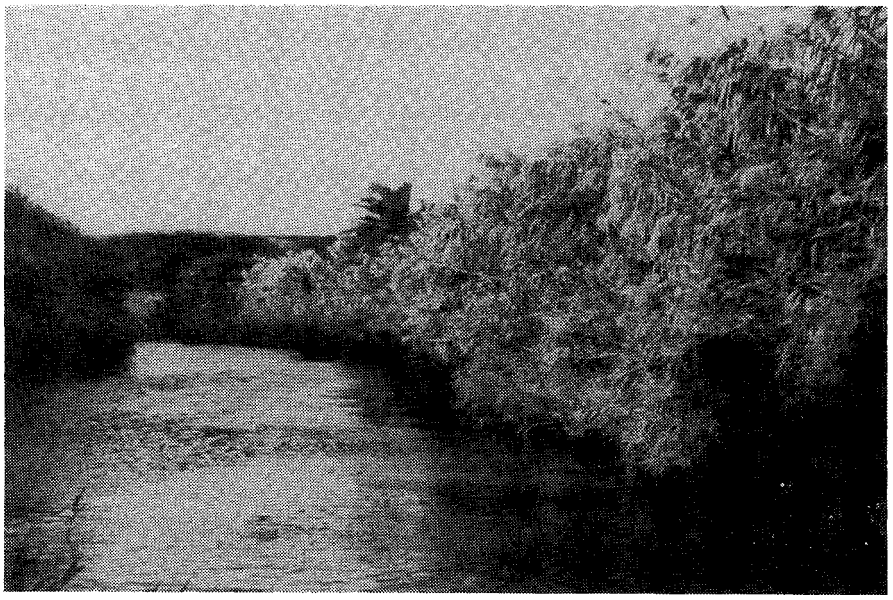


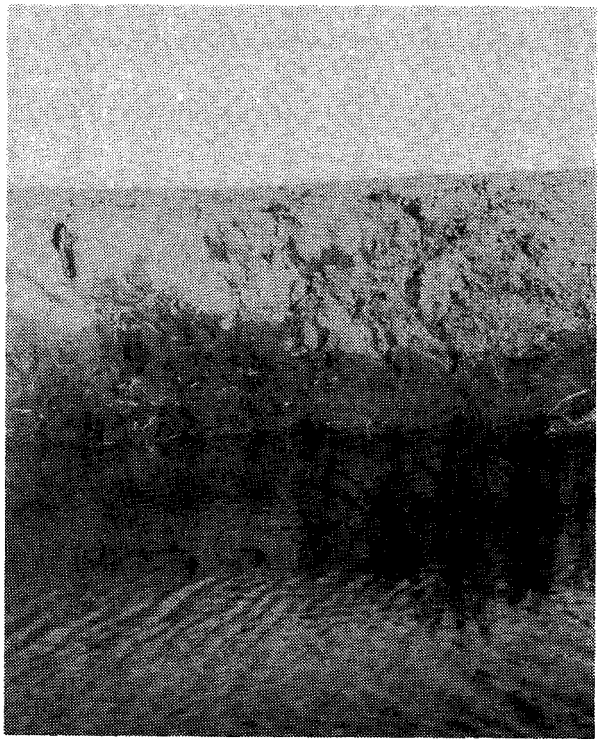
Waterfront property development alongside the Zinkwasi lagoon.

Siltation. No quantitative records are available. However, over the past 30 years siltation has accounted for shallowing of the lagoon from depths which were once in excess of 4 m (Theunissen, pers. comm.) to depths of ±1,2 m. With the entire catchment under sugar cane, silt sources appear to be cane fields and tracks. Bank erosion also occurs as a result of cultivation on the edges of the river during which process, natural bank binding vegetation is destroyed.

Land ownership/use. The entire catchment as well as the lagoon surrounds are owned by Huletts and used for cultivation of sugar cane.

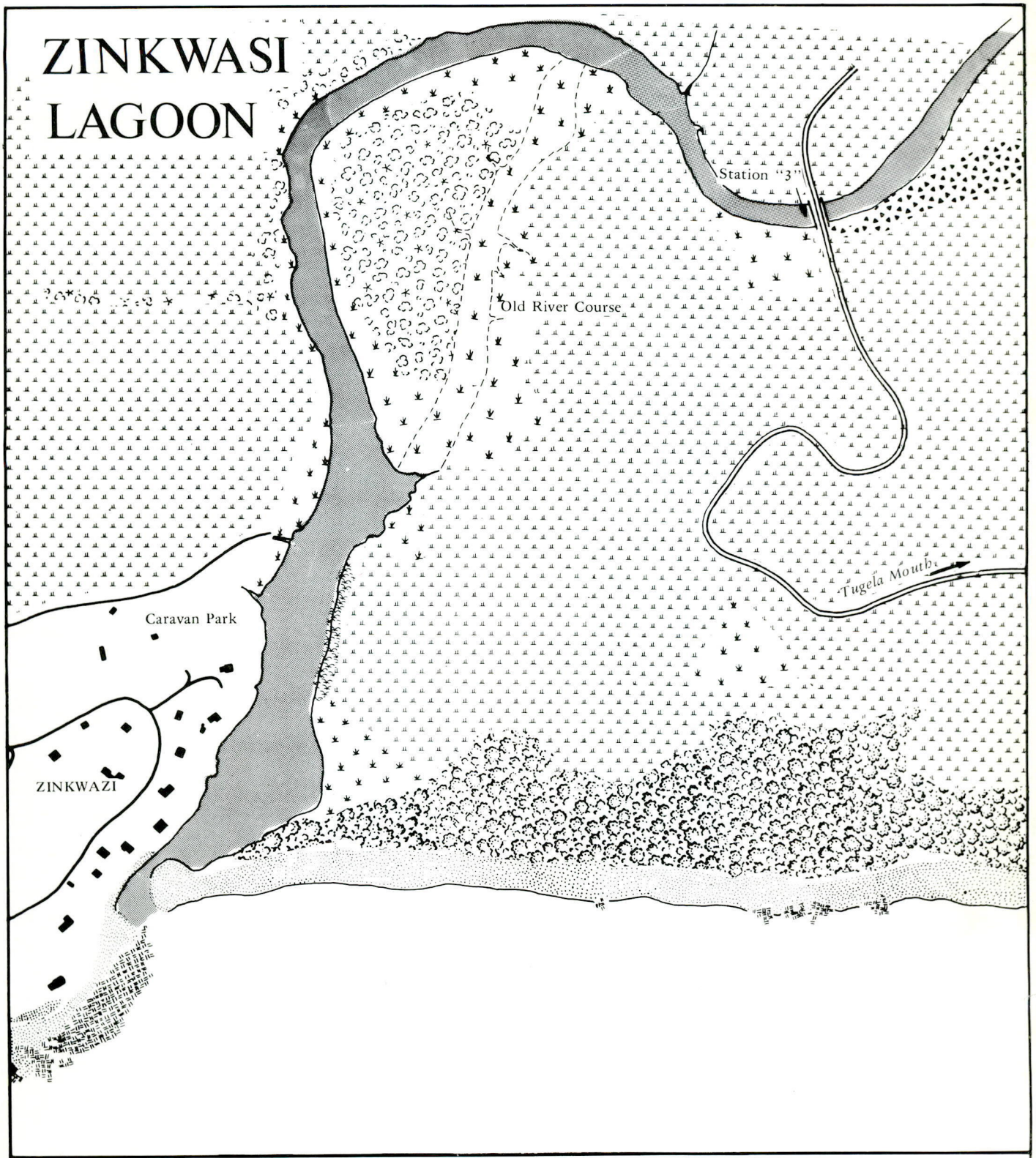
At the mouth of the lagoon, property development has been confined to the southern bank. There are 366 registered lots in the Zinkwasi settlement but only 86 have been built on, accommodating some 120 people (Orwin, pers. comm.). A 116 berth caravan park can also accommodate approximately 500 people.





The banks of the Zinkwasi river as they should be (above) and as they should not be (below).

Local authority. The lagoon is part of the Admiralty Reserve but on lease to the Zinkwazi Beach Health Committee. The Committee has jurisdiction over the lagoon in the region which is tidally influenced. A 'boundary' has never really been determined, but the road bridge over the lagoon to Tugela mouth (see Fig. **37**) is generally considered as "the extreme head of the lagoon" ([43]).



Station Numbers after Brand et al 1967 (43)

Coastal Dune Forest

Coastal Riverine Forest

Exotic Plantations

Reed Swamp

Hibiscus

Cane

100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 37

Estuary uses. The lagoon is a popular recreational facility. During the height of the season 200 people may frequent the beach, with the lagoon mouth being the most popular swimming area. Up to 30 boats of various types (yachts, rowboats and powerboats) make use of the lagoon for pleasure purposes, including water-skiing. Some angling also occurs.

Morphometry of the lagoon (see Fig. **37**).

Area. 18,2 ha to 19,6 ha.

Axial length. 4,8 km.

Shoreline length. 10,3 km.

Width.
Maximum: 215 m
Channel: 15 m during normal flow periods.
Floodplain: Up to 350 m wide.

Shape. Although presently serpentine in shape, the lagoon formally split around a large island in the middle reaches (see Fig. **37**). After an attempt by farmers to reclaim the area of this island as potential caneland (by constructing a causeway across the lagoon at this point) this particular arm of the lagoon has become lost to the system (Manock, pers. comm.).

Bathymetry. The average depth is estimated at 1,2 m. The maximum depth is 2,5 m (at normal lagoon levels) (pers. obs.).

Geomorphology

Geology. The geology of the catchment (Dwyka conglomerates) apparently accounts for the high mineralization of the Zinkwasi river water ([43]). This high degree of mineralization of geological origin, is not often encountered in estuarine systems on the Natal coast.

There was a small fluospar mine in the catchment ([43]).

In the lower reaches of the river, Ecca shale is encountered ([43, 78]).

Nature of bottom materials. These have not been determined but appear to be black anaerobic, organic sediments which overlie silt and, closer to the sea, overlie sand (pers. obs.)

Sandbar characteristics. The Zinkwasi sandbar is a 200 m long, south extending feature and is the first of many systems south of the Tugela which exhibit this characteristic. This can be attributed to:

(i) beach erosion in the lee of the rocky headland which protrudes into the sea south of the mouth;
(ii) the diffraction of south approaching waves, and
(iii) the direct influence of beach drift during north east storms.

Local opinions maintain that the lagoon is closed to the sea for periods varying between 8 to 10 months annually.

Breaching. The sandbar is breached artificially when levels in the lagoon either threaten to flood peripheral property or flood canefields upstream. Breaching may also be undertaken if the water in the lagoon appears to become "unhealthy" and requires flushing. The latter condition is a result of organic pollution arising from the irrigation of sugar cane fields ([43]) (see under Physico-chemical characteristics). Breaching of the bar is a bone of contention at Zinkwasi because there are many views as to how often and where it should be done.

The crest level of the sandbar is variable, and naturally dictates the level at which artificial or natural breaching must take place. A breach has normally been made by encouraging the water to leave the lagoon towards the centre of the bar, by opening a channel manually. In 1976 the Health Committee permitted the lagoon to breach naturally — which it did in the characteristic fashion of such systems, at the southernmost point of the bar. In so doing it scoured away beaches on private property, washed away the lifesavers' hut (now being rebuilt for R15 000 in almost the same spot), smothered the rocks with sand (to the detriment of mussels and oysters established there) and did not apparently flush the lagoon adequately.

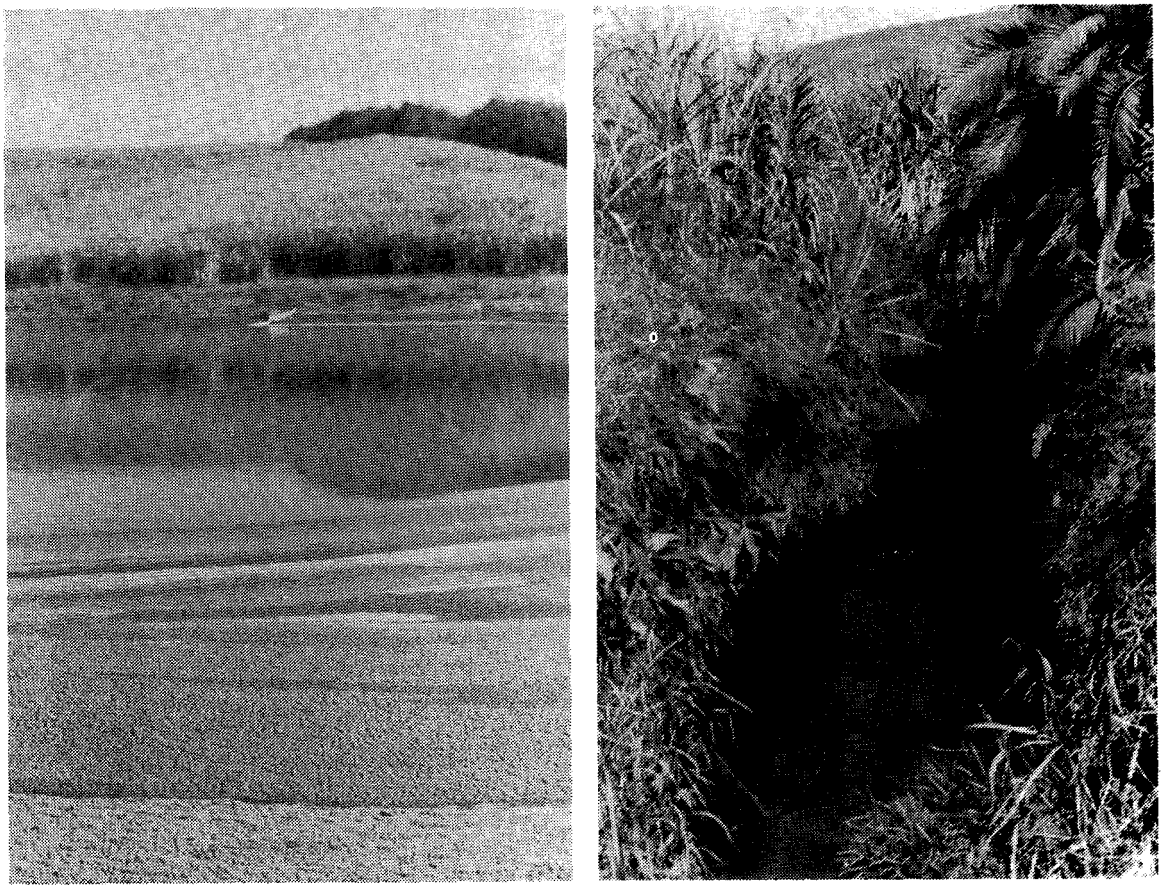
Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics (see Table **18**).

In 1964 the water quality of the Zinkwasi lagoon was classified as "Class V" ([43]) (i.e. water of low quality verging on nuisance levels) ([42]). Brand *et al* attributed this to the fact that the whole catchment was under sugar cane, as well as huts and compounds near the river ([43]).

The water was characterized by high conductivity (11 500 micromhos in dry season) and a noticeable degree of organic enrichment (biological oxygen demand value of 11,7 mg/litre in the dry season). On 2 June 1976 Josso (pers. comm.) recorded chemical oxygen demand values of 140 mg/litre in the lagoon, following a complaint to the Department of Water Affairs from the Health Committee. This was attributed directly to run-off from the spray irrigation of canefields. In this instance, the company responsible was advised of the pollution caused (the general chemical oxygen demand standards for an industrial effluent being laid down as 75 mg/litre) and speedboats were used in the lagoon to reaerate the water. Thus in an attempt to dispose of dunder by land application ([25]), pollution problems appear to have been partially transferred from the Nonoti to the Zinkwasi catchment by irrigation.



A photograph of a dunder dam in the vicinity of the Zinkwasi lagoon to which wastes from the Darnall Mill are pumped. These are then used to irrigate sugar cane, the run-off from which accounts for the organic enrichment of the Zinkwasi lagoon.

Public health aspects

Bacteriology. A total plate count of 16,5 million organisms/ml ([43]) on 14 July 1964 certainly confirms that the water of the lagoon can be chronically enriched by dunder.

Faecal pollution from huts and compounds near the river upstream was also suspected ([43]). Africans also use the upper reaches of the lagoon for bathing and washing clothes.

On 20 December 1976 *E. coli* levels in the lagoon were 2 500/100 ml and in the stream running past the caravan park *E. coli* levels were in excess of 180 000/100 ml (Zinkwazi Health Committee, pers. comm.). Pollution from septic tanks (especially during the wet season when the ablution facilities at the caravan park may become overloaded) is consequently suspected.

Table 18. Physico-chemical characteristics ([43]).

Locality: Zinkwasi Lagoon at the road bridge to Tugela mouth (Station 3).	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.68	7.29
Saturated pH value	7.5	6.7
Conductivity micromhos/cm	1 458	11 557
Total dissolved solids ppm (calcd.)	883	6 189
Dissolved oxygen mg/litre	3.1	4.5
% Saturation	40	48
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	4.1	11.7
Kjedahl nitrogen mg/litre	Trace	0.9
Ammonia mg/litre	Trace	0.1
Nitrites mg/litre	.036	Nil
Nitrates "	.08	2.60
Phosphates "	.09	.17
Total alkalinity "	215	182
Total hardness "	292	1 246
Calcium "	45.2	342.3
Magnesium "	43.6	94.8
Sodium "	224	1 830
Potassium "	4.1	70.2
Sulphates "	75	360
Chlorides "	343	3 360
Silica "	17.3	9.2
Iron "	0.8	0.3
Fluorides "	1.3	0.9
Free carbonic acid (as ppm carbon dioxide)	10.5	12.3
Temperature °C	28.5	18.5
Turbidity (ppm silica scale)	27	25
Colour (APHA units)	30	18
Appearance	dirty	dirty
Odour	-	-

Values underlined significant of disturbance.

In view of the recreational activities at Zinkwasi (skiing, boating, swimming) such conditions are obviously unsatisfactory. However, a sewage treatment plant has been recently installed by the caravan park and this should bring about an improvement in such conditions in the future.

Bilharzia. On 31 March 1971 Jackson (pers. comm.) located both *Physopsis* and *Biomphalaria* in the catchment. However, the State Department of Health have declared the lagoon to be bilharzia free, attributing this condition to its salinity. It should be noted that the maximum salinities recorded during the dry season appear to be 6‰ (if calculated from mg/litre chloride) ([43]). Metz ([222]) would consider these to be sufficiently low to advise that contact with such water be avoided.

BIOTIC CHARACTERISTICS

Flora.

A thin strip of coastal dune forest occurs on the northern bank of the Zinkwasi lagoon from whence it runs towards the Tugela.

Due to severe encroachment by sugar cane, the lagoon is botanically unimportant, as very little vegetation (other than *Phragmites*) remains alongside the lagoon or the river. Apart from a short belt of *Hibiscus tiliaceus* on the northern bank, the lagoon is characterized by a fringe of reeds (*Phragmites*) which, due to the gradual shallowing of the system, have encroached into the lagoon and become somewhat of a menace ([95]). Certain residents have attempted to spray the reeds on an experimental basis, to ascertain whether sprays will solve the problem. However *Phragmites* is an important component of the lagoon for the following reasons:

(a) reeds stabilize the banks, especially when the banks are subjected to the wash from powerboats and water skiers;
(b) reeds generate detritus upon which detritus feeding animals probably depend;
(c) reeds provide a suitable habitat for a great variety of birds;
(d) reeds act as a particularly effective filtering device (especially by removing phosphates) and consequently probably exclude a variety of harmful substances that could otherwise accumulate in the lagoon.

Fauna

Lower trophic levels. Only one bottom sample has been examined from the lagoon ([43]), upon which conclusions cannot be drawn other than that the fauna comprised typical estuarine forms. Furthermore none of the five species of animals recorded were biota indicative of badly polluted conditions. The high mineralization of the water may exclude certain of the faunistic components that would normally be encountered in such a lagoon. However, Jackson (pers. comm.) has reported the presence of the mollusc *Assiminea* in the lagoon on 15 May 1971 and penaeid prawns occur periodically (Manock, pers. comm.).

Higher trophic levels.

Fish: Wallace ([328]) netted the Zinkwasi lagoon on "an irregular basis" several years ago and recorded juveniles of two species of mullet. The quantities of mullet (*Liza macrolepis*) were particularly impressive in November 1976 (pers. obs.) and indicated that conditions were highly suitable for this species at the time. It would be interesting to establish whether this was related to the organic enrichment of the water by dunder, which may in turn create profusive growth of epipelic organisms on which the mullet feed.

Birds: Eight out of the 15 species of birds seen in the vicinity of the Zinkwasi lagoon on 18 June 1978 by Nichols and Newman (pers. comm.) were estuary associated. Although not an important system in this respect, the birds which do occur still contribute significantly to the pleasures of living alongside the Zinkwasi lagoon.

Reptiles: Leguaans are frequently sighted along the banks in the upper reaches of the lagoon (pers. obs.).

SYNTHESIS.

Our general state of knowledge of the Zinkwasi lagoon is lacking in many respects and is regarded as poor. In view of its popularity, it would appear justified to direct research towards identifying pollution sources, with a view to providing solutions to the problems they present. There is also the need for guidance, from a competent authority (such as NRIO) as to what policy the local Health Committee should adopt with regard to bar breaching.

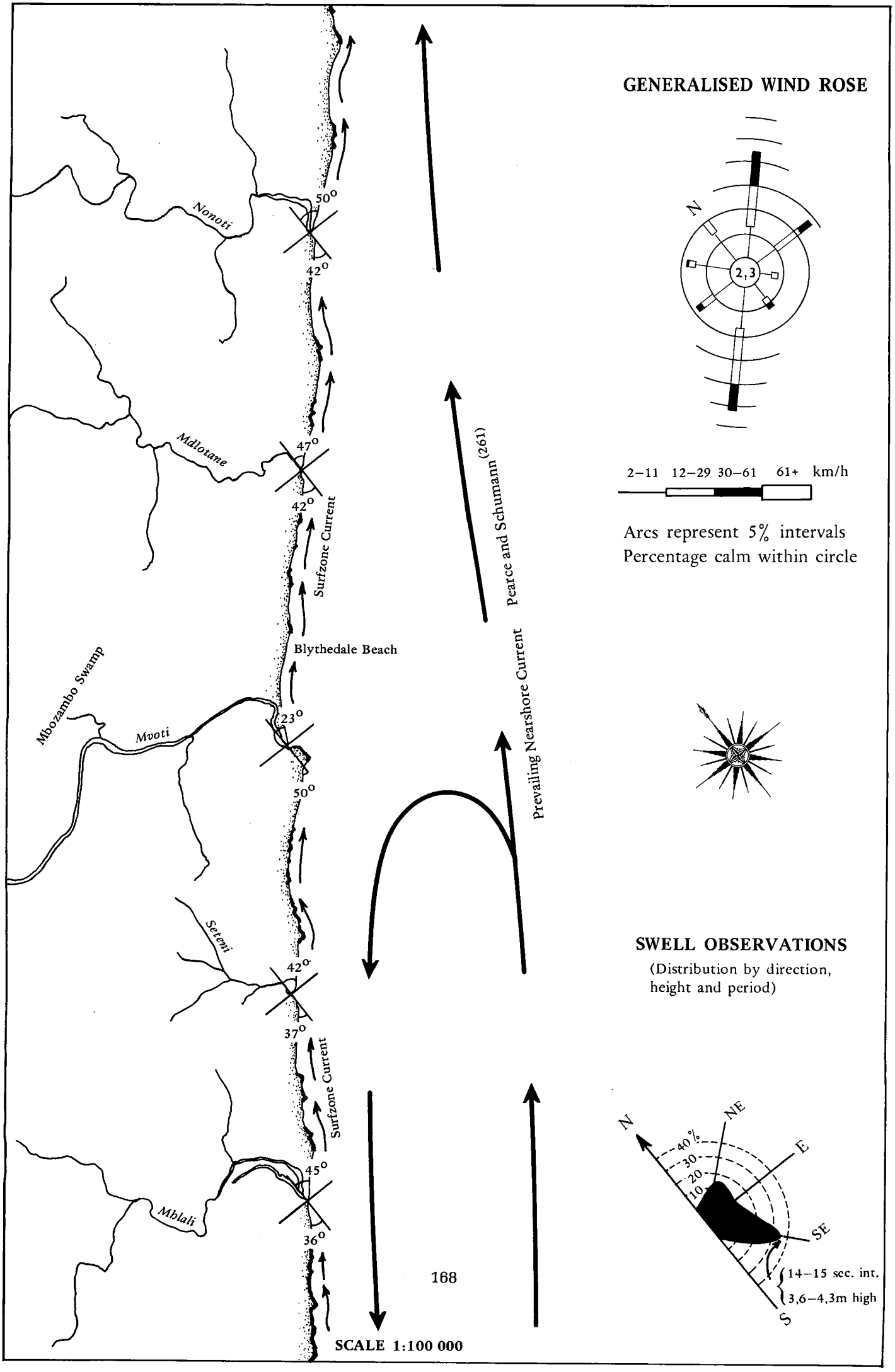
In its present environmental condition, the lagoon is by no means a valuable estuarine resource, and only protection of the coastal dune forest to the north of Zinkwasi seems justified.

Together with sewage pollution, several sugar cane associated problems are apparent. These include:

(a) organic pollution by dunder water, giving rise to periods of oxygen depletion;
(b) siltation;
(c) cane encroachment;
(d) reed encroachment (a consequence of siltation); and
(e) drainage diversions.

Should restoration of the Siyai be successful (see Sections 2.1.4.2 and 4.1) the Zinkwasi would be the next most suitable system on which to undertake the same exercise on a larger scale.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora		Fauna									Food Webs
ZINKWASI			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids							★					★			★																	
Source of Information	Summary of available information																																
Brand *et al*	1964	43	●		●			●			●				●											●						
Chew & Bowen	1971	78	●		●			●																								
Orme	1971	257	●																													
Jackson	1971	pers. comm.																								●						
Cooper *et al*	1972	95																					●									
Wallace	1976	328																									●					
Manock & Orwin	1977	pers. comm.		●						●										●						●						
Nichols & Newman	1978	pers. comm.																										●				
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 250	1976	124		●						●													●									
1:25 000 Job No. 251	1976	454	●	●																												


Nonoti
Mdlotane
Mbozambo Swamp
Mvoti
Setemi
Mhlali
50°
42°
47°
42°
23°
50°
42°
37°
45°
36°
Surfzone Current
Surfzone Current
Blythedale Beach
Pearce and Schumann (261)
Prevailing Nearshore Current
GENERALISED WIND ROSE
N
2,3
2–11 12–29 30–61 61+ km/h
Arcs represent 5% intervals
Percentage calm within circle
SWELL OBSERVATIONS
(Distribution by direction, height and period)
N
NE
E
SE
S
40%
30
20
10
14–15 sec. int.
3,6–4,3m high
SCALE 1:100 000

Synonyms
Nil.

Zulu meaning
Two possible meanings have been proposed:
(i) A river named after the "nono trees" (*Strychnos henningsii*) growing thereabouts ([289]); or
(ii) a river with "pure and tasty" water ([43, 289]).

Location
29°17'S; 31°25'E.

Accessibility
The Nonoti lagoon is ±85 km north east of Durban, but relatively inaccessible, being 15,5 km from the national road and accessible only through private property (Huletts). The lagoon is best approached from the north, via Zinkwasi Beach. Access is controlled by a gate guard who allows permit holders into the Seula/Iti Bay Reserve.

Bridges.
There are no bridges across the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 176 km² ([78, 257]) to 326 km² ([223]).

River length. 23 km ([25]) to 52 km ([78]).

Mean annual run-off. 34,4 x 10^6 m³ ([78]) to 61,3 x 10^6 m³ ([223]).

Flow. During the survey period in 1964 ([43]), flows of ,05 m³/sec. to ,28 m³/sec. were observed. Flows of ,64 m³/sec. were observed in March 1967 in the upper reaches of the river ([25]).

Flood history. No record. However, floods since May 1969 appear to have washed away several vegetated islands that were formerly present in the lagoon (observation from early photos in ORI collection).

Dams.
Existing: Nil.

Proposed: A dam at Darnall (for domestic and irrigation use) 8 km above the lagoon ([78]).

Siltation. Because of the obviously elevated bed levels and the distribution of mud and sand banks which are apparent from aerial photos (14.5.76 Scogings series), considerable quantities of silt enter the system. Sources in the catchment are likely to be cane lands, road surfaces and river banks.

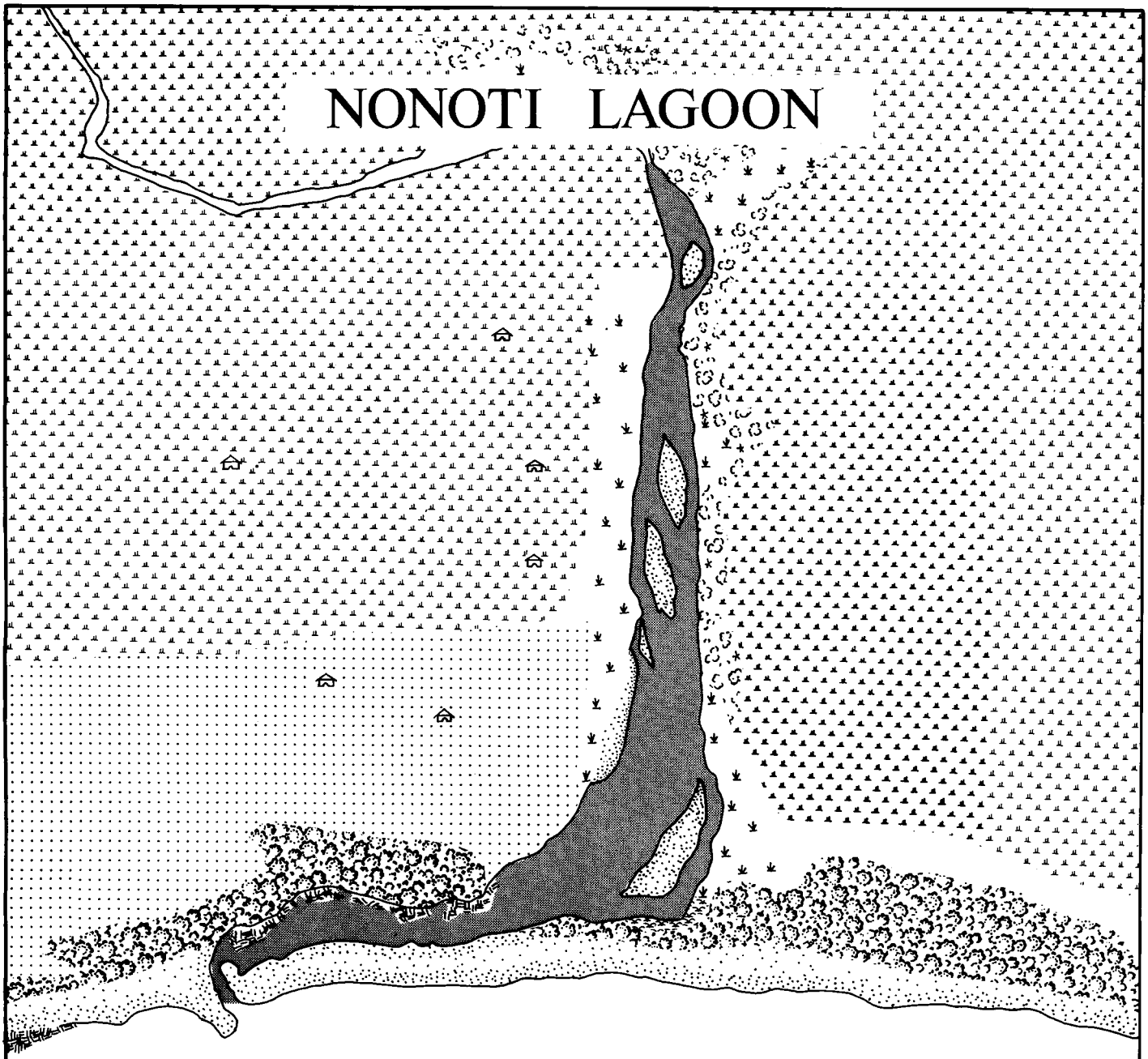
Land ownership/use. Virtually the whole catchment is cultivated with sugar cane. The Doorn/Doringkop Mill (near the source of the river) and the Darnall Mill (8 km above the lagoon) have the potential to pollute the system.
Surrounding the lagoon is a sugar cane farm ("Chantilly") belonging to Huletts.

Local authority. Huletts.

Estuary uses. Nil. Sugar mills above the lagoon abstract water from the river for industrial, domestic and irrigation purposes.

Morphometry of the lagoon (see Fig. **38**).
Area. 18 ha.

Axial length. 1,9 km.



Coastal Dune Forest

Coastal Riverine Forest

Reed Swamp

Cane

Grasslands

Hibiscus

100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 38

Shoreline length. 4,2 km.

Width.
Maximum: 240 m.
Channel: 20 m (during normal discharge periods).
Floodplain: ±300 m.

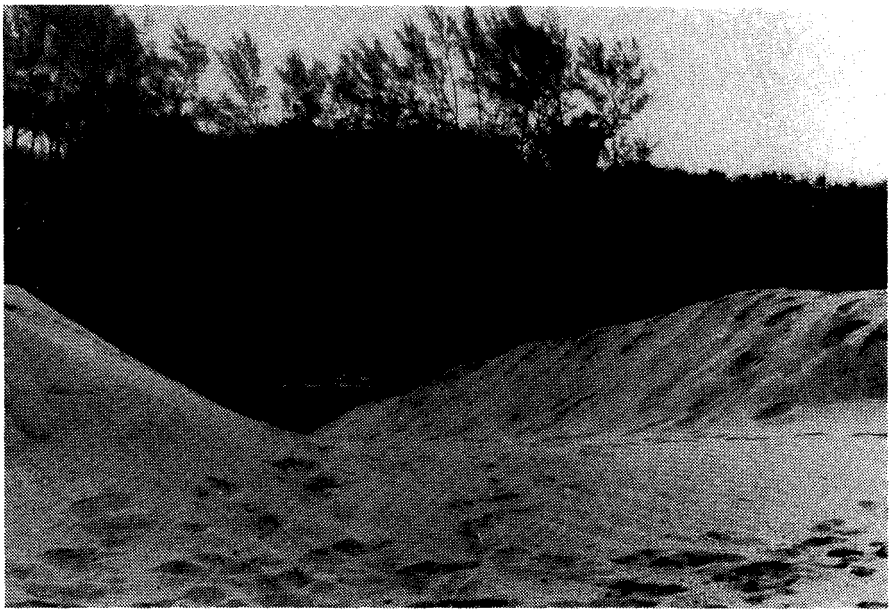
Bathymetry. The maximum depth on 8 September 1977 was 2 m near the mouth (pers. obs.).

Geomorphology

Geology. ([43], [78]) Table Mountain Sandstone dominates the catchment area, although outcrops of Dwyka tillite and Ecca shales also occur. Rocks on the west bank of the lagoon near its mouth, comprise sandstone of the Cape System, according to interpretations by the Department of Geological Survey (du Preez, pers. comm.).

Nature of bottom materials. There is no information available on this subject. With sugar mills upstream and water hyacinth decomposing in the lagoon, the sediments are liable to be organically enriched (black) and anoxic (foetid smelling).

Sandbar characteristics. The Nonoti sandbar is 700 m long and south extending. It is partially covered by *Scaevola*, but 450 m of the bar is not stabilized by vegetation. With no prominent rocky headland to the south of the system, it is very unusual to find a lagoon that is south extending (for significance see section 3.1).



Evidence of a channel dug through the Nonoti sandbar (8 September 1977) to artificially lower the water level in the lagoon.

Breaching: With sugar cane planted on the Nonoti floodplain at the headwaters of the lagoon, the system is breached artificially. This is also evident from aerial photos (in ORI collection) dated May 1969. Two breach positions were evident, neither being at the natural point of exit (pers. obs., 8 September 1977).

Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

There is no information available on the physico-chemical characteristics of the Nonoti lagoon. Hemens (pers. comm.) recalls the lagoon as being "black and lifeless" in the 1960's.

The presence of heavy pollution of the system by sugar mills in 1964 ([43]) (see Table **19**), precipitated a very detailed and thorough survey of the Nonoti during the period January 1967 to

Table 19. Physico-chemical characteristics ([43]).

Locality: Nonoti River	SUMMER	WINTER
Distance above estuary: 7.5km	1964	1964
Hydrogen ion concentration (pH)	7.03	5.41
Saturated pH value	8.1	7.8
Conductivity micromhos/cm	298	510
Total dissolved solids ppm (calcd.)	205	-
Dissolved oxygen mg/litre	Trace	Nil
% Saturation	Trace	Nil
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	10.9	> 35
Kjedahl nitrogen mg/litre	Trace	2.3
Ammonia mg/litre	Trace	0.1
Nitrites mg/litre	.029	Trace
Nitrates "	.07	.25
Phosphates "	.32	-
Total alkalinity "	97	110
Total hardness "	85	147
Calcium "	19.5	36.4
Magnesium "	8.9	13.7
Sodium "	32.8	41.7
Potassium "	8.5	37.0
Sulphates "	9.3	-
Chlorides "	46.0	65.8
Silica "	17.7	23.8
Iron "	2.6	5.3
Fluorides "	0.7	0.5
Free carbonic acid (as ppm carbon dioxide)	17.7	786.5
Temperature °C	29.5	20.0
Turbidity (ppm silica scale)	25	62
Colour (APHA units)	90	33
Appearance	Foul	Foul
Odour	-	-

Values underlined significant of disturbance.

March 1968. Ways and means of reducing pollution of the river system were sought ([25]). This involved a study of the river above and below the Doorn/Doringkop Mill (said to be 16 km above the river mouth in ([25]), but in fact closer to 40 km from 1:50 000 map) and included its chemistry, algology, bacteriology and hydrobiology. The river was found to recover quite rapidly below the Doorn/Doringkop Mill. However it is the Darnall Mill which is more likely to be responsible for pollution in the lagoon being that much closer (8 km away). Oxygen deficiencies or high total plate counts would be indicative of such pollution.

The various recommendations made as a "code of practice" to be adopted by the sugar mills is contained in ([25]). No follow up survey has been undertaken to assess whether the adoption of such practices has resulted in an abatement of pollution in the Nonoti system. However, the satisfactory condition of the Nonoti lagoon in September 1977 (pers. obs.) was indicative of success in this regard.

Public health aspects

Bacteriology. There is no information available on the bacteriology of the Nonoti lagoon. Indications of gross organic pollution above the lagoon were apparent from the 1964/67 studies of the river ([25, 43]). Assigned as "Class VI" in quality, the river was said to contain "foul water that is a public nuisance . . .". With the admixture of sewage and dunder water from the sugar mills, the dangers of faecal pollution exist. Mention of a poultry farm adjacent to the river, causing faecal pollution, has also been made ([43]).

Table 20. Bacteriology of the Nonoti river (7,5 km above the lagoon).

Date	Total Plate Count per ml x 10^3	*E. Coli* I per 100 ml
	5 days @ 32°C	Confirmed
19 May 1964	**51 200**	1 100
24 May 1964	—	**315 000**
14 July 1964	14 000	—

Values in bold significant of disturbance.

Bilharzia. To date there has been no evidence of the presence of bilharzia snails in the Nonoti system.

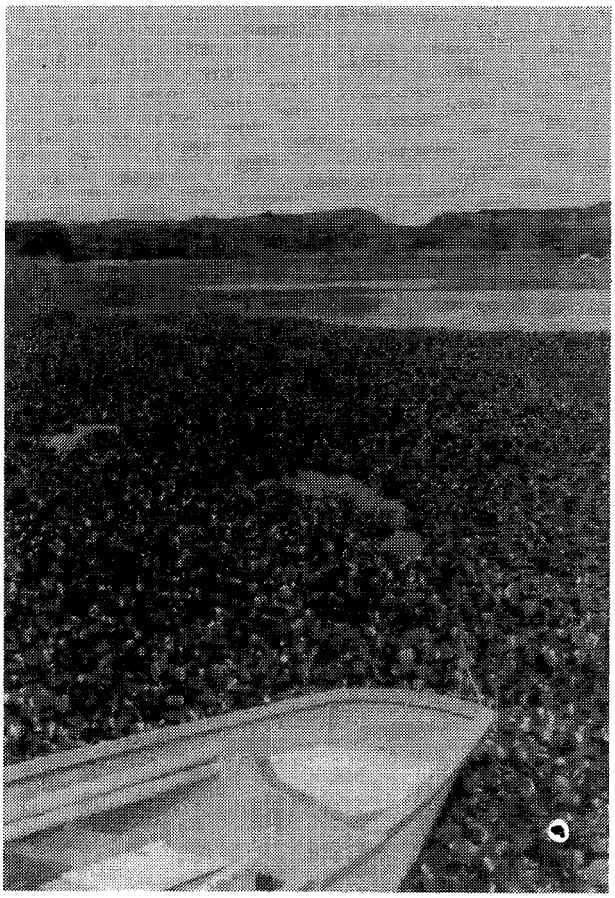
BIOTIC CHARACTERISTICS

Flora.

As a result of the encroachment of sugar cane adjacent to, and onto the floodplain of the Nonoti lagoon, the system is botanically speaking unimportant. On the northern bank towards the upper reaches of the lagoon, a few patches of indigenous forest occur on slopes too steep for cultivation. Near the coast, a dune forest runs both north and south of the lagoon. These have been preserved to prevent salt spray killing the sugar cane. On both banks of the lagoon *Phragmites/Echinocloa* associations extend as fringes and some *Barringtonia* remains. A dense stand of *Hibiscus tiliaceus* occurs at the water's edge, on the northern bank.

From the saprobiological/algological studies of the river system ([25]) (specifically, the identity, distribution, species composition and periodicity of the blue-green species of algae) certain algae in the lagoon could serve as indicators of water quality. The presence of *Oscillatoria tenuis* or *Lyngbya aerugineo-coreulea* would indicate water of foul quality. These appeared to be absent in September 1977.

The lagoon is partially covered in water hyacinth (*Eichornia*), which is generally an indicator of nutrient enriched water. However, the extensive beds of *Potamogeton pectinatus* containing much aquatic life, were encouraging signs of a healthy system. This plant seems to have become established during recent times, judging from aerial photos by Scogings dated 14 May 1976.



A fringe of water hyacinth (Eichornia crassipes) alongside the Nonoti lagoon is suggestive of nutrient enriched water.

Fauna

There is no data available on the fauna of the Nonoti lagoon. Furthermore no faunal sampling was undertaken in 1964 at that station nearest to the lagoon ([43]), at which the heavily polluted conditions already described prevailed. However, under these circumstances aquatic life is destroyed or reduced to a few animals capable of tolerating such conditions. During a visit in September 1977, the lagoon gave the impression of being biologically viable, with fish being conspicuous, and eight species of estuarine associated birds present, amongst which were Jacana and Dabchicks.

Amongst the tiny patch of riverine forest at the head of the lagoon, a bushbuck was seen, and the spoor of water mongoose was evident elsewhere.

SYNTHESIS

Our state of knowledge of the Nonoti lagoon is extremely poor. It is important that the river system and the lagoon be re-examined to evaluate the response of the system to the "good housekeeping" practices which have been adopted by the sugar mills (since ±1970) above the lagoon ([25]). In its present condition, the lagoon shows encouraging signs of life and is suggestive of recovery from a formerly polluted, lifeless condition. Without further surveys of the lagoon, its present resource value cannot be accurately evaluated.

Several sugar cane associated problems are apparent in the Nonoti lagoon. These include siltation, cane encroachment, control by artificial breaching and, at certain times pollution by sugar mills upstream.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC											
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Historical	Flora			Fauna								Food Webs
NONOTI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization		Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids												★			★										←	★	→						
Source of Information	Summary of available information																																		
Brand *et al*	1964	43	●		●			●			○				○										○	○								
Archibald *et al*	1967	25	●		●						○				○								○			○								
Midgley & Pitman	1969	223	●		●																													
Orme	1971	257	●							●																								
Chew & Bowen	1971	78	●		●			●																										
Aerial photos (Scogings)		No.																																
1:10 000 Job No. 250	1976	117		●						●														●										
1:25 000 Job No. 251	1976	456	●																															

2.1.6.2 **MDLOTANE**

Synonyms
Ndlotane (1:250 000 Map No. 2930); (u)Mhlutini ([43]) (most commonly used name by locals).

Zulu meaning
No record.

Location.
29°21'S; 31°22'E.

Accessibility
The Mdlotane lagoon lies ±80 km north east of Durban and although only 8,6 km away from the national road, is not easily accessible, because all the approach roads are on private land. It is most easily approached from the northern bank through the property of Mr R. Bodasing, via the headquarters of the New Guelderland Estate.

Bridges
There are no bridges across the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. Estimates range from 33,6 km^2 ([43]) to 52 km^2 ([78, 257]).

River length. 10 km ([78]) to 16 km ([43]).

Mean annual run-off. 9,86 x 10^6 m^3 ([78]).

Flow. River flow is very erratic ([78]), and on several occasions in 1964 the average flow was less than 0,02 m^3/sec. ([43]).

Flood history. No record.

Dams.
Existing: Ashdene and New Guelderland.

Proposed: None.

Siltation. No record.

Land ownership/use. Virtually the entire catchment is used for the production of sugar cane. Around the lagoon, canefields dominate the area to the north, whilst exotic plantations (principally eucalyptus) occupy the area to the south.

Land ownership around the lagoon is complicated by the fact that the boundary between New Guelderland Estates (owned by a Mr Stewart) and Mr Bodasing's estate crosses from one side of the lagoon to the other (see Fig **39**). Negotiations are underway for all land north of the lagoon to become "Bodasing owned" and all that south of the lagoon to become "Stewart owned". If the "land exchange agreement" is concluded, Stewart will in effect lose control of the mouth. On the northern bank, at the mouth of the lagoon, a settlement to accommodate farm labour exists.

Local authority. Privately owned by Messrs Stewart and Bodasing.

Estuary uses. It has been mutually agreed (between the owners) to preserve the lagoon and its immediate environs as a wildlife sanctuary or nature reserve. A boat on the lagoon (8 Sept. 1977) is indicative of some utilization, and old fires and litter on the banks in the upper reaches are indications of angling.

Morphometry of the lagoon (see Fig. **39**).
Area. 9,4 ha.

Axial length. 2,25 km.

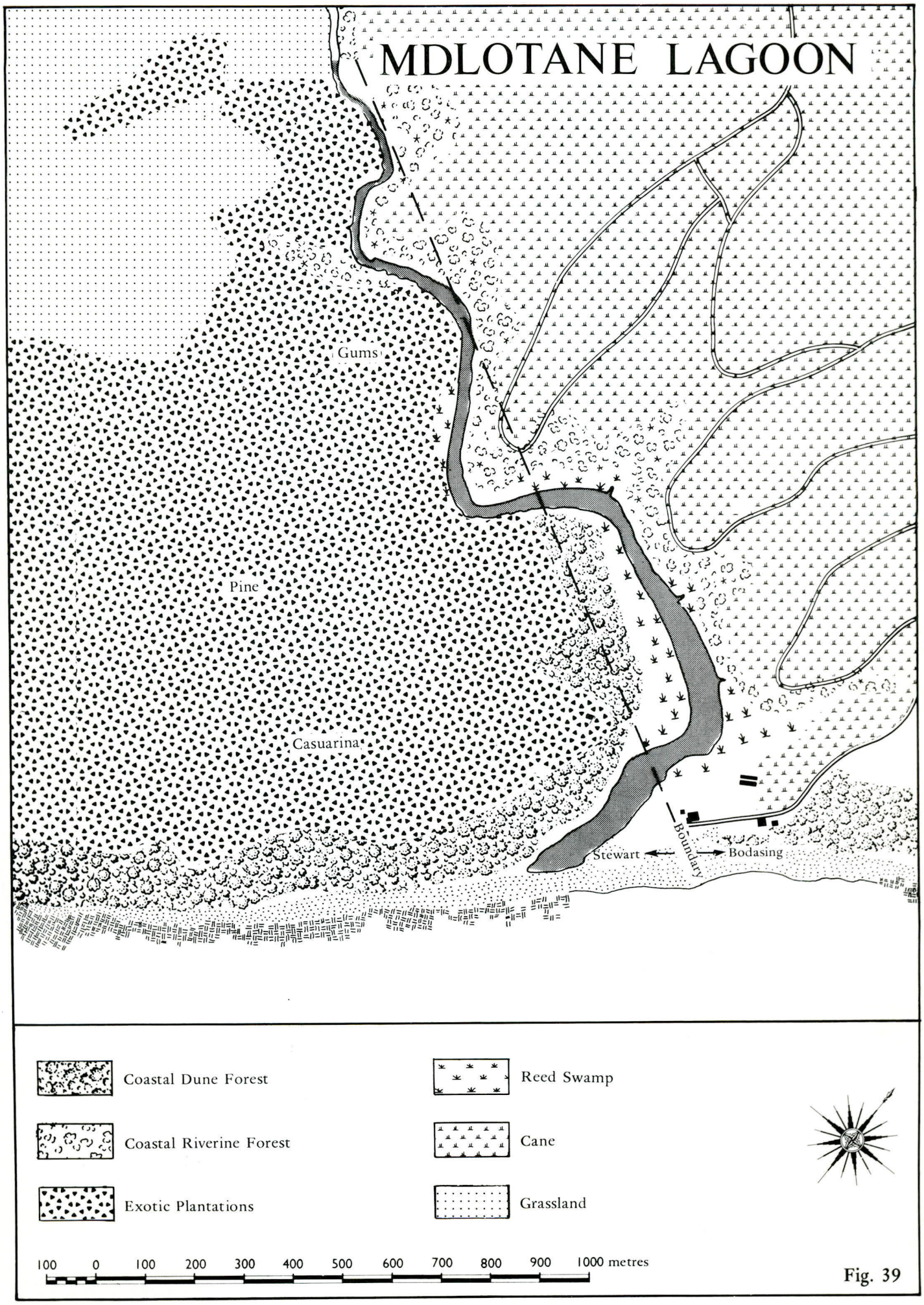

MDLOTANE LAGOON
Gums
Pine
Casuarina
Stewart
Boundary
Bodasing
Coastal Dune Forest
Coastal Riverine Forest
Exotic Plantations
Reed Swamp
Cane
Grassland
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 39

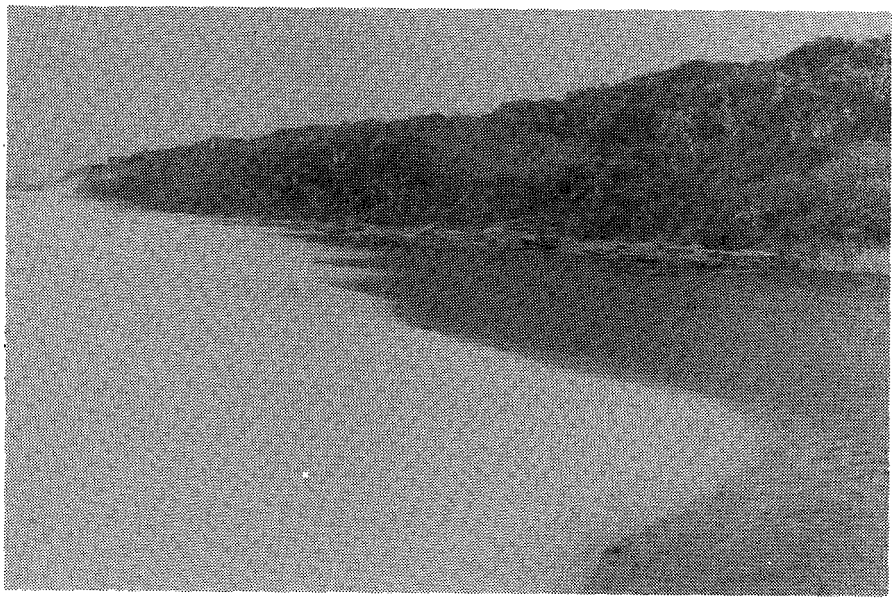
Shoreline length. 5 km.

Width.
Maximum: 100 m
Channel: No record.
Floodplain: 180 m.

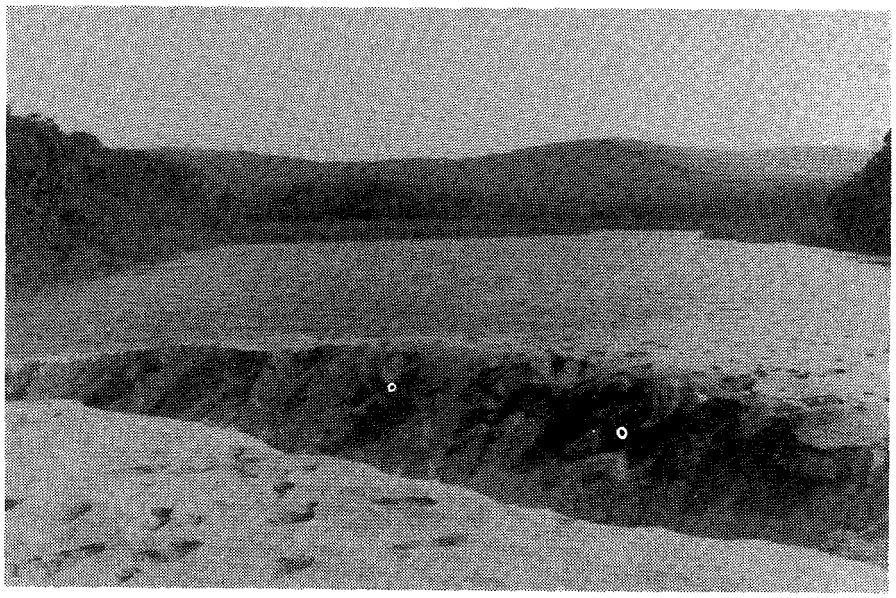
Bathymetry. A maximum depth of 3,1 m was recorded near the mouth. At the head of the lagoon, the depth midstream was 2,5 m (pers. obs. 8 Sept. 1977).

Geomorphology

Geology ([43, 78]). The catchment is built of a variety of rocks comprising Ecca shales, Table Mountain Sandstone, Dwyka tillite and recent deposits ([43]). There are rocky outcrops on the southern bank near the mouth and also further up the lagoon at several places. According to du Preez (pers. comm.) these are likely to be a sandstone formation (of Natal facies). The sandy soils south of the lagoon are apparently unsuitable for sugar cane cultivation (Stewart, pers. comm.).



An impression of the Mdlotane sandbar and the rocks which outcrop near the mouth.



Evidence of a channel dug through the Mdlotane sandbar means the water level is artificially controlled.

Nature of bottom materials. No record. Near the mouth, an occasional rock is encountered on the floor of the lagoon (pers. obs.).

Sandbar characteristics. The Mdlotane sandbar is a short south extending barrier. On occasions, the lagoon opens into the sea over the southernmost point of the sandbar. It remains closed for almost all of the year (Stewart, pers. comm.).

The landowners do not permit the lagoon to open naturally, despite the fact that there does not appear to be any form of floodplain encroachment. However a breach in the centre of the bar (evident on 8 Sept. 1977) is presumably necessary because lagoon levels would otherwise flood adjacent cane or gum plantations.

Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics.

No information is available on the physico-chemical characteristics of the Mdlotane lagoon. Although scarcely representative, some data from the river 7 km above the lagoon was collected in 1964 ([43]) (see Table **21**). The highly mineralized nature of the water (revealed by a conductivity of 636 micromhos in the rainy season, instead of the expected average of 84 micromhos) was thought to be due to run-off from the irrigation of canefields. In the dry season the water was organically enriched (high biological oxygen demand values, nitrate and free carbonic acid concentration, and low dissolved oxygen values). This was thought to be due to cut cane being washed into the river from a nearby railway siding ([43]).

Chew and Bowen also consider the water of the Mdlotane river to be polluted ([78]).

Public health aspects

Bacteriology. There is no information available on the bacteriology of the lagoon and even the information from the river 7 km above the lagoon is exceedingly sparse ([43]) (see Table **22**). Nevertheless, results in 1964 confirmed that the river water was organically enriched (7 million organisms per ml) during the dry season. From the general conditions apparent around the settlement at the mouth of the lagoon (pers. obs.) it seems reasonable to suggest that the lagoon could be faecally polluted.

Table 22. Bacteriology of the Mdlotane river (7 km above lagoon).

	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml
	5 days @ 32°C	Confirmed
1 April 1964	1	700
14 July 1964	**7 000**	230

Values in bold significant of disturbance.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

Botanically speaking, the Mdlotane lagoon is of considerable value, as much of the periphery of the system is undisturbed despite the fact that sugar cane lands (to the north) and plantations of pine, eucalyptus and *Casuarina* (to the south) overlook the system. It is only in very few places that sugar cane or gum trees do approach too close to the edge of the lagoon. Where the hillsides slope steeply towards the lagoon, coastal forest (dominated by *Mimusops* and *Strelitzia*) has remained undisturbed. The edge of the lagoon is well endowed with *Barringtonia racemosa* (in very good condition), *Hibiscus tiliaceus* and *Phragmites*. In the upper reaches of the lagoon *Echinochloa* extends beyond the *Phragmites* as a floating raft and makes passage difficult. *Nymphaea* (water lilies) also occur. In the lower reaches, where salinities are presumably more suitable, extensive beds of *Potamogeton pectinatus* (pond weed) are found.

Table 21. Physico-chemical characteristics ([43]).

Locality: Mdlotane River Distance above lagoon: 7km	SUMMER (Rainy Season) 1964	WINTER (Dry Season) 1964
Hydrogen ion concentration (pH)	7.61	7.54
Saturated pH value	8.1	7.4
Conductivity micromhos/cm	636	1 100
Total dissolved solids ppm (calcd.)	358	651
Dissolved oxygen mg/litre	6.5	4.9
% Saturation	78	48
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	0.8	4.4
Kjedahl nitrogen mg/litre	-	1.8
Ammonia mg/litre	0.7	1.1
Nitrites mg/litre	0.015	0.182
Nitrates "	.18	Nil
Phosphates "	.22	.29
Total alkalinity "	121	229
Total hardness "	131	221
Calcium "	17.6	48.0
Magnesium "	21.2	24.6
Sodium "	78.4	164.0
Potassium "	2.3	8.5
Sulphates "	23.0	3.1
Chlorides "	119	244
Silica "	20.7	18.2
Iron "	0.6	0.2
Fluorides "	0.8	0.2
Free carbonic acid (as ppm carbon dioxide)	5.9	14.0
Temperature °C	25.0	14.5
Turbidity (ppm silica scale)	12	1
Colour (APHA units)	70	9
Appearance	Fair	Good
Odour		

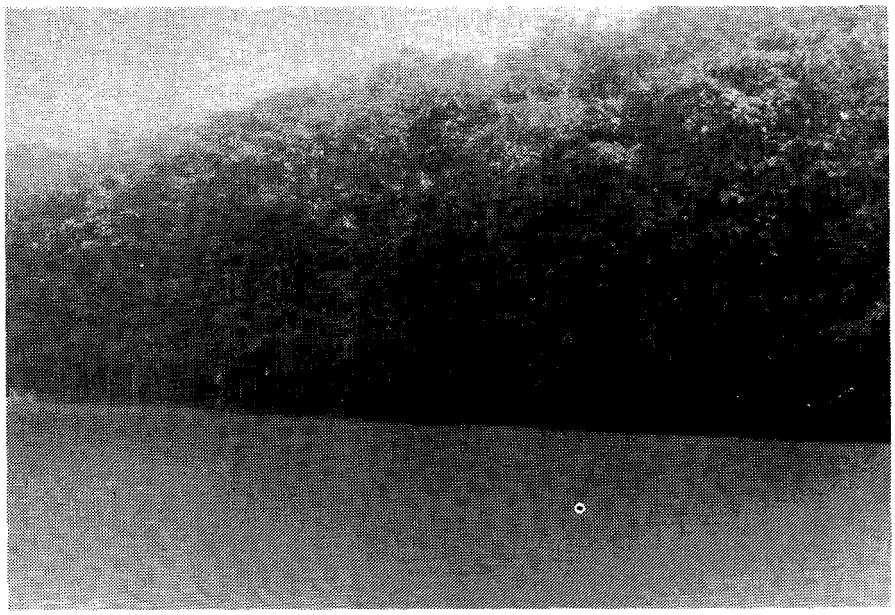
Values underlined significant of disturbance.

Above the lagoon, the riverine vegetation has also been left intact as a thin strip alongside the river course.

Fauna

There is no information available on the fauna of the Mdlotane lagoon. However with the well preserved vegetation adjacent to the system, it can be assumed that both the terrestrial and aquatic fauna associated with such vegetation, abound.

Amongst the eight species of lagoon associated birds (present in September 1977, pers. obs.), Jacana and Dabchick were noteworthy. Both species frequented the *Potamogeton/ Echinochloa* fringes on the edge of the lagoon.



The freshwater mangrove (Barringtonia racemosa) thrives on the edge of the Mdlotane lagoon.



In a few places sugar cane has been planted too close to the edge of the lagoon. Note the raft of Echinocloa (antelope grass) which extends from the edge.

SYNTHESIS

Regrettably our state of knowledge of the Mdlotane lagoon is very poor, and ecological surveys are urgently required to assess the resource value of the system.

In its present environmental condition, the Mdlotane lagoon is outstanding as one of the best preserved systems on the North Coast, south of the Tugela. It has definite conservation potential because of the undisturbed flora and fauna which it appears to maintain. Furthermore, there are no severe problems apparent in the lagoon, although various sugar cane associated problems (organic enrichment, siltation and cane encroachment) could materialize in the future. Comparisons between the Mdlotane and other lagoons adjacent to it (such as the Zinkwasi or the Mhlali, which have similar catchments, but disturbed peripheral vegetation) are of particular interest, because the Mdlotane is almost certainly reflective of their former condition.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC											
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other						Flora			Fauna							Food Webs
MDLOTANE ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids				★						★	★					★								◄	★	►							
Source of Information	Summary of available information																																
Brand *et al*	1964	43	●		●						○					○																	
Chew & Bowen	1971	78	●		●																												
Orme	1971	257	●		●			●		●																							
Stewart	1977	pers. comm.															●			●				●									
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 250	1976	111		●						●														●									
1:25 000 Job No. 251	1976	460	●																														

2.1.6.3 **MVOTI**

Synonyms
Umvoti.

Zulu meaning
A river named after headman Mvoti Ncashange, of the L'la clan (the people of rest), who settled on the banks of this river ([289]).

Location
29°24'S; 31°21'E.

Accessibility
By road the Mvoti estuary is ±80 km north east of Durban. The national road is 5 km away and the nearest railhead 9 km distant at Stanger. There is a landing strip for light aircraft at Umvoti mouth.

Bridges
There are no bridges across the estuary.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 2 551 km² ([78, 257]); 2 618 km² ([223]); 2 701 km² ([43]); 2 736 km².

River length. 180 km ([43]) to 215 km ([78]). The only major tributary is the Hlimbitwa river.

Mean annual run-off. 134 x 10^6 m³ ([223]) to 461 x 10^6 m³ ([78]).

Flow. Data is scant ([43, 345]). The average total flow has been estimated to be greater than 11 m³/sec. ([43]). Approximate information on river flow for the period November 1964 to December 1965 ranged from 6,7 m³/sec. to 14,8 m³/sec. ([345]).

Flood history. Dramatic floods each causing many changes in the estuary occurred in the following years (Jex, pers. comm.):

1917
1925
1940 (June) — when rain came in from the sea from a hurricane;
1974 — from a cloudburst over Mapomulo in the catchment; and
1976 — characterized by floods which persisted for an abnormally long period of time.

Flooding of the Mvoti is a subject of grave implication to sugar farmers who have planted their crops on the floodplain. During floods, it is the debris which preceeds the floodwater which is particularly destructive from the farmer's point of view.

Floods of the Mvoti are also of great significance to ski-boat owners who leave up to R100 000's worth of ski-boats on the Mvoti sandbar. In its "flood position" the mouth of the Mvoti (see Fig. **41**) severs contact between ski-boaters (from Blythedale Beach) and their boats.

The river course has moved across the Mvoti floodplain since 1920 and its orginal positions are still clear in aerial photos. As the river migrated towards the northern bank, Mr Jex re-claimed the floodplain by establishing sugar cane in its wake.

The Gledhow Sugar Co. mechanically alter the channel positions upstream of the river during low flow periods. This encourages the river to adopt a different course and desist from eroding a particular bank beyond which is planted sugar cane.

After a long flood free period (e.g. 1940 to 1974) the main channel becomes extremely narrow. It is opened up again by floods such as those in 1974 and 1976.

Dams.
Existing: Lake Merthley, with a total capacity of 11,6 x 10^6 m³ supplies Greytown.

Proposed: (i) Mtendeni, ±90 km above the estuary (with hydro-electric power potential).
(ii) Mvoti Poort, ±200 km above the estuary.

A weir constructed just above the national road bridge was washed away in February 1977 (pers. obs.).

Siltation ([345]). The average percentage of sediment content varied from ,003% (15 December 1965) to 0,157% (10 December 1964). Ranges in the approximate sediment load/24 hours for the period November 1964 to December 1965, were from 38 tons to 1 788 tons. Due to the elevated bed levels of the Mvoti estuary, tidal exchange is limited, and sea water does not penetrate much further than 400 m inland (Jex, pers. comm.).

Land ownership/use. 36% of the catchment is Bantu influenced, (incorporating parts of the Mvoti location and the African reserves of Mapomulo and Kranskop) and is to remain as such as KwaZulu. Much silt is said to originate from these areas.

There are two principal towns in the catchment:

Greytown (Popn. 7 737 in 1960) ([43])
Stanger (Popn. 9 557 in 1960) ([43, 267]) — on the outskirts of which are industries such as sugar milling, sugar refining and paper milling. The sugar mills provide the paper mill with bagasse for pulping.

There are three sugar mills in the catchment:
Gledhow Mill;
Glendale Mill and
Melville Mill.

On the southern bank of the estuary, the land is leased by Mr F. Jex from the Gledhow Sugar Co. and is used for the production of sugar cane. On the northern bank, are the sugar cane estates of the Gledhow Sugar Co. Blythedale Beach is 1,5 km further north with a population of 250 in 1960 ([267]) and influxes of ±500 people in the holiday season (Dixon, pers. comm.). The trend in development is inland, as opposed to being towards the estuary.



An impression of the Mvoti mouth (12 January 1977). Notice the ski-boats on the sandbar.

Local authority. Mr Jex (on the southern bank) and the Blythedale Beach Health Committee.

Estuary uses. The Mvoti sandbar is used by ski-boaters who launch boats from the bar, using landrovers and tractors.

At one stage ESCOM investigated the Mvoti for its potential as a site for a nuclear power station, but the sediments (in excess of 50 m) were considered to be too deep for suitable foundations (Jex, pers. comm.). Considerable use is made of the river water above the lagoon

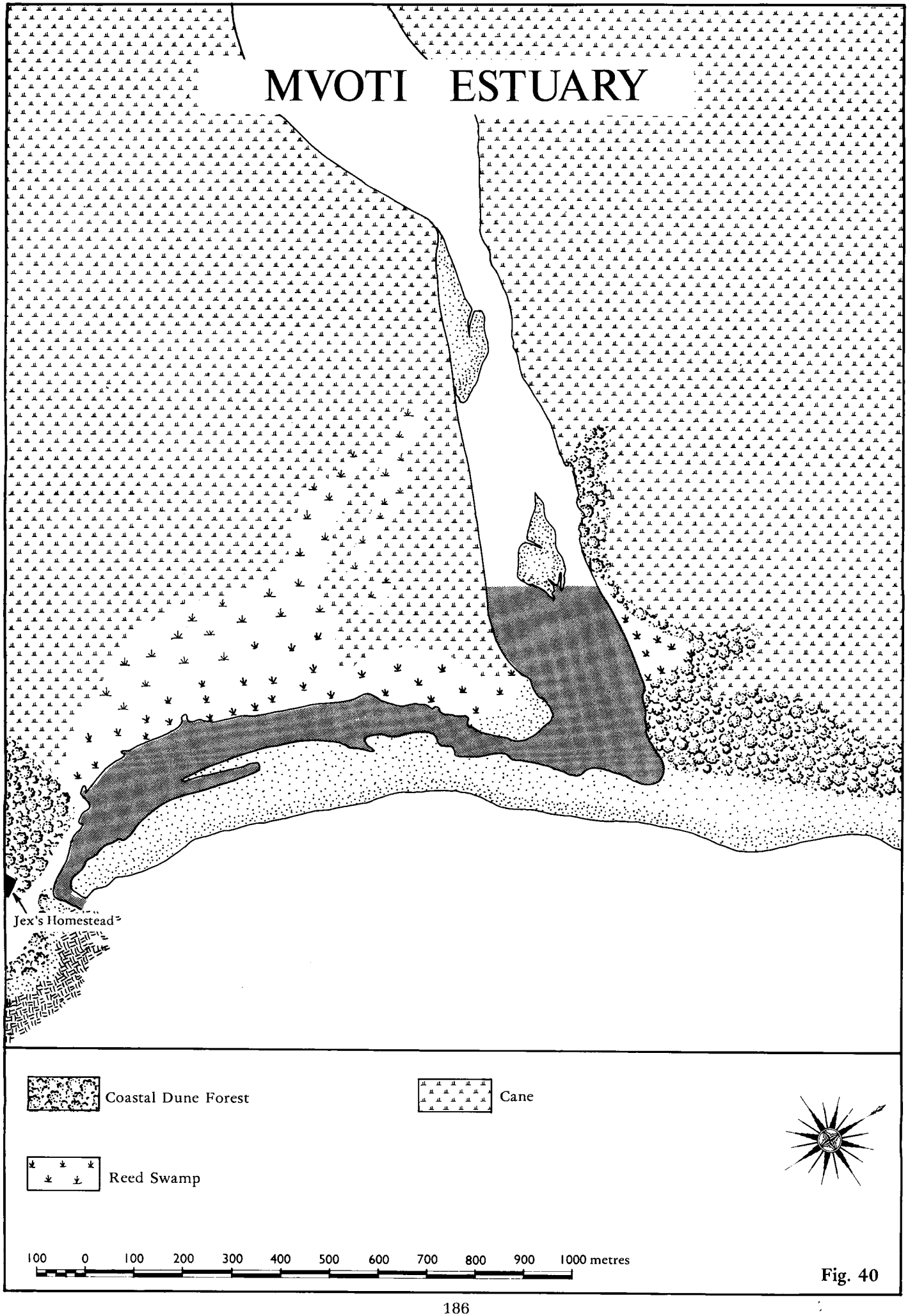

MVOTI ESTUARY
Jex's Homestead
Coastal Dune Forest
Cane
Reed Swamp
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 40

to supply Stanger, for irrigation, for hydro-electric power production, for the Glendale and Gledhow Sugar Mills, for the Natal Tanning Extract Co., etc.

Bird watchers visit the Mvoti estuary regularly to observe the birdlife.

Morphometry of the estuary (see Fig. **40**).

Area. 18,4 ha.

Axial length. 1,75 km.

Shoreline length. 3,8 km.

Width.
Maximum: 275 m.
Channel: ±40 m.
Floodplain: 1 150 m in 1974 floods (Jex, pers. comm.) ([257]).

Shape. Scouring of the estuary on the 90° bend at the coast has caused the estuary to move towards the Blythedale forest (this being evident from aerial photographs of the estuary in May 1969). Consequently what was a large grassy parking area on the northern bank of the estuary, has since become water area.

Bathymetry. The maximum depth of 1,8 m occurs at the "scour point" on the main bend of the system. During the 1974 floods, with water over the entire floodplain, depths approach 4,5 m (Jex, pers. comm.).

Geomorphology

Geology ([43, 78, 260]). Geologically the Mvoti catchment is varied and includes Natal Coal Measures, Ecca shales, Table Mountain Sandstone, Granite, Gneiss and Dwyka conglomerates. According to the Department of Geological Survey, the estuary is surrounded by Berea red sand, silt-stones and shale. Dolerite outcrops along the coast in the vicinity of the estuary (du Preez, pers. comm.).

Nature of the bottom materials ([257]). Approximately 5 km above the estuary the alluvium is 34 m deep. The colour of the sands are variable ranging from grey to yellow, and organic debris is abundant. Lenses of black silt indicate "backswamp deposition".

Sandbar characteristics (see Fig. **41**). The Mvoti is normally characterized by an impressive south extending spit, which is over 1 km in length. Consequently the river deflects through 90° at the coast, and opens to the sea in the extreme south, in the lee of a rocky headland of Ecca shale.

In winter a temporary north extending spit may begin to form, as the north-east winds subside and a south-east storm regime begins (Jex, pers. comm.).

On five occasions in the past 10 years, scouring at the 90° bend referred to, has broken through the bar at this point, and in creating a new mouth, isolated the lower reaches of the estuary. It is interesting to note that under these circumstances another temporary north extending bar begins to develop, under the direct influence of swells from the south-east.

Breaching: The system very seldom closes but if necessary, a breach is made using a bulldozer to ensure that sugar cane does not become flooded (Jex, pers. comm.).

Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

No data specific to the estuary itself exists, however some idea as to the expected conditions can be obtained from the analysis of Brand *et al* ([43]) made in 1964, 4 km above the estuary (see Table **23**). From his results gross pollution of the river was clearly established. During the dry season, biological oxygen demand values were excessively high, as were values for conductivity, potassium, calcium and concentrations of free carbonic acid. Dissolved oxygen and acidity were low. This pollution was almost certainly due to drainage from the Mbozambo swamp and caused by factory effluents from the Gledhow Sugar Mill.

Fig. 41. Variation in mouth position — Mvoti estuary.

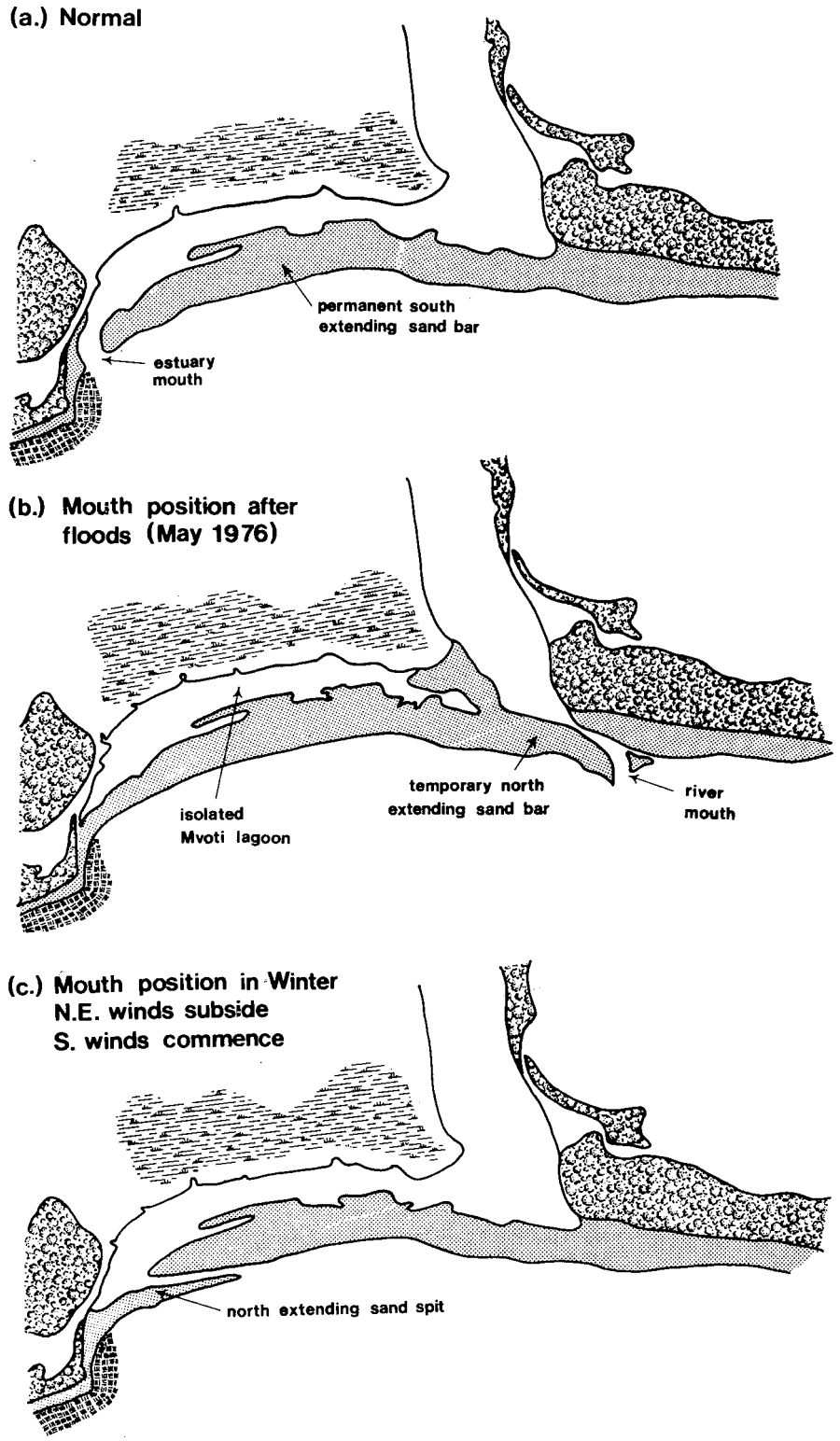
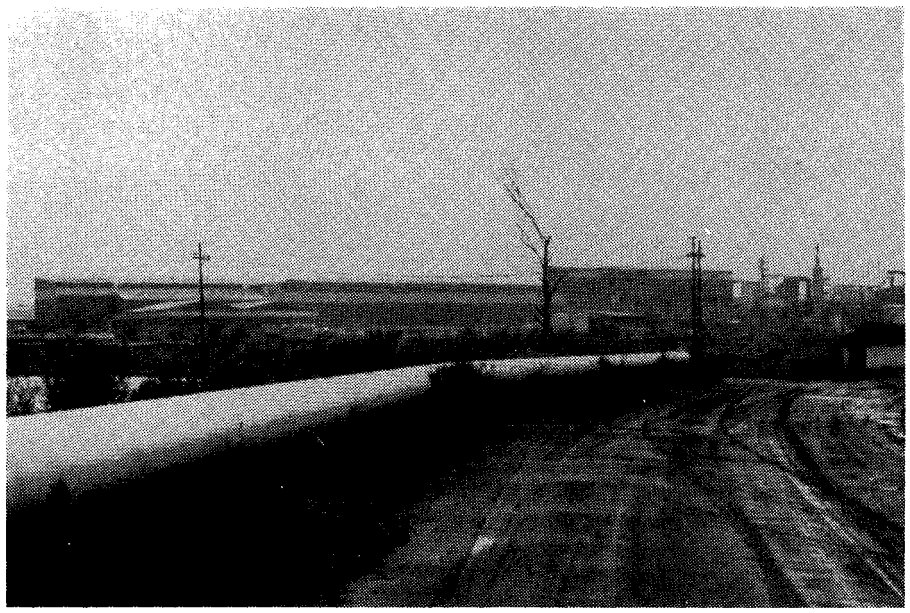


Table 23. Physico-chemical characteristics ([43]).

Locality: Mvoti River Distance above estuary: 4km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.3	6.8
Saturated pH value	8.3	7.2
Conductivity micromhos/cm	218	600
Total dissolved solids ppm (calcd.)	124	344
Dissolved oxygen mg/litre	3.2	2.2
% Saturation	39	23
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	3	40
Kjedahl nitrogen mg/litre	Trace	1.5
Ammonia mg/litre	Trace	0.1
Nitrites mg/litre	Nil	Nil
Nitrates "	0.18	0.07
Phosphates "	0.49	0.78
Total alkalinity "	77	222
Total hardness "	66	214
Calcium "	16.6	85
Magnesium "	6.0	0.3
Sodium "	22.6	30.6
Potassium "	2.5	24.7
Sulphates "	1.2	4.3
Chlorides "	29.1	40.4
Silica "	17.8	21.1
Iron "	-	2.2
Fluorides "	-	0.6
Free carbonic acid (as ppm carbon dioxide)	7.5	68.3
Temperature °C	26.2	19.0
Turbidity (ppm silica scale)	40	14
Colour (APHA units)	-	120
Appearance	Foul	Foul (dark)
Odour	-	maladorous

Values underlined significant of disturbance.



Industrial development 5 km above the Mvoti estuary accounts for the organic enrichment of the system.

Today a paper mill (despite stringent effluent treatment) also has the potential of polluting the Mbozambo swamp.

In the past, raw molasses was dumped into the river and the run-off from the dump of "filter cake" also used to pollute the water (Jex, pers. comm.). Today neither situation exists since there is a demand for molasses (as food) and for filter cake (as fertilizer). At low river levels, drainage from the Mbozambo swamp resulted in obnoxious odours developing in the estuary and the bottom used to become covered in a black slime. It is highly significant to note that the birdlife on the estuary seems to flourish best under such conditions.

Public health aspects.

Bacteriology. There is no information available which is pertinent to the estuary. In 1964 organic pollution was detectable 4 km above the estuary (see Table **24**) ([43]). The only notable faecal pollution occurred well above the estuary near Greytown, where no municipal sewage disposal scheme was operative.

Table 24. Bacteriology of the Mvoti river (4 km above estuary).

Date	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml
	5 days @ 32°C	Confirmed
10 March 1964	150	200
21 July 1964	**35 000**	221

Values in bold significant of disturbance.

Bilharzia. Faunal surveys of the river, undertaken in 1964 by Brand *et al* ([43]) failed to show the presence of bilharzia snails in the Mvoti catchment.

BIOTIC CHARACTERISTICS

Flora

Due to severe sugar cane encroachment, the Mvoti estuary is botanically unimportant. Such impressions are also confirmed by the results of surveys using colour infra-red techniques ([260]). Orme ([257]) comments on the replacement of a mangrove forest alongside the

Mvoti estuary by sugar cane, however Jex (pers. comm.) says he must have been referring to a small patch of *Barringtonia* which did once exist. A small patch of coastal dune forest extends northwards of the estuary towards Blythedale Beach. Running through this forest, a rough track, used mainly by ski-boat operators, leads onto the Mvoti sandbar.

Above the estuary, bank erosion is such that sugar cane collapses into the water, and service roads themselves become threatened.

After floods, Mr Jex re-shapes and stabilizes the vertical banks that have resulted from the scouring action of the water, using a bulldozer. He then plants a "water grass" (*Echinochloa*?) to prevent the banks from continuing to collapse due to undercutting. Once stabilized by grass, *Phragmites* then establishes itself. The 1940 floods destroyed 1,5 km of bamboos which he tried to establish alongside the river. Only totally flexible plants such as *Phragmites* appear to be able to tolerate such floods.

In the Mbozambo swamp, water hyacinth (*Eichornia*) occurs (pers. obs.).

Fauna

Whilst there is no published information available on the fauna of the Mvoti estuary, only the birdlife associated with this system appears to be of exceptional importance.

Surveys above the estuary in 1964 revealed biota reflective of the polluted conditions already described ([43]). In the 1920's, prior to the silting up of the estuary, large quantities of fish (perch and mullet) used to be netted in the Mvoti. These were salted, packed into barrels and sent inland (Jex, pers. comm.). Today the situation has deteriorated beyond recognition but the occasional influx of mullet (e.g. February 1977) is still experienced. At such times, ski-boaters turn their attention to these resources for bait (Dixon, pers. comm.).

With regard to birdlife, the Mvoti is one of the most richly endowed systems in Natal. It is noted as a very important tern roost and an area in which several rare tern species have been sighted, such as the Black-naped, Roseate and White cheeked terns ([281]). It is one of the most important sites in Natal for the occurrence of Little terns, then on their most southerly limits of distribution. It is also noted as one of the two known breeding sites in Natal of the Red-winged pratincole.

During the course of 15 counts, spanning a period of five years (29 April 1972 to 28 February 1977) Sinclair and Nicholls recorded 77 species of estuarine associated birds at the Mvoti estuary (pers. comm.). The rich variety of duck species and the regular occurrence of flamingoes is noteworthy. The birdlife of the Mvoti is zealously protected by Mr Jex.

As already mentioned, the birdlife appears to be at its best when organic pollution is at its worst. This is because of the substrate enrichment and response of certain benthic organisms under such conditions. After floods, and a flushing of the system, the birdlife dwindles.

SYNTHESIS

Other than the information that has been accumulated on the birdlife of the Mvoti estuary, our general state of knowledge of this system is very poor.

In its present environmental condition the estuary is severely degraded. Despite this, the estuary is outstanding in terms of the birdlife it supports. Consideration could be given to declaring the Mvoti estuary as a bird sanctuary, particularly as approval of the land owner (Mr Jex) would most certainly be forthcoming.

The Mvoti estuary displays several of the classical problems which affect so many of Natal's estuaries. These are very severe rates of siltation, (with African reserves and sugar cane being responsible) and organic pollution from sugar and paper mills. However, one must bear in mind that in this instance, organic pollution appears to be "permissable" because of the beneficial effects upon the birdlife of the Mvoti estuary. One avenue towards which research should be directed, should be to study the feeding habits of the birds so as to establish exactly how this is related to organic pollution.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text.	ABIOTIC																				BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other							Flora		Fauna							Food Webs
MVOTI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids												★																★			★
Source of Information	Summary of available information																															
Brand *et al*	1964	43	●		●			●			○				○											○						
Wylie	1965	345								○																						
Midgley & Pitman	1969	223	●		●																											
Chew & Bowen	1971	78	●		●			●																								
Orme	1971	257,260	●		●			●	●	●														●								
Nicholls & Sinclair	1972 to 1977	pers. comm.																										●				
Sinclair	1976	281																										●				
Jex	1977	pers. comm.	●	●	●		●			●									●				●				●	●				
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 250	1976	105		●						●														●								
1:25 000 Job No. 251	1976	463	●	●																												

On the 1:50 000 map 2931 AD, this river system is unnamed. According to the landowner, Mr L. Jackson, upon whose farm this lagoon is situated, it is known as the Seteni.

Meaning
Unknown.

Location
29°25'5"S; 31°18'E.

Accessibility
Accessibility is poor and confined to a dirt road through a private farm. The lagoon is 5,5 km from the national road, and is some 75 km north east of Durban.

Bridges.
None.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 16 km^2.

River length. 5 km.

Mean annual run-off. No record.

Flood history. No record.

Dams. Existing or proposed — none.

Siltation. Siltation within the Seteni lagoon is severe. With the entire catchment under sugar cane, the silt within the lagoon can only have originated from canefields.

Land ownership/use. The Seteni catchment comprises several sugar cane estates. Although owned by Mr Jackson, the land on which the lagoon is situated is leased from the Gledhow Sugar Co.

Local authority. Being privately owned, there is no local authority.

Estuary uses. Mr Jackson has built a holiday cottage above the lagoon on the southern bank. However, the lagoon itself is not used for any purpose.

Morphometry of the lagoon (see Fig. **42**).
Area. 1,13 ha.

Axial length. 350 m.

Shoreline length. 1 km.

Width.
Maximum: 70 m in the lowermost reaches.
Channel: 2 m at low flow periods.
Floodplain: 50 m.

Bathymetry. With the mouth closed, and water levels high, the maximum depth in the lagoon is probably 1,5 m. When open to the sea, depths do not exceed 0,5 m (pers. obs.).

Geomorphology
Geology. The lagoon is contained within alluvium, on the edges of which are Berea Red Sands. Dolerite outcrops on the coast just south of the lagoon mouth (du Preez, pers. comm.).

Nature of bottom materials. A superficial examination of these suggests they comprise coarse sand, which is overlain by a blanket of fine silt and clay (pers. obs.).

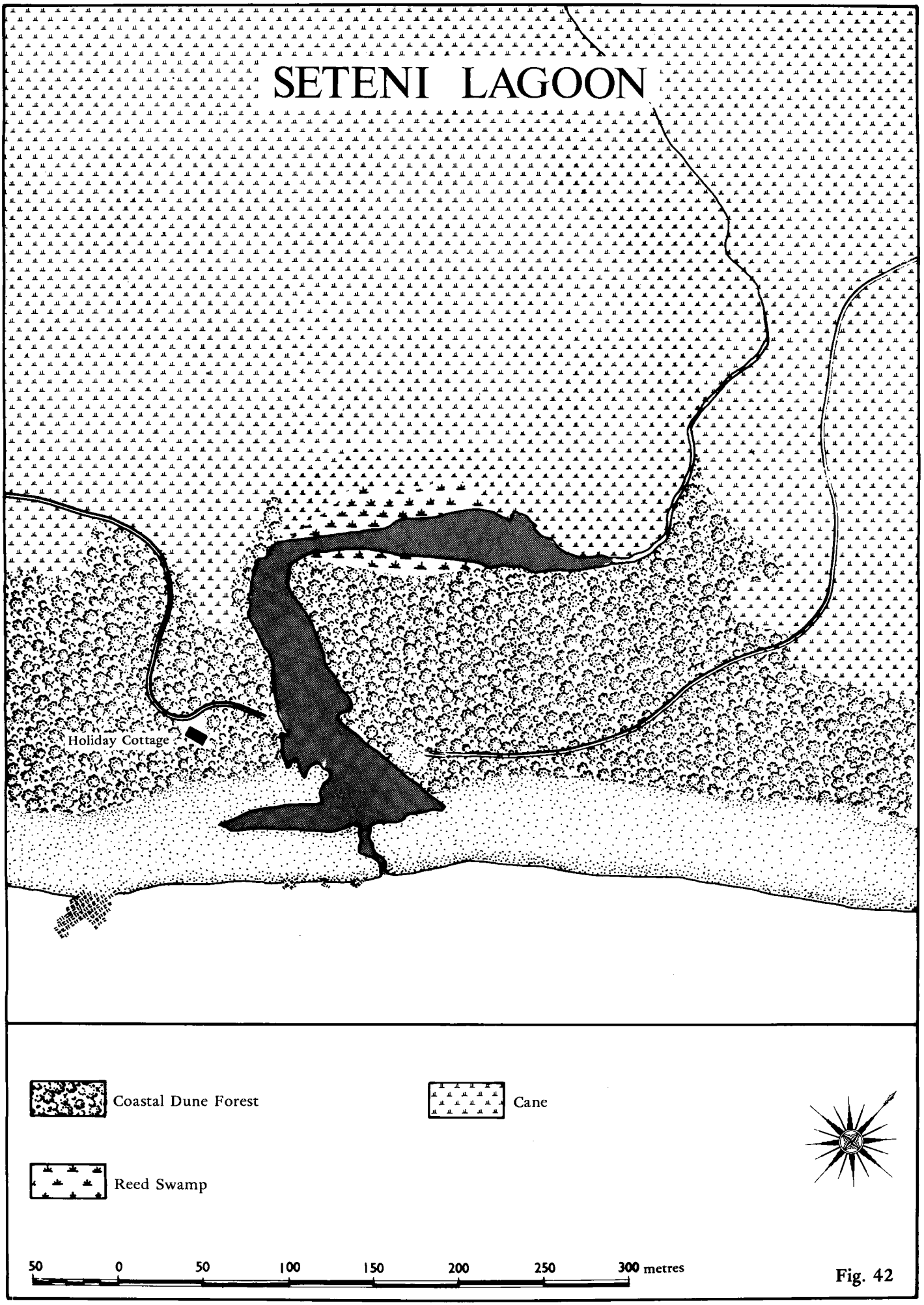
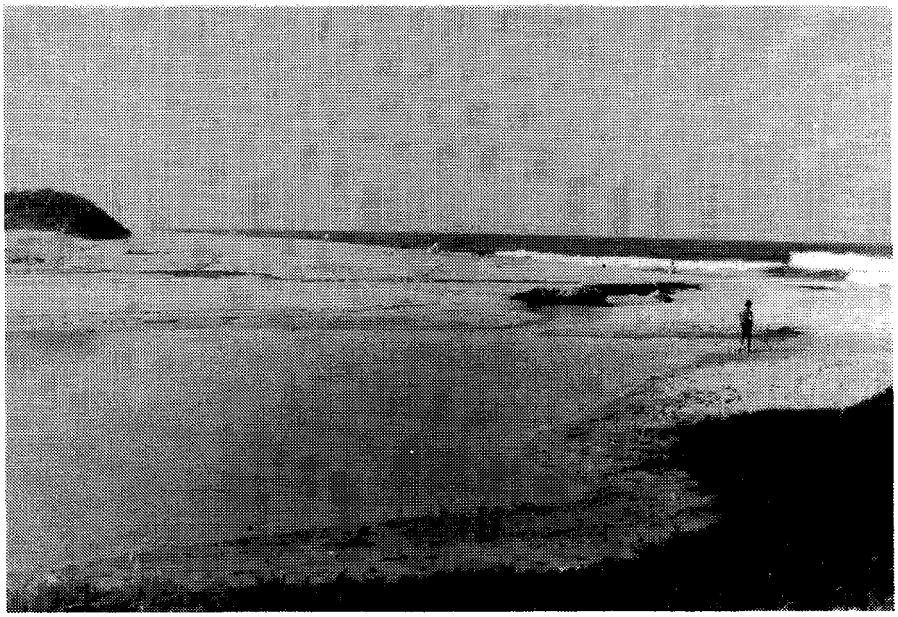

SETENI LAGOON
Holiday Cottage
Coastal Dune Forest
Cane
Reed Swamp
50 0 50 100 150 200 250 300 metres

Fig. 42



General view of the Seteni lagoon (8 July 1977).



The mouth of the Seteni lagoon in a central position.

Sandbar characteristics. The Seteni sandbar is probably a south extending barrier, although the mouth position (on 8 July 1977) was central. Within the channel to the sea, rocks lying immediately below the beach, were exposed.

The lagoon is permitted to open naturally (Jackson, pers. comm.).

Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

No record. With a sugar cane influenced catchment the water in the Seteni lagoon is probably mineralized and organically enriched. On 8 July 1977 the surface salinity ranged from 6‰ to 8‰ (pers. obs.).

Public health aspects.

Bacteriology. No record.

Bilharzia. No record.

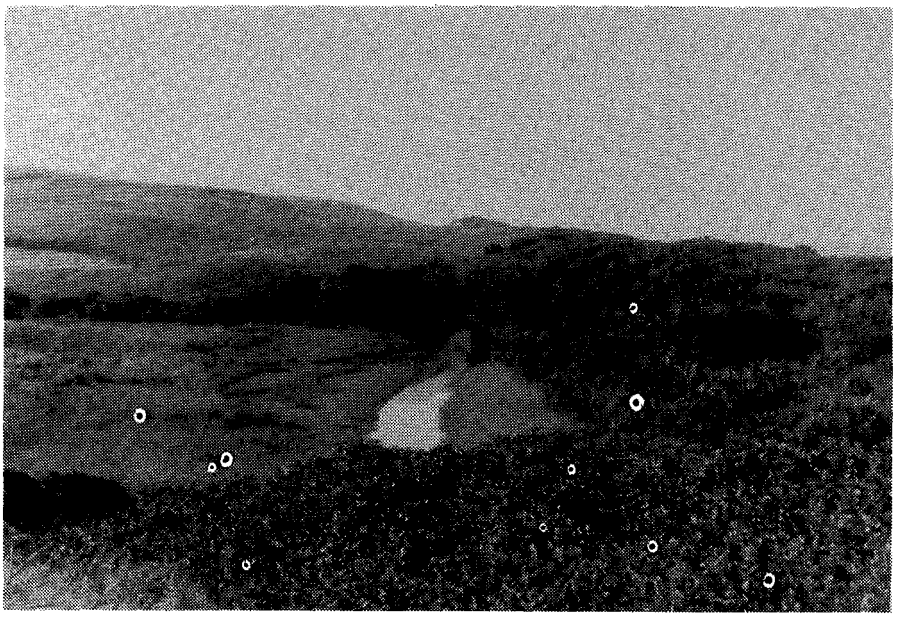
BIOTIC CHARACTERISTICS

Flora

The vegetation of the Seteni lagoon is essentially undisturbed although cane encroachment above the lagoon is severe.

The lagoon is fringed by *Hibiscus tiliaceus*, which merges with dune forest communities that extend both northwards and southwards from the lagoon.

The upper reaches are colonized by *Phragmites*.



Upper reaches of the Seteni lagoon. Water levels are low due to the mouth being open.

Fauna.

No record. The sand prawn (*Callianassa*) is present in fairly large numbers (pers. obs. 8 July 1977).

SYNTHESIS

Our state of knowledge of the Seteni lagoon is non-existent and no further investigations seem warranted. The system is in a degraded condition and is certainly of no resource value. The only apparent problem is siltation.

| | | |

Synonyms
As above, but with 'e' or 'u' preceding it.

Zulu meanings
One of Shaka's kraal sites called the resting place or the place of the sitter ([289]).

Location.
29°27'5"S; 31°16'5"E.

Accessibility
The lagoon is easily accessible, being 68 km north east of Durban and 4,5 km away from the national road.

Bridges.
There are no bridges across the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. Estimates range from 256 km^2 ([78, 256]) to 295 km^2 ([43]) to 331 km^2 ([223]).

River length. 38 km ([43]) to 55 km ([78]).

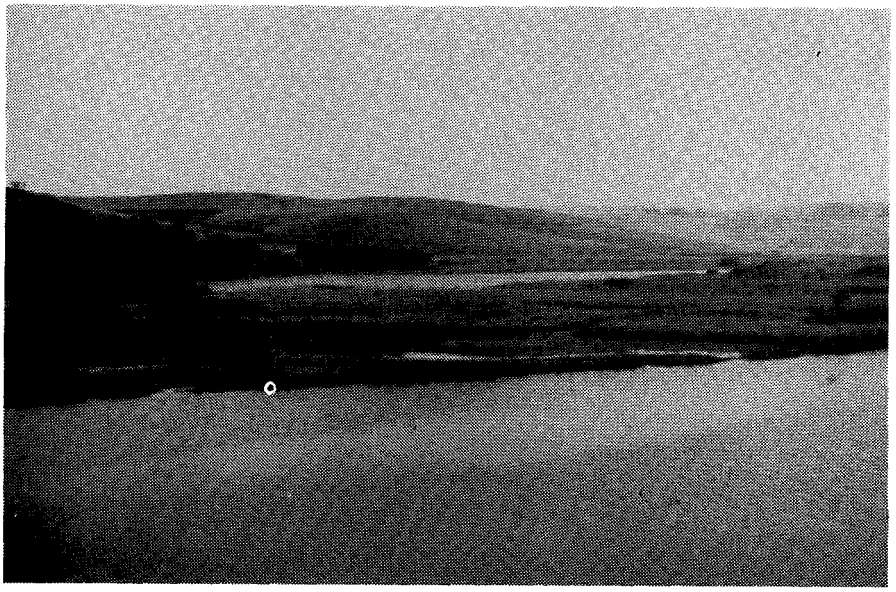
Mean annual run-off. 49,85 x 10^6 m^3 ([78]) to 59,76 x 10^6 m^3 ([223]).

Flow. There are no gauging stations on the Mhlali river. However, the mean annual flow has been estimated at 1,1 m^3/sec and flows are considered to be erratic ([43]).

Flood history. No record.

Dams. No dams exist nor are proposed on the Mhlali river ([78]). A weir across the headwaters of the lagoon exists.

Siltation. No record. Aerial photographs show a rather severely silted system, which can only have originated from the sugar cane influenced catchment. A very large island between the two arms of the Mhlali lagoon is almost completely under sugar cane. The fact that the southern arm of the Mhlali lagoon retains clear water, whilst the northern arm remains muddy and turbid (see aerial photographs, Scogings series, dated 14 May 1976) is suggestive of the latter functioning as the main channel in which the river is contained.



A general view of the Mhlali lagoon showing the large, sugar cane covered island in the centre.

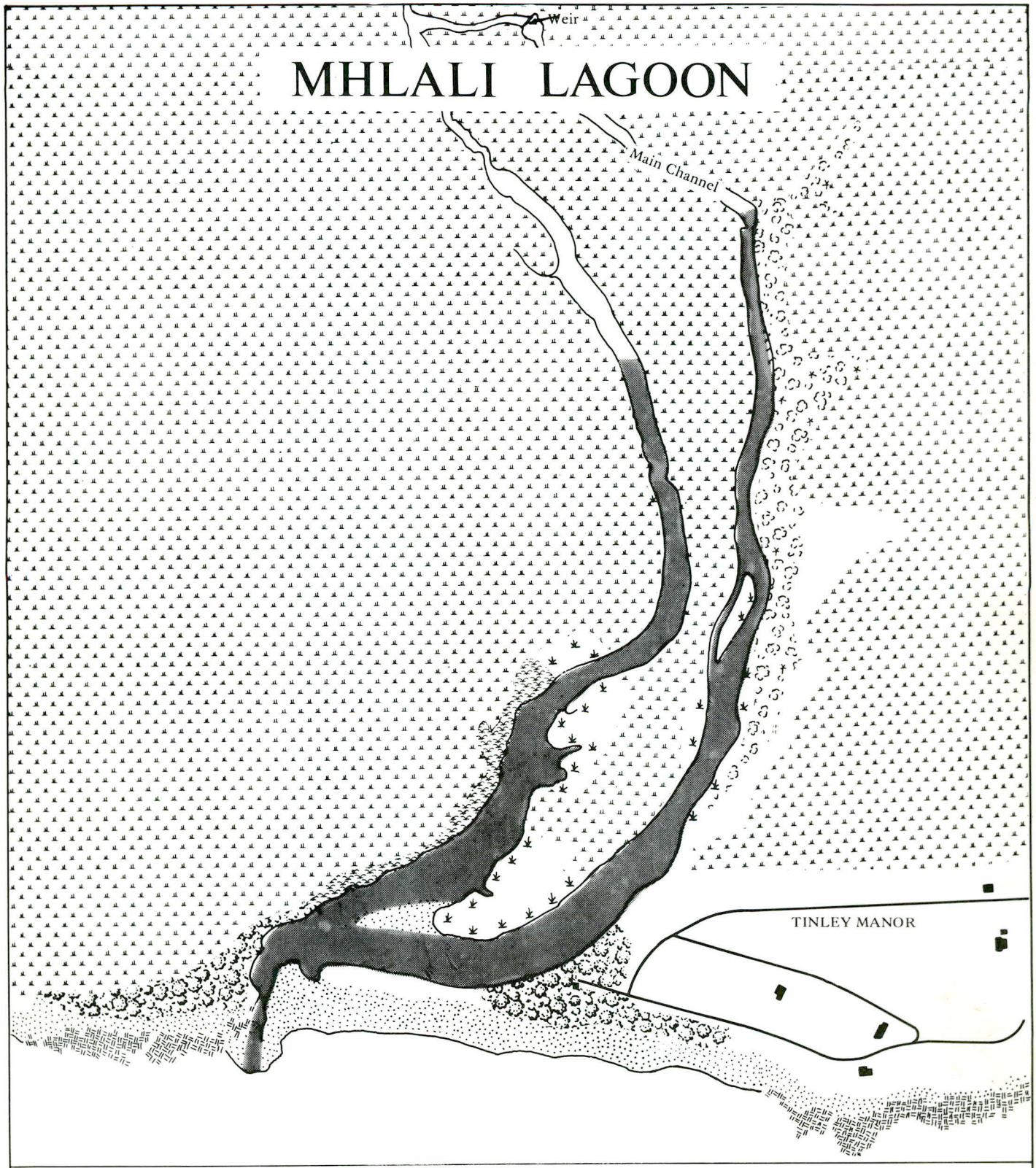

Weir
MHLALI LAGOON
Main Channel
TINLEY MANOR
Coastal Dune Forest
Coastal Riverine Forest
Reed Swamp
Hibiscus
Cane
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 43

Land ownership/use. Only 2% of the catchment is Bantu influenced (comprising part of the Umvoti Location) and is destined to remain as such as KwaZulu. Otherwise the catchment comprises sugar cane estates. The township of Chaka's kraal (with a population of 2 384 in 1960) ([43]) is just north of the Mhlali river.

Around the lagoon are sugar cane farms owned by Huletts. 2 km north of the lagoon is Tinley Manor which is an Indian resort comprising 231 lots ([266]). Several homesteads now overlook the lagoon on the northern bank, and beachfront chalets have become established on the sandbar.

Local authority. Tinley Manor Development and Services Board.

Estuary uses. The lagoon is used for no other purpose than angling, swimming and picnicking by Indians.

Morphometry of the lagoon. (see Fig. **43**)

Area. 21 ha.

Axial length. 2 km; although given as 1,25 km by Cockcroft ([86]).

Shoreline length. 6,4 km, a figure significantly increased by the bifurcated shape of the lagoon.

Width.

Maximum: 180 m; also given as 75 m to 200 m ([86]).
Channel: No record.
Floodplain: 400 m; given as 500 m in ([257]).

Bathymetry. No record.

Geomorphology

Geology. Table Mountain Sandstone, Ecca shales and Natal Coal Measures are the principal geological features in the catchment area ([78]), although Granite and Dwyka tillite are also listed ([43]).

Around the estuary, Berea red sands occur, within which are intrusions of Ecca shales and Dolerite, both of the Karroo system. Dolerite also outcrops at the mouth of the lagoon on the southern bank (du Preez, pers. comm.).

Nature of bottom materials. No record. 3 km inland 15 m of alluvium composed of clayey, coarse and gravelly sands has been reported ([257]).

Sandbar characteristics. Orme describes the system as being "deflected south against a massive spit" ([257]). In actual fact the bar is 500 m long and well stabilized by *Scaevola*. The mouth is rock defended (by dolerite), but more often than not closed to the sea. With sugar cane planted on the floodplain, the bar is presumably breached by sugar farmers when water levels rise too high.

Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

There is some information available on temperature and salinity in the lagoon in 1975 ([86]).

Surface temperatures ranged between 22°C to 26°C over the period 12 March to 12 May 1975 and channel temperatures were colder than inshore temperatures. During the same period, surface salinities ranged from 5‰ to 19‰. It is significant to note that during flow periods, salinities midstream dropped much lower than those inshore. The substrate (or interstitial) salinity was very much higher than the salinity of the lagoon water itself. On 8 July 1977 surface salinities inshore were 3,5‰ (pers. obs.).

In 1964 Brand *et al* ([43]) found the water of the river 2,5 km above the lagoon to be mineralized and attributed this feature to excessive run-off from the irrigation of sugar cane lands. The low dissolved oxygen values found in summer were suggestive of slight organic enrichment (see Table **25**).

The Etete river (a tributary 6,4 km above the mouth) is used by Bantu for bathing and washing and is enormously enriched and faecally polluted ([43]).

Table 25. Physico-chemical characteristics ([43]).

Locality: Mhlali River Distance above estuary: 2.5km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	6.7	7.5
Saturated pH value	9.0	8.6
Conductivity micromhos/cm	289	325
Total dissolved solids ppm (calcd.)	198	198
Dissolved oxygen mg/litre	4.1	10.1
% Saturation	49	91
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	0.8	0.9
Kjedahl nitrogen mg/litre	-	0.1
Ammonia mg/litre	0.2	0.1
Nitrites mg/litre	.033	Nil
Nitrates "	.90	.16
Phosphates "	Trace	Nil
Total alkalinity "	25.5	54.5
Total hardness "	65.3	69.3
Calcium "	10.1	12.9
Magnesium "	9.7	9.0
Sodium "	40.5	46.0
Potassium "	3.5	2.9
Sulphates "	41.0	18.7
Chlorides "	57.7	60.5
Silica "	15.4	13.7
Iron "	0.6	0.3
Fluorides "	1.0	0.1
Free carbonic acid (as ppm carbon dioxide)	8.9	3.3
Temperature °C	25.0	11.0
Turbidity (ppm silica scale)	64	8.0
Colour (APHA units)	25	25
Appearance	Turbid	Good
Odour		

Values underlined significant of disturbance.

Public health aspects

Bacteriology. The only indication of possible conditions in the lagoon comes from the results of Brand *et al* ([43]) made in 1964, 2,5 km above the lagoon (see Table **26**). Signs of sporadic organic enrichment and faecal pollution were evident.

Table 26. Bacteriology of the Mhlali river (2,5 km above lagoon).

Date	Total Plate Count per ml × 10^3	*E. coli* I per 100 ml
	5 days @ 32°C	Confirmed
20 January 1964	56,6	> 1 800
13 May 1964	120	130
21 July 1964	**15 000**	130

Values in bold significant of disturbance.

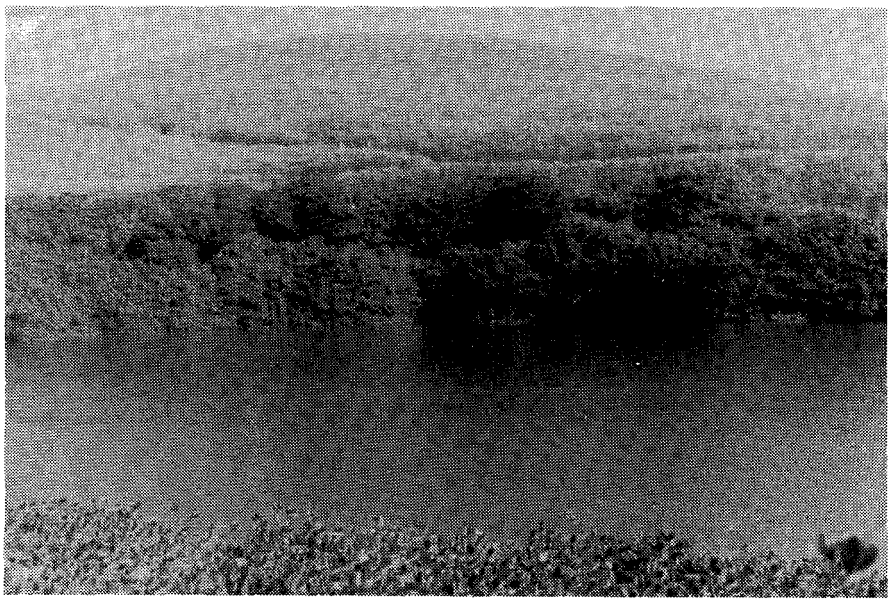
Bilharzia. From faunal collections amongst marginal vegetation in 1964 ([43]), *Physopsis* was located in the catchment. Consequently the chances of bilharzia in the system exist.

BIOTIC CHARACTERISTICS

Flora

Orme reports that "a few mangroves and reedswamp patches survive within the estuary..." ([257]). These must be the *Hibiscus* community evident on the southern bank and the *Phragmites* beds which occur principally on the island between the two arms of the lagoon. A few scattered clumps of *Barringtonia* have also remained on the island. Above the weir (on the northern arm of the lagoon) *Echinocloa* is well developed.

Cane encroachment is severe with the inevitable consequence that the lagoon is unimportant from a botanical point of view. The gum plantations on the northern bank (shown as present in aerial photographs dated 14 May 1976) had been eradicated by July 1977 and the area is destined to be planted under sugar cane. All gum plantations in the area are destined to go the same way (McKinley, pers. comm.).



The Hibiscus tiliaceus fringe on the southern bank of the Mhlali lagoon.

Fauna

Other than a survey of the sand prawn or cracker shrimp (*Callianassa*) done by Cockcroft in 1975 ([86]), there is no information available on the fauna of the Mhlali lagoon. The *Callianassa* were confined to a marginal strip along the northern bank in the lower reaches of the lagoon.

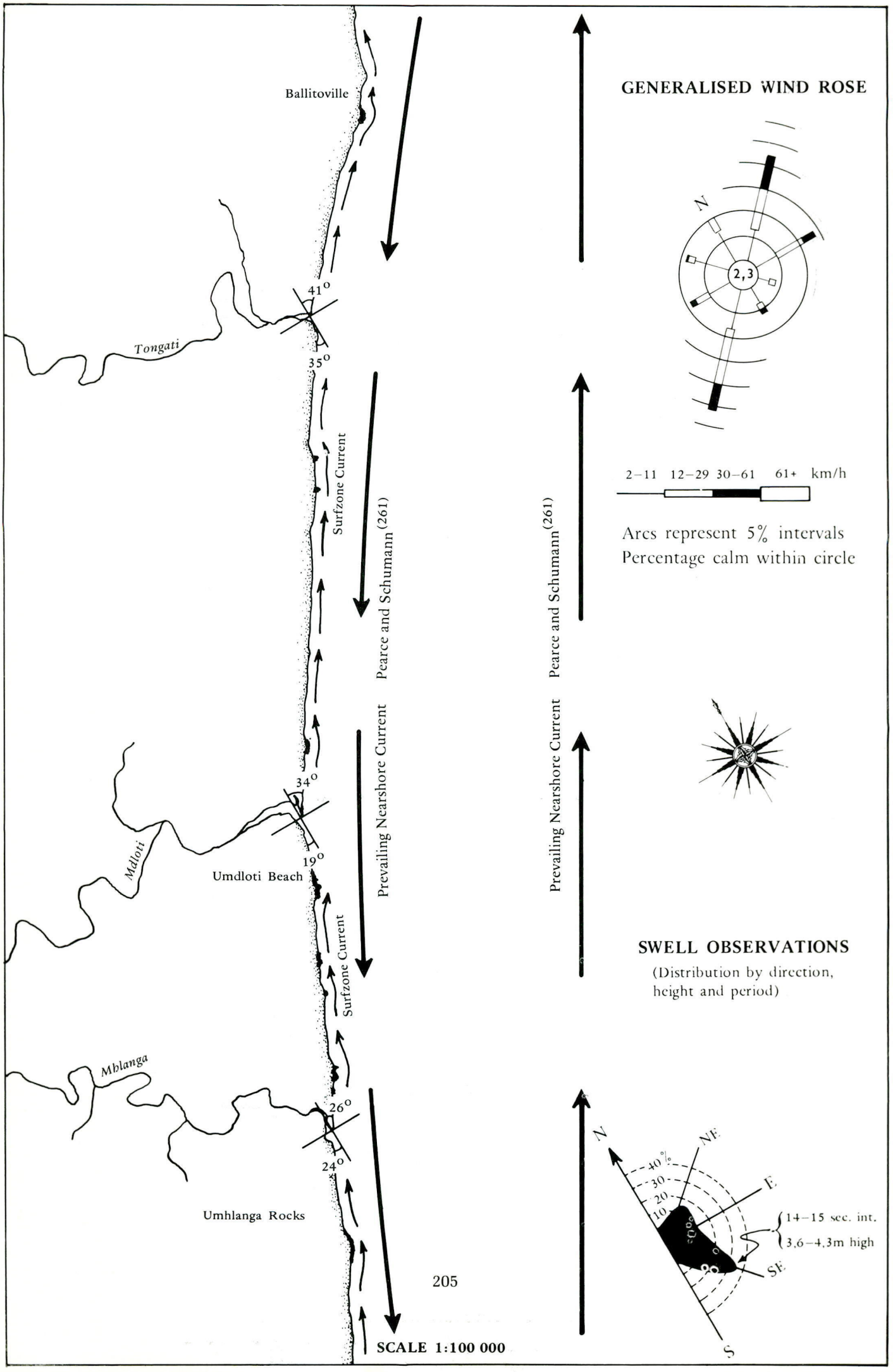
In 1964 the faunal surveys of Brand *et al* ([43]) 2,5 km above the lagoon, revealed reasonably diverse and abundant communities, indicative of slight organically enriched conditions.

SYNTHESIS

Our state of knowledge of the Mhlali lagoon is poor.

Although degraded in its present environmental condition and of no great resource value, a better understanding of what lives in the lagoon would be useful. Problems which reflect themselves in the lagoon (such as siltation and cane encroachment) are entirely sugar cane associated, and weir construction across the headwaters is considered to have ecologically adverse effects.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text.	ABIOTIC																						BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other							Flora			Fauna								Food Webs
MHLALI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																									←	★	→						
Source of Information	Summary of available information																																		
Brand *et al*	1964	43	●		●			●			○					○										○	○							
Midgley & Pitman	1969	223	●		●																													
Chew & Bowen	1971	78	●		●			●																										
Orme	1971	257	●		●					●													●											
Cockroft	1975	86		●		●																					●							
Aerial photos (Scogings)		No.																																
1:10 000 Job No. 250	1976	93		●						●														●										
1:25 000 Job No. 251	1976	468	●																															


Ballitoville
41°
Tongati
35°
Surfzone Current
Pearce and Schumann (261)
Prevailing Nearshore Current
34°
Mdloti
19°
Umdloti Beach
Surfzone Current
Mhlanga
26°
24°
Umhlanga Rocks
GENERALISED WIND ROSE
N
2,3
2–11 12–29 30–61 61+ km/h
Arcs represent 5% intervals
Percentage calm within circle
Pearce and Schumann (261)
Prevailing Nearshore Current
SWELL OBSERVATIONS
(Distribution by direction, height and period)
N
NE
E
SE
S
40%
30
20
10
14–15 sec. int.
3,6–4,3m high
SCALE 1:100 000

2.1.7.1 **TONGATI**

Synonyms

Tongaat (most commonly used synonym);
Tongaati; Thongathi; Umtongate (from maps dated 1850 in Natal Archives).

Zulu meaning

inTongati means "to us, it is something" (Parkhouse, pers. comm.).
Various meanings are given by Stayt ([289]):

(1) the twisting river;
(2) a river named after Chief Thongasi of the Shu-Shu Tribe;
(3) the place of the Thonga (*Strychnos mackensi*) trees.

Location

29°33'S; 31°11'E.

Accessibility

The Tongati lagoon is 35 km north east of Durban. Access down to the water's edge is limited to a few footpaths.

Bridges.

The national road crosses the lagoon 100 m from the mouth. The bridge of the North coast freeway is to be located well upstream.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 370 km^2 ([43]); 399 km^2 ([78, 257]); 413 km^2, 468 km^2 ([223]).

River length. 40 km ([43]) to 60 km ([78]).

Mean annual run-off. 84,8 x 10^6 m^3 ([223]) to 92,7 x 10^6 m^3 ([78]).

Flow. From a gauging station at Maidstone (thus representative of two-thirds of the total flow) the annual average flow is given as 2,18 m^3/sec. ([78]). The seasonal average flow is greater than 2,4 m^3/sec. for summer and less than 1,2 m^3/sec. for winter ([43]). Additional seasonal, monthly and daily flow data from 1960 to 1970 is available from Bosch & Associates (Schmidt, pers. comm.).

Flood history. The highest recorded flood level is shown as ±3 m above mean sea level ([257]). The 1953 floods were estimated to discharge 934 m^3/sec. (Schmidt, pers. comm.). In 1958 and in 1976 floods of a similar magnitude were encountered.

Dams.

Existing: Two dams exist on a tributary named the Wewe river. These were built by the Tongaat Group to supply Maidstone Mill, as well as for domestic and irrigation use. They are:

(a) Dudley Pringle Dam (capacity 2,31 x 10^6 m^3);
(b) Siphon Dam (capacity 0,35 x 10^6 m^3).

Proposed: A dam has been proposed at a site called Doornkloof ([78]). The latter will also receive water diverted by a tunnel from the Mona river (another tributary).

Siltation. Very little quantitative data exists. During the peak of the floods in March 1977 the percentage of suspended sediment in the Tongati river was ,23% (Schmidt, pers. comm.). However, the system is obviously silted up, probably as a result of sugar cane cultivation, the Bantu influenced catchment and bank erosion. Aerial photos taken in May 1976 show badly eroding canefields immediately south of the lagoon. Earthworks associated with the construction of the La Mercy airport have also generated much silt, which has found its way into the river system (Parkhouse, pers. comm.). It has been proposed that the Tongati river be diverted, to short circuit a large meander in the river immediately below Tongaat township; this being necessary to accommodate an expansion to the Dores Flats industrial area. Such a diversion

would lead to accelerated rates of siltation downstream, whilst the river re-establishes its bed levels. Velocities would increase which in turn would increase the soil carrying capacity of the water. Increased rates of siltation in the lagoon would occur.

Land ownership/use. 44% of the catchment area is Bantu influenced (comprising parts of the Umvoti location) and is to become incorporated into KwaZulu in the near future. All other land is owned by the Tongaat Group and used for the growing of sugar cane. The township of Tongaat, 10 km above the lagoon, has an estimated present population of 30 000 (Parkhouse, pers. comm.) made up principally of Asiatics. Important industries include sugar refining and textiles both of which have pollution potential.

The lagoon is surrounded by sugar cane. To the south is the settlement of Tongaat Beach, which on a fine day may be visited by 15 000 people (Parkhouse, pers. comm.). Mr C. Saunders owns the land which presently supports coastal forest south of the lagoon

1 km to the north lies the remains of Port Zimbali — a prospective township development by Glen Anil.

Local authority. Tongaat Town Board.

Estuary use. None, although the mouth of the system is a particularly popular bathing area for Asiatics and Bantu. In 1972 the Tongaat Group had plans for damming the Tongati river to develop a water related recreational amenity (Parkhouse, pers. comm.).

Morphometry of the lagoon. (see Fig. **44**)

Area. 7,6 ha.

Axial length. 2,0 km

Shoreline length. 4,7 km

Width.
Maximum: 150 m
Channel: 10 m during normal, low flow periods, a feature confirmed by the measurements of Davies (pers. comm.).
Floodplain. 200 m ([257]).

Shape. The shape of the lagoon (as depicted by old maps (dated 1850) in the Natal Archives) was formerly very different and far more extensive. Some remnants of the former lagoon have remained as a tongue of *Phragmites* extending into the canefields on the northern bank.

Bathymetry. From a transect made beneath the road bridge by Davies on an outgoing tide (13 March 1977) depths ranged from 0,65 m to 2,70 m. The lagoon was deepest adjacent to the northern bank.

Geomorphology

Geology ([43, 78]). Table Mountain Sandstone (or Waterberg Sandstone) Granite, Dwyka conglomerates and Ecca shale have been shown to occur in the catchment. Below the lagoon, bedrock of shale, sandstone and dolerite was encountered, sloping down to a maximum of 30 m below mean sea level ([257]).

Nature of bottom materials (see Fig. **45**). Orme ([257]) considers the bottom materials which underlie the lagoon to comprise a "homogenous mixture of fluvial muds and marine sands, becoming less muddy and more sandy towards the north . . ." and concluded that ". . . a comparatively small volume of fluvial debris reaches the mouth . . .". He described the Tongati sand spit "to merge without marked discontinuity into estuarine muds and sands . . ." ([259]). Other than this there is no information on the subject.

Sandbar characteristics. The Tongati sandbar is 150 m long and south extending. It is 30 m to 70 m wide and rises in places to 5 m above mean sea level ([257]). On the southern bank, the mouth opens across a rocky shelf and on the northern bank, a steep sand bank drops into the lagoon. Orme ([259]) considers that tidal effects in the lagoon are diminished because of "weak tidal scour competing with large volumes of sand" being transported by littoral drift.

Breaching is unnecessary since the mouth is very seldom closed, despite the fact that Orme refers to the persistence of the sandbar across the mouth ([257]). Thus the Tongati lagoon

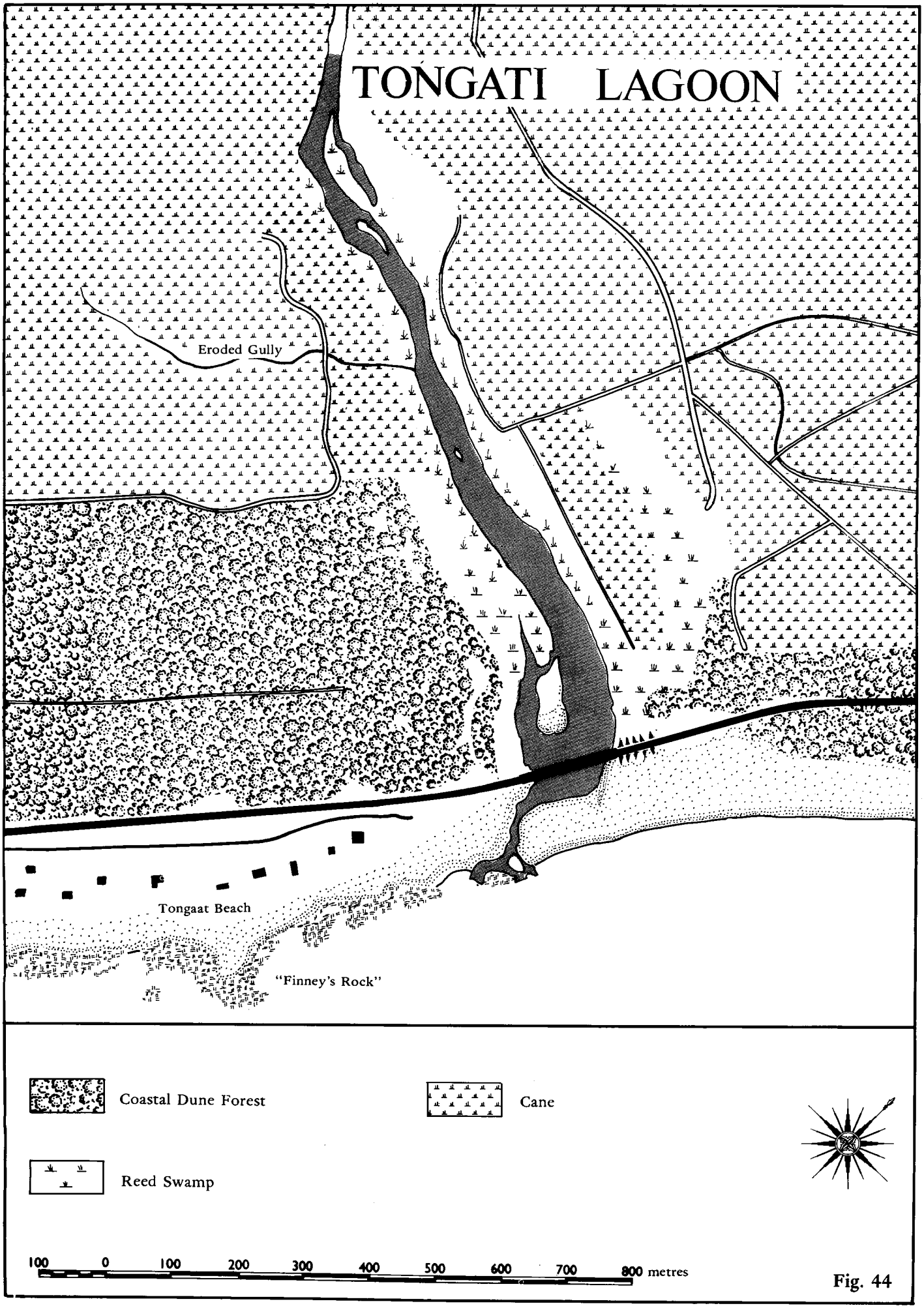

TONGATI LAGOON
Eroded Gully
Tongaat Beach
"Finney's Rock"
Coastal Dune Forest
Cane
Reed Swamp
100 0 100 200 300 400 500 600 700 800 metres

Fig. 44

is atypical in that the perennial flow of the river is sufficient to keep it open. In addition to this, the lagoon opens across a rocky sill which ensures that whatever tidal scour does occur, is effective in removing sand accumulating in the channel.

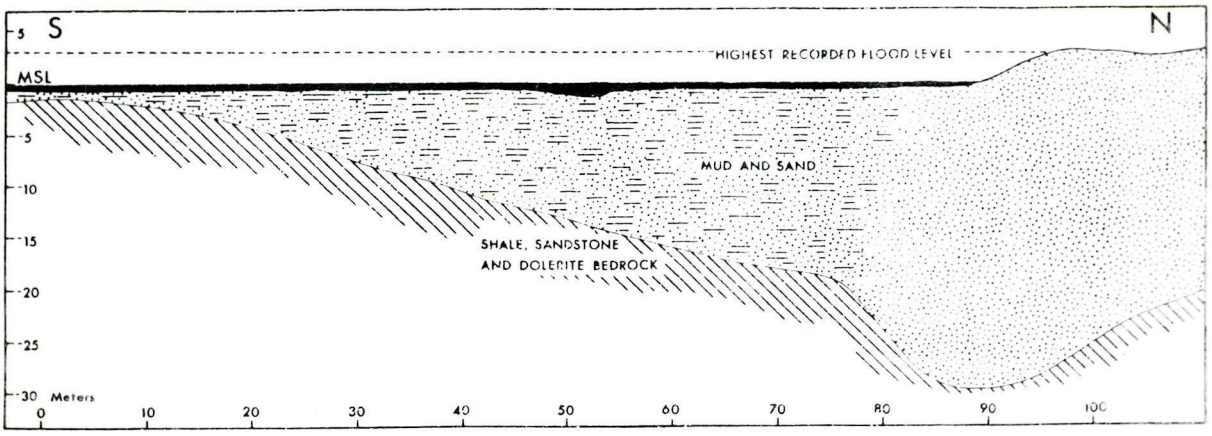


Fig. 45. Cross section through the Tongati lagoon after Orme ([257]).

Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

No information pertinent to the physico-chemical characteristics of the lagoon itself exists. From the results obtained by Brand *et al* from a station 5 km above the lagoon in 1964 (see Table **27**), a deduction as to the expected conditions can be made ([43]).

The river below the Tongaat township was found to be Class VI (i.e. "foul water that is a public nuisance . . .") and in a condition in which it was considered "a matter of urgency that active efforts be made to improve the quality". The river was found to be discoloured right down to the mouth, such that the lagoon contained dark water "quite unlike the lagoons of other rivers along this part of the coast" ([43]). The water smelled, was low in oxygen (3% saturation) and was characterized by a high biological oxygen demand (30 ppm to 40 ppm). Heavy pollution from various sources was apparent at the time (these being the Tongaat Sugar Mill, dunder dams, the mill compound, ash dumps, the Kenaf fibre works, *et al*).



Bright blue textile effluents flowing from the mouth of the Tongati lagoon in June 1968 (photo by A. Gifford).

Table 27 Physico-chemical characteristics. ([43])

Locality: Tongati River Distance above estuary: 5km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	6.4	6.4
Saturated pH value	8.5	8.7
Conductivity micromhos/cm	203	175
Total dissolved solids ppm (calcd.)	147	130
Dissolved oxygen mg/litre	0.2	0.2
% Saturation	3	3
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	39.3	33.2
Kjedahl nitrogen mg/litre	Trace	1.5
Ammonia mg/litre	Trace	0.2
Nitrites mg/litre	.016	Nil
Nitrates "	.11	.07
Phosphates "	.78	.42
Total alkalinity "	57	47.4
Total hardness "	63.4	44.7
Calcium "	13.4	9.1
Magnesium "	7.3	5.3
Sodium "	22	21.6
Potassium "	5.6	5.8
Sulphates "	5.7	3.7
Chlorides "	29.8	29.6
Silica "	22.5	21.0
Iron "	3.3	4.6
Fluorides "	0.8	0.1
Free carbonic acid (as ppm carbon dioxide)	43.1	29.1
Temperature °C	37.0	29.5
Turbidity (ppm silica scale)	12	26
Colour (APHA units)	50	100
Appearance	Foul	Foul, black
Odour		"unpleasant and tarry"

Values underlined significant of disturbance.

Textile effluents from the David Whitehead factory also pollute the river (Davies, pers. comm.). In the past, the lagoon has turned a variety of colours depending on the dye being used at the time. A caustic liquid is pumped along a pipe from the factory into the sea. In recent times, permissible concentrations have been exceeded by a factor of ten (Buckley, pers. comm.). The Department of Water Affairs have insisted on this situation being rectified. Pollution of the Tongati lagoon by alkalis is also commented on by Grindley ([137]).

Today, additional sources with pollution potential in the catchment include a poultry farm, piggery, mushroom farms and drainage from refuse dumps. Increased industrialization is anticipated (Parkhouse, pers. comm.).

Public health aspects.

Bacteriology. No data specific to the lagoon exists. In 1964 Brand *et al* found the main river (see Table **28**) and its tributaries (the Amanzimnyama and Wewe) to be faecally and organically polluted ([40, 43]). At that stage the township of Tongaat was still on septic tanks, pits and bucket latrines. Fibre pollution was also evident (from the Kenaf fibre works which are now closed).

Today 95% of Tongaat is on reticulated water-borne sewage. Treated sewage effluents (from the Hambanati works) and some untreated sewage, still enters the river (Harris, pers. comm.). In the near future, a large sewage works is to be located on the southern bank of the river, 3,5 km above the lagoon. This is to serve Dores Flats, Compensation and extensions to Tongaat.

Table 28 Bacteriology of the Tongati river (5 km above lagoon).

Date	Plate Count per ml x 10^3	*E. coli* I per 100 ml
	5 days @ 32°C	Confirmed
27 February 1964	120	1 700
29 April 1964	5,5	**17 200**
3 August 1964	**3 400**	**3 480**
25 January 1965	240	2 500

Values in bold significant of disturbance.

Bilharzia. There is no evidence to date to suggest that bilharzia occurs in the lagoon or the catchment, although it is highly probable that the host snails do occur.

BIOTIC CHARACTERISTICS

Flora

Only on the southern bank of the lagoon has a patch of coastal dune forest (protected under private ownership) remained intact, and retained its botanical value. Sugar cane encroachment onto the floodplain is particularly severe on the northern bank and upper reaches of the lagoon.

In certain areas *Phragmites* reed swamps have developed. The most significant of these is an area on the northern bank which once comprised part of the lagoon.

Hillary ([187]) studied the plant ecology of the coastal dunes at Tongaat Beach in 1947.

Water hyacinth *(Eichornia)* occurs sporadically within the lagoon (pers. obs.).

Fauna

Virtually no information exists on the fauna of the Tongati lagoon. Brown ([54]) mentions *Neritina gagates* (gastropod) as being present at an unspecified date in the past.

From the results of Brand *et al* in 1964 (from a point 5 km above the lagoon) the meagre bottom fauna, and numerical dominance of certain species, were indications of a community tolerating "moderate to heavy pollution, with possible toxicity . . ." ([43]).

Although fishing in the lagoon was once of an "unsurpassed standard" (the late Dr. Helm, pers. comm.) — such characteristics are unheard of today. Deterioration in the fishing and

occurrence of various other forms of estuarine life in the lagoon, has been described as "chronic" by local residents.

Some utilization is made of the island-like sandbank upstream of the road bridge, by terns. On 16 January 1977 Nicholls (pers. comm.) counted 800 common terns in this locality. However, in all only five species of estuarine dependent birds have been seen to utilize the lagoon.

SYNTHESIS

The present poor understanding of the Tongati lagoon is to a certain extent a result of the degraded, polluted state of the system. This is because in such a condition any desire to work there is lacking. However for pollution control purposes, attention should be drawn to the Tongati, with a view towards eliminating the causes.

In its present environmental condition the Tongati lagoon is of no resource value and exhibits several problems all related to catchment utilization. These are a potentially toxic degree of industrial pollution, the likelihood of receiving increased volumes of treated sewage effluent in the future, proposed river diversions upstream, sugar cane encroachment and inevitably siltation.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora		Fauna								Food Webs
TONGATI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids											←		★		→																
Source of Information	Summary of available information																														
Hillary	1947	187																					●								
Bosch & Associates	1960 to 1970	pers. comm.			●					●																					
Brand *et al*	1964	43	●		●			●			○				○										○						
Brown	1964	54																								●					
Brand	1965	40													○																
Midgley & Pitman	1969	223	●		●																										
Grindley	1970	137									●																				
Chew & Bowen	1971	78	●		●																										
Orme	1971	257, 259	●		●					●																					
Nicholls	1977	pers. comm.																									●				
Davies	1977	pers. comm.		●																											
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 250	1976	73		●						●													●								
1:25 000 Job No. 251	1976	476	●																												

Synonyms
Umdloti; Umhloti ([345]); Mhloti; Mdhloti.

Zulu meaning
Various meanings are given to the word mDloti ([289]) :

(a) the plough share;
(b) the violent river;
(c) the river of the bitter, wild tobacco plant.

Location
29°38'S; 31°08'E.

Accessibility
The Mdloti lagoon is 25 km north east of Durban. Access to the mouth is through the township of Umdloti Beach, which lies immediately south of the lagoon. There are also tracks which lead to the northern end of the sandbar and along the edge of the floodplain to the upper reaches of the lagoon. The La Mercy International Airport is under construction within a few kilometres of the lagoon.

Bridges
The national road crosses the lagoon on a bridge 500 m from the mouth. Associated with it is a 250 m long embankment across the Mdloti floodplain. Consequently old channels on both the southern bank and the northern bank have been infilled and lost to the system. This is clearly seen when the present morphology of the lagoon is compared to that shown in maps (dated 1850) in the Natal Archives.

In the near future a bridge for the north coast freeway is destined to be built across the head of the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics

Area. 481 km^2 ([43]); 497 km^2 ([78, 257]); 550 km^2 ([287]); 704 km^2 ([223]).

River length. 74 km ([43]) to 88 km ([78]).

Mean annual run-off. 97 x 10^6 m^3 ([287]); 105 x 10^6 m^3 ([78]); 134 x 10^6 m^3 ([223]). Records show that during the season 1963/1964 to 1968/1969 run-off was the lowest on record ([287]).

Flow. The Mdloti river flows perennially ([287]). The mean annual average flow is given as 2 m^3/sec. ([43]) to 2,5 m^3/sec. ([78]). These figures are representative of three-quarters of the total flow due to the position of the gauging station. The lowest daily flows in 1951/1952 were ,34 m^3/sec. ([43]). The maximum flows recorded were 5 m^3/sec. on 14 December 1964. Additional flow information can be obtained from ([345]) and ([346]).

Flood history. For design purposes, the probable maximum flood has been estimated to be 4 130 m^3/sec. ([287]). Flood scour to depths of 4 m within the bottom materials, is evident ([257]).

Dams.
Existing. The Hazelmere dam is situated 20 km above the lagoon and has a total capacity of 24 x 10^6 m^3 ([287])

Proposed: A dam site at Inanda has been located 45 km above the lagoon ([78]).

Siltation. The annual silt load has been estimated to be 0,15% of the mean annual run-off (i.e. 51 920 m^3/year ([287])) and silt accumulation in Hazelmere dam to be, 105 x 10^6 m^3/year. The highest percentage sediment concentration determined for the Mdloti river was 0,87% (on 8 December 1964) when the flow was ,82 m^3/sec. ([345]). The total suspended sediment load determined for December 1964 was 2 399 tons ([345, 346]).

Siltation arising from the earthworks associated with the construction of the La Mercy International Airport, has been severe in recent years (Parkhouse, pers. comm.).

Land ownership/use. The state of the natural vegetation in the upper catchment is poor, due to overstocking ([287]). It is rugged, hilly country comprising the Inanda Bantu Reserve, and practically uncultivated. 68% of the catchment is destined to become incorporated into KwaZulu in the near future. Also within the catchment, is the Oakford Priory Mission and Verulam (an Indian township) with a present population of 20 000 (Naicker, pers. comm.). Verulam is 9 km above the lagoon.

Around the lagoon are cane farms owned by the Tongaat Group. To the south of the lagoon is the township of Umdloti Beach with a present population of 530 and influxes of ±1 000 people during holiday seasons. The newly developed La Mercy township lies north of the lagoon.

Amongst the various ideas proposed for the development of the southern bank (by Messrs Hargovan and Desai) are the construction of a Holiday Inn type hotel, filling station and drive-in cinema. Power-boating is envisaged on the lagoon as well as the building of a waterfront restaurant elevated on stilts (Smaill, pers. comm.).

Local Authority

	To seaward of national road bridge	Inland of national road bridge
South Bank:	Umdloti Beach Health Committee.	Development and Services Board.
North Bank:	Mr Hargovan	Mr K. P. Desai

The Mdloti lagoon is a classical example of a tangle of who owns what.

Estuary uses. Besides the odd Indian angler and the occasional boat and canoe launched for exploratory purposes, no other use is made of the Mdloti lagoon. Water from the Mdloti river is used for domestic (Verulam, La Mercy), industrial (Timberit factory) and irrigation (Tongaat Sugar Co., Natal Estates) purposes.

Morphometry of the lagoon. (see Fig. **46**).

Area. 13,6 ha.

Axial length. 1,5 km.

Shoreline length. 6,5 km, a figure significantly increased by the main channels which bifurcate around a 4 ha island. There are also several side channels which add to this dimension.

Width.
Maximum: 380 m
Channel: during low flow periods, 15 m to 20 m.
Floodplain: 600 m ([257]).

Bathymetry. On 21 May 1978, the deepest point located in the lagoon was 2,5 m (pers. obs.).

Geomorphology

Geology. The river traverses Archaean Granite (Gneiss), Table Mountain Sandstone, Dwyka conglomerates (tillites), Ecca shale and recent deposits in its drainage basin ([43, 78]). Borehole data reveals bedrock at 31 m to be Ecca sandstone ([257]). Maud ([219]) makes mention of a marine platform at the Mdloti lagoon 5,8 m above sea level, carrying on it an old oyster bed.

Nature of bottom materials (see Fig. **47**). Orme describes these as "typical estuarine deposits, representing deposition in a tranquil lagoon", and points out that there is a distinct lack of any appreciable scour. The first 2 m of the Mdloti deposits are made up of fine sand. Below these is coarse fluvial sand and lenses of mud and clay ([257]).

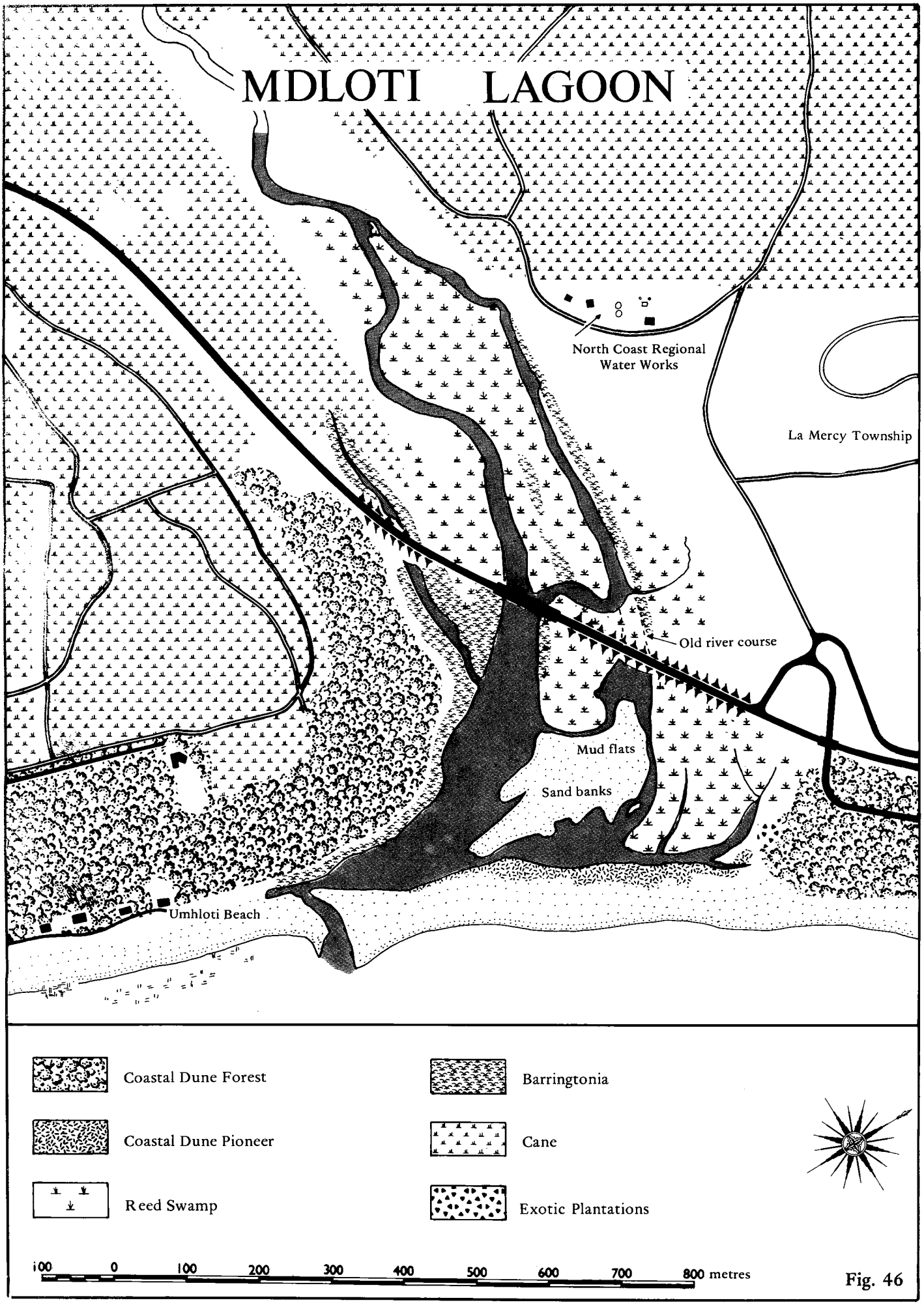

MDLOTI LAGOON
North Coast Regional Water Works
La Mercy Township
Old river course
Mud flats
Sand banks
Umhloti Beach
Coastal Dune Forest
Coastal Dune Pioneer
Reed Swamp
Barringtonia
Cane
Exotic Plantations
100 0 100 200 300 400 500 600 700 800 metres

Fig. 46

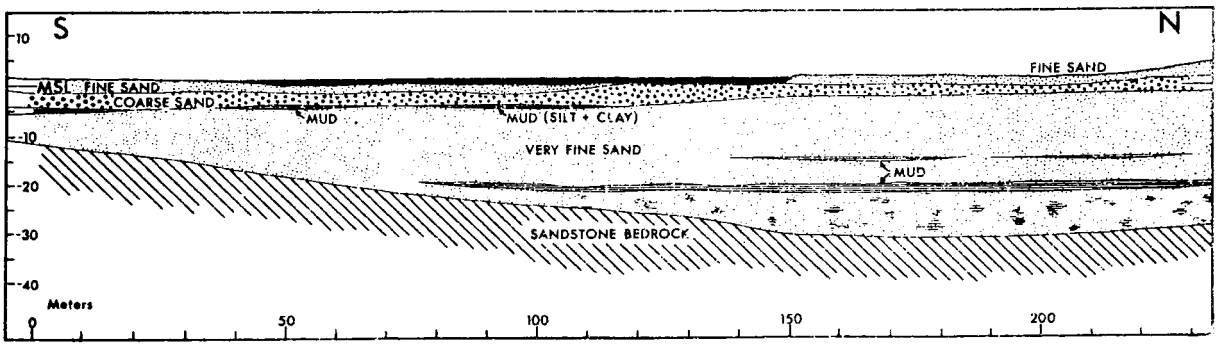


Fig. 47. Cross section through the Mdloti lagoon, after Orme ([257]).

Sandbar characteristics. The Mdloti sandbar is 600 m long and south extending. 400 m of the bar is well stabilized by *Scaevola*. The bar is due to become part of an African bathing beach.

If permitted to do so, the mouth opens across rocks in the extreme south of the system although Orme ([257]) suggests the mouth position changes considerably. The crest of these rocks is at such a level that the lagoon, when open in a southerly position, never empties itself completely.



A rocky sill at the southern end of the Mdloti sandbar prevents the lagoon from draining itself completely (photo by C. Sheppard).

Breaching: The bar is breached artificially at various times of the year by sugar farmers, when water levels in the lagoon rise too high. The breach position is central. The channel is cut into pure sand so that it becomes deep and wide, to ensure the maximum long term benefit of emptying the lagoon (see Section 3.2.4). Most of the lagoon is above mean sea level which means it empties almost completely. When the bar is breached the stench of organic materials that have been decomposing on the bottom (typical of a sugar cane influenced system) becomes almost overpowering, as such materials are disgorged into the sea (Sheppard, pers. comm.).

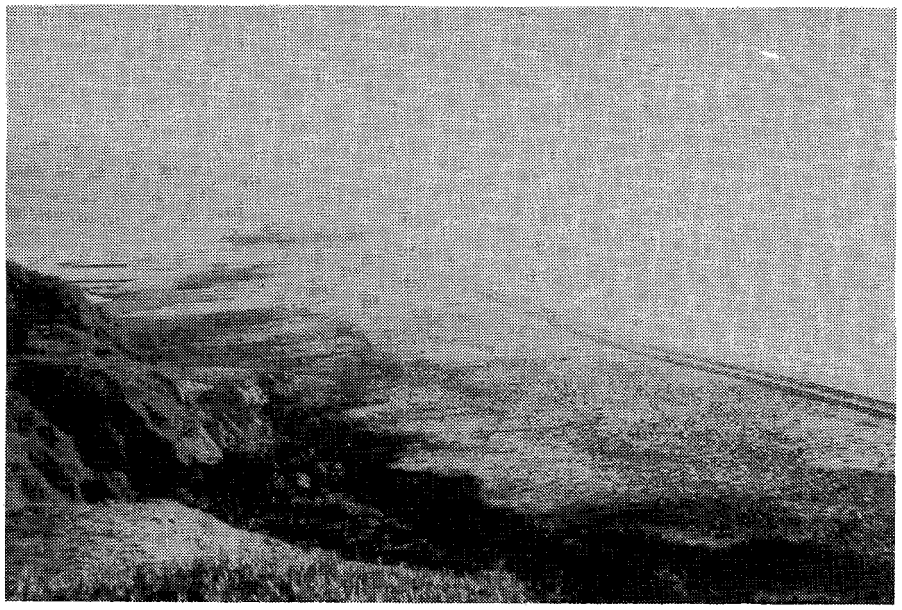
Configuration of the adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

There is no information available which is specifically from the lagoon itself. However in

1964, at a point 3 km above the lagoon, the water was considered to be in "fairly good condition" ([43]) (see Table **29**). Several potential sources of pollution occur in the vicinity of Verulam. Worst of these are the effluent ponds (26 ha in extent) of the African Building Board Corporation (who produce Timberit and Masonite from gumwood). Seepage from these ponds into the river is suspected and on occasions a retaining wall has been known to collapse after floods. On 29 March 1977, a fish kill in the lagoon was attributable to such an event. Several effluent pipes from septic tanks drain into the river, as well as the effluent from the "Packo" meat canning factory ([43]).



A photograph of the Mdloti lagoon being drained artificially through the centre of the sandbar (photo by C. Sheppard — March 1977).

Public health aspects

Bacteriology. There is no information available on this subject which is specific to the lagoon itself. However, in 1964, at a point 3 km above the lagoon, "conditions appeared normal for a river of this nature" ([43]) (see Table **30**). Above this point (nearer Verulam) conditions were far less satisfactory. Several sources of faecal pollution (the village of "Canelands", effluent from septic tanks, and the Oakford Priory) were evident. Moderate organic pollution of the river system was also apparent from the survey.

The construction of a new sewage works immediately above the lagoon (on the northern bank) has been proposed. This is necessary to serve the La Mercy Airport, La Mercy township and Umdloti Beach. The implications are obvious.

Table 30. Bacteriology of the Mdloti river (3 km above lagoon).

Date	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml
	5 days @ 32°C	Confirmed
12 February 1964	9	**5 950**
22 April 1964	**240**	500
3 August 1964	**2 300**	330

Values in bold significant of disturbance.

Bilharzia. No record.

Table 29. Physico-chemical characteristics ([43]).

Locality: Mdloti River Distance above estuary: 3km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.6	7.6
Saturated pH value	8.4	9.4
Conductivity micromhos/cm	294	272
Total dissolved solids ppm (calcd.)	189	178
Dissolved oxygen mg/litre	6.4	9.5
% Saturation	<u>78</u>	107
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	0.6	0.8
Kjedahl nitrogen mg/litre	Trace	Nil
Ammonia mg/litre	Trace	Nil
Nitrites mg/litre	.007	Nil
Nitrates "	.10	.22
Phosphates "	.10	<u>.74</u>
Total alkalinity "	84.6	79.1
Total hardness "	70.4	66.1
Calcium "	12	11.8
Magnesium "	9.8	8.9
Sodium "	40	36
Potassium "	1.9	2.1
Sulphates "	7.8	6.0
Chlorides "	44.7	43.8
Silica "	20.4	19.8
Iron "	0.3	0.2
Fluorides "	0.9	0.2
Free carbonic acid (as ppm carbon dioxide)	4.0	3.1
Temperature °C	26.0	22.0
Turbidity (ppm silica scale)	7	17
Colour (APHA units)	30	55
Appearance	<u>Poor</u>	Fair
Odour	-	-

Values <u>underlined</u> significant of disturbance.

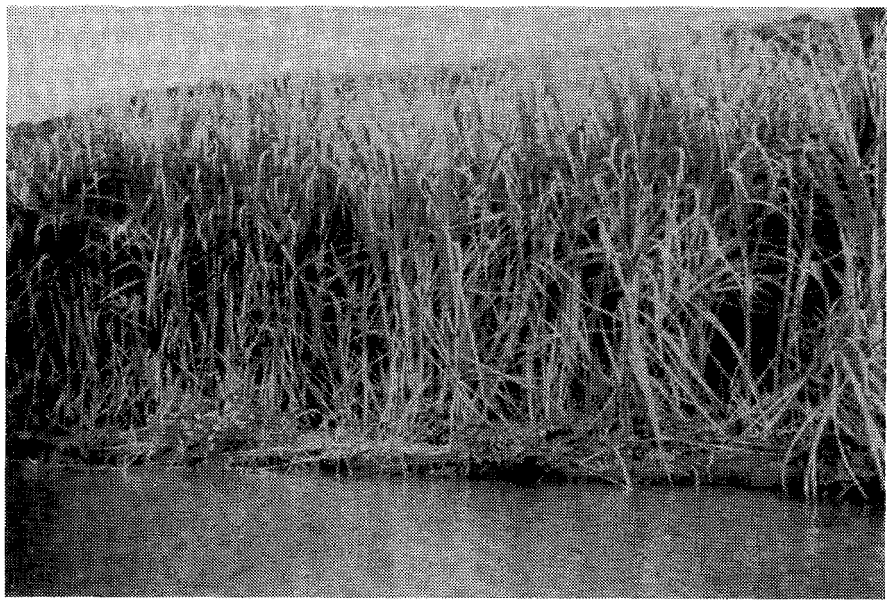
BIOTIC CHARACTERISTICS

Flora

One of the most impressive botanical characteristics of the Mdloti lagoon (on its southern bank) is a dense and flourishing fringe of *Barringtonia racemosa*. Above this is a hillside of well preserved coastal dune forest.

On the northern bank (seaward of the road) *Casuarina* has been planted.

Most of the floodplain is intact, due to a substantial proportion being under *Barringtonia*/*Phragmites* swamps. Some halophilous communities (e.g. *Juncus*) occur on semi-exposed mudflat areas adjacent to the water's edge. However cane encroachment from the southern bank onto the head of the lagoon is noticeable.



Sugar cane planted alongside the upper reaches of the Mdloti lagoon entitles farmers to open the lagoon as soon as the crop becomes flooded (21 May 1978).

Fauna.

Other than that on birdlife, there is very little information available on the fauna of the Mdloti system. In 1964, sampling of the river 3 km above the lagoon ([43]), revealed "normal" results indicative of an only slightly enriched environment.

Fish. Wager (pers. comm.) has seen juvenile eels massing at the foot of the Hazelmere dam. These must therefore have passed through the lagoon after entering it from the sea.

From the fish species killed in the lagoon on 29 March 1977 by pollution from the Timberit factory, the following were identifiable: various Mugilidae (mullet), *S. mossambicus* (bream), *Leiognathus equulus* (slimy), *Acanthopagrus berda* (river perch) and *Pomadasys commersoni* (spotted grunter) (Joubert, pers. comm.).

Birds. An impressive amount of estuarine birdlife is normally associated with the Mdloti system. From the results of Sinclair, Nicholls and Joubert (pers. comm.), 66 species have been recorded over a five year period, at the Mdloti lagoon. It is particularly well used by sea birds for bathing, preening, drinking and resting after feeding at sea. The sandbanks and mudflats (when exposed) are important roosting sites, and up to 10 000 Common terns have been seen to utilize them on some occasions. This species and Grey-headed gulls are commonly present. A large variety of waders and piscivorous birds have been seen in addition to species such as Egyptian and Spurwing geese and Yellowbill and White-faced whistling duck.

SYNTHESIS

Other than information on hydrology and on the birdlife of the Mdloti lagoon, our state of knowledge is poor, which is a situation that should be rectified.

Although degraded in various ways, the Mdloti lagoon appears to be worth protecting, largely because of existing features such as its *Barringtonia* (a swamp forest community), and its birdlife. Protection of such a system must be seen in the light of its present condition in

comparison to similar lagoons adjacent to it. The Mdloti lagoon then emerges as one of the better ones.

Estuarine problems occuring are:

- siltation;
- cane encroachment;
- periodic influxes of industrial pollutants;
- impacts associated with the construction of the roadbridge; and
- potential problems, such as eutrophication, once the new sewage works immediately upstream become operative.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC										
			Physio-graphy	Physics				Geomor-phology			Chemistry				Bacteriology	Other							Flora			Fauna								Food Webs
MDLOTI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																						←★→		←★→									
Source of Information	Summary of available information																																
Stott (Natal Archives)	1850			●																													
Brand *et al*	1964	43	●					●			○				○										○	○							
Wylie	1966 to 1967	345, 346			●					●																							
Maud	1968	219							●																								
Midgley & Pitman	1969	223	●		●																												
Chew & Bowen	1971	78	●		●			●																									
Dept. of Water Affairs	1971	287	●		●																												
Orme	1971	257	●		●			●		●																							
Nicholls, Sinclair and Joubert	1972 to 1977	pers. comm.																									●						
Joubert	1977	pers. comm.																								●							
Smaill	1978	pers. comm.																	●														
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 250	1976	60		●						●													●										
1:25 000 Job No. 251	1976	481	●																														

2.1.7.3 **MHLANGA**

Synonyms

Umhlanga, Umslanga (map dated 1850 in Natal Archives). Use of the name Ohlanga (as on the 1:50 000 sheet 2931 CA) has deliberately been avoided because it is never used locally. Adoption of the name Mhlanga (as on the 1:250 000 series 2930) is recommended.

Zulu meaning

"(e)mhlanga" is said to mean "the reedy place" ([289]).

Location

29°42'S; 31°06'E.

Accessibility

By road the Mhlanga lagoon is 17,5 km (given as 25 km in ([86])) north east of Durban. Despite its proximity to the City, vehicular access is restricted and pedestrians confined to a few footpaths which lead to the edge of the lagoon in several places.

Bridges

The main national road crosses the lagoon on a bridge 200 m inland from the coast, although it is 750 m from the mouth itself. Approximately 250 m of the road has been built upon a causeway across the floodplain, and a loss of what was formerly water area has resulted.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 85 km ^{2}([43]); 124 km ^{2} ([78, 257]); 196 km ^{2} ([223]).

River length. 28 km ([78]).

Mean annual run-off. 19,7 x 10 ^{6} m ^{3} ([78]) to 29,5 x 10 ^{6} m ^{3} ([223]).

Flow. There is no gauging weir on the river, but estimates made in 1964 ranged from .02 m ^{3}/sec to 1,75 m ^{3}/sec. The average flow has been estimated to be .28m ^{3}/sec ([43]).

Flood history. Despite its small catchment, the river has been reported to rise to "remarkable heights" ([227]). In 1953 floodwaters rose to the level of the bridge, which means they were 2,4 m higher than the normal high tide mark. They broke through the sandbar at the point where the system deflects through 90° towards the south, forming a completely new, temporary mouth ([227]).

Dams.

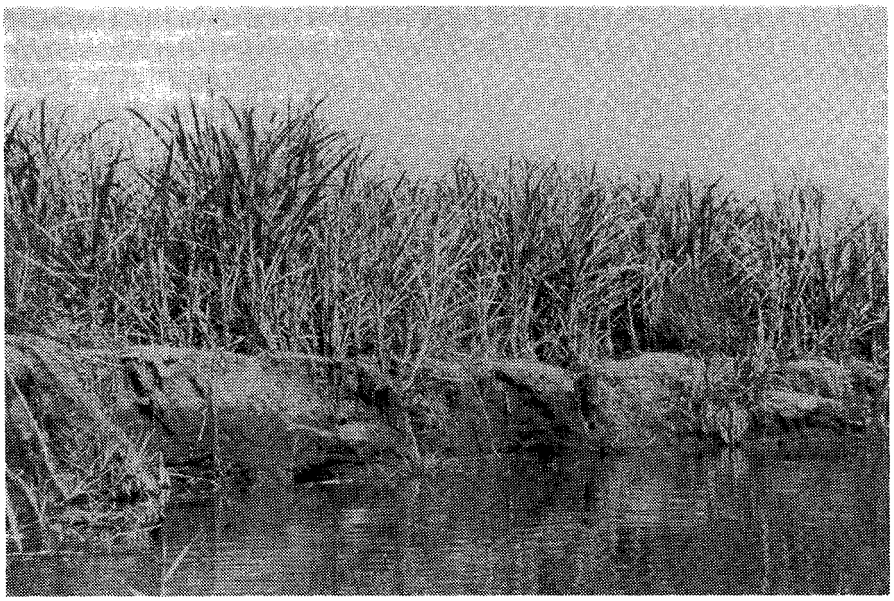
Existing: Nil.

Proposed: The river system was considered as unsuitable for dams because of low flows and the lack of a good storage site ([78]). Hulett's Property Division have, however, considered building a dam immediately upstream of the existing road bridge over the lagoon. At one stage they envisaged three such dams as part of their development proposals (Voss, pers. comm.).

Siltation. No quantitative estimates are available. Although Whitfield (pers. comm.) considers soil erosion in the Mhlanga catchment to be minimal because of "the modern farming methods practised by Natal Estates", early descriptions (see under estuary morphometry) ([324]), suggest the opposite. Apart from sugar canefields, freeway construction is another source from which silt has emanated more recently (Ward, pers. comm.) ([178]).

Land ownership/use. Apart from the Indian residential area of Ottawa and 15,2% of the upper catchment which is destined to become incorporated into KwaZulu in the near future, virtually the whole catchment is used for the cultivation of sugar cane by Natal Estates. The catchment is free of industrial development.

The Borough of Umhlanga, with a population of 9 000 in 1977 (Watson, pers. comm.), lies 1 km south of the lagoon. On the southern bank is the Hawaan forest, also owned by Natal Estates.



Sugar cane encroachment onto the edges of the Mhlanga river (19 April 1977).

North of the lagoon (but inland of the national road) are the sugar cane lands of Natal Estates. Seaward of the national road, the lower reaches of the lagoon are privately owned by the Anglo American Corporation. The Natal Parks Board have been asked to consider taking over this area (Watson, pers. comm.) after the conclusion of a land exchange agreement between the Anglo American Corporation and the Borough of Umhlanga. A strip of dune forest which runs towards Umdloti beach, is leased by Natal Estates to Dr G. D. Campbell. When this lease expires, Hulett's Property Division have plans to develop the land as a country club (Voss, pers. comm.).

Local authority. The lagoon is at present privately owned by the Anglo American Corporation and Natal Estates.

Estuary uses. Picnicking and angling by non-Europeans are the principal ways in which the lagoon is presently utilised. It is also used for water skiing and bait (in the form of sand prawns) is collected from the lagoon. Relatively recently it was proposed that the Mhlanga lagoon be opened to the sea, dredged and developed as "Marina Natalia", with facilities for 900 boats (including cruisers, ski-boats and keel boats). The proposal was considered to be unfeasible from both an economic and engineering point of view, as well as being ecologically damaging.

Morphometry of the lagoon. (see Fig. **48**).

Area. 11,4 ha. The lagoon was formerly much larger in water area and as recalled by Campbell ([324]) . . . "It was the draining of a vast swamp area (for planting cane) at the head of the lagoon which spelt its doom, causing the rapid silting of the deep areas, and the extensive growth of reeds which previously had been held in check by the inflow of tidal, salty water".

Axial length. 2,2 km although considered to be 0,5 km long by Cockcroft ([86]) and 1,6 km long by Orme ([157]).

Shoreline length. 5,3 km.

Width.
Maximum: 90 m to 100 m.
Channel: Normally 10 m to 15 m wide but during floods may open up to 100 m or more.
Floodplain: 500 m ([257]) but actually closer to 350 m.

Bathymetry. In most places the lagoon is 1,5 m to 2 m deep. It was 3,5 m deep below the national road bridge in April 1977 (pers. obs.). Several people have drowned at this particular spot (Bradley, pers. comm.). Whitfield (pers. comm.) has recorded depths of 3 m at several points in the lagoon.

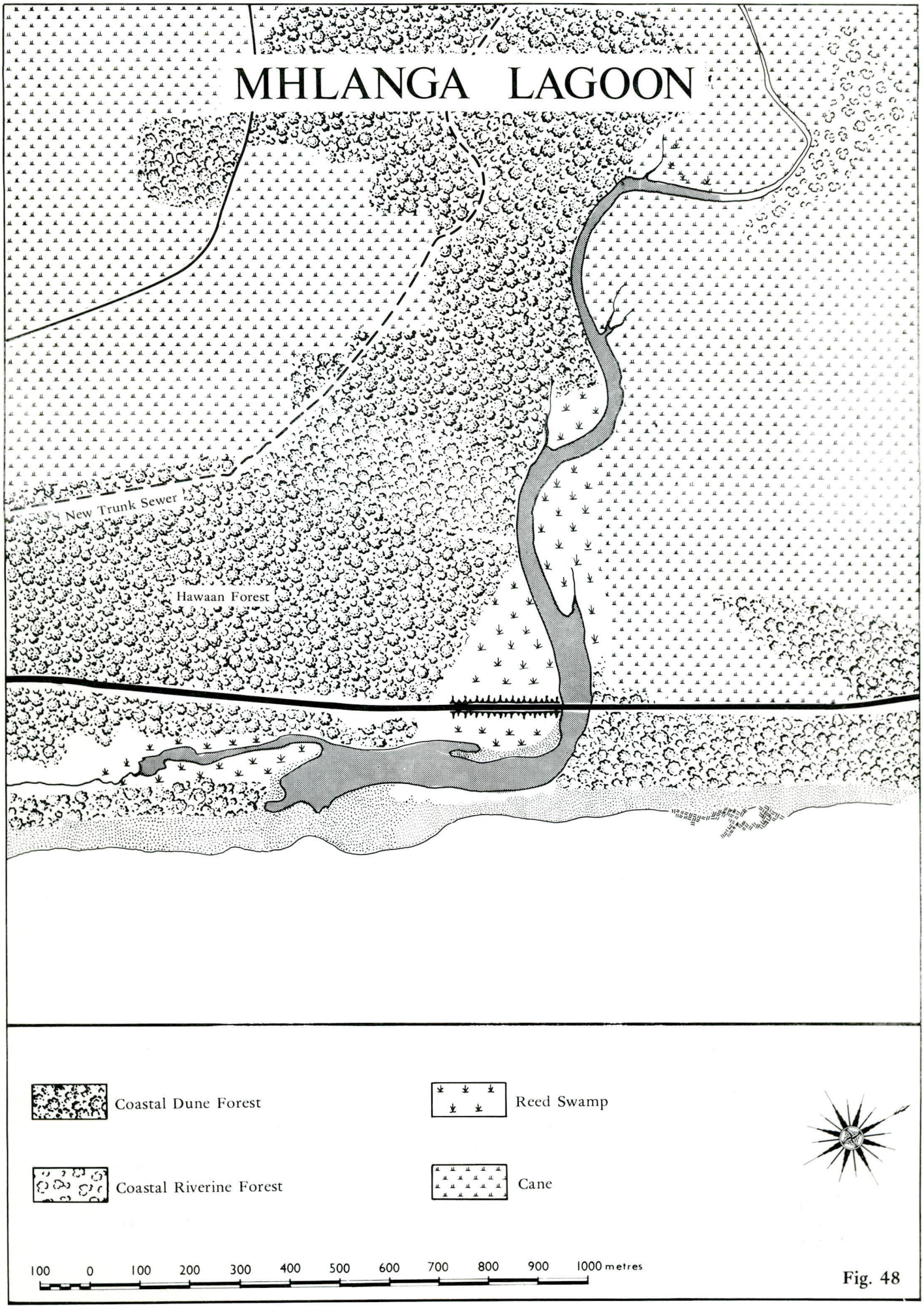

MHLANGA LAGOON
New Trunk Sewer
Hawaan Forest
Coastal Dune Forest
Coastal Riverine Forest
Reed Swamp
Cane
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 48

Geomorphology

Geology. In flowing from its source to the sea, the river traverses Table Mountain Sandstone, Dwyka conglomerates and Ecca shale ([78]). More recent Tertiary sediments surround the lagoon ([43]). Boreholes penetrated to 16,5 m below mean sea level without encountering bedrock ([257]). The area has not been remapped geologically since 1937 (du Preez, pers. comm.).

Nature of bottom materials. These are said to consist of fine sand and fine clayey sand ([257]). There are thick deposits of very soft mud in the deeper parts of the lagoon (Bradley, pers. comm.).

Sandbar characteristics. The sandbar is 500 m long and south extending, with only 200 m of it properly stabilized by *Scaevola*. The tendency for the river to break out directly opposite the national road bridge during severe floods, has already been mentioned. On occasions, the whole bar has been washed away and the sea reported to wash in on a broad front and break on the western shore of the lagoon ([227]). It should be noted that the sandbar is becoming increasingly vulnerable through the destruction of vegetation on the bar ([178]). Geologists at the University of Natal have been monitoring the development of dunes at the Mhlanga lagoon in recent years (Whitfield, pers. comm.). On one position of the sandbar an interesting Iron Age archaeological site (Strandloper shell midden) occurs (Davies, pers. comm.).

The lagoon is breached artificially by Natal Estates once water levels begin to back up into the sugar cane which has been planted on the floodplain.

Configuration of the adjacent shore. No record.

Surf zone currents. No record.



The Umhlanga sewage works are located 2 km above the lagoon. In the background is the Hawaan forest.

Physico-chemical characteristics

The chemistry of the lagoon has never been thoroughly studied. However, some indication as to expected characteristics can be obtained from the analyses of samples taken 2,4 km above the lagoon in 1964 ([43]) (see Table **31**). An outstanding characteristic of the water was the high degree of mineralization, apparent from its conductivity and proportions of chloride and carbonate. It seemed clear that these effects arose from the excessive run-off of water used for irrigation. The water quality of the lower reaches of the system were assigned to be verging on public nuisance levels.

From the salinity measurements made by Cockcroft ([86]) in February 1975, the system can exhibit salinity stratification (7‰ at surface, 32‰ at bottom). In April 1977, surface salinities throughout the system were less than 1‰ (pers. obs.). The Umhlanga sewage works discharge a treated effluent into the river 2 km above the lagoon (Sinclair, pers. comm.). Although the lagoon does not appear to exhibit any of the eutrophic characteristics which would normally result, tertiary treatment should be considered, to minimize the nutrient loading.

Table 31. Physico-chemical characteristics ([43])

Locality: Mhlanga River Distance above lagoon : 2.5km	SUMMER 1964	WINTER 1964	
		during dry conditions	after heavy rains
Hydrogen ion concentration (pH)	7.9	8.0	7.8
Saturated pH value	8.2	7.7	7.9
Conductivity micromhos/cm	615	750	766
Total dissolved solids ppm (calculated)	362	417	384
Dissolved oxygen mg/litre	3.8	9.3	8.9
% Saturation	45	89	85
Biological oxygen demand mg/litre	0.6	1.5	1.1
Kjedahl nitrogen mg/litre	Trace	Trace	Trace
Ammonia "	Trace	Nil	Nil
Nitrites "	0.28	Trace	.020
Nitrates "	.45	.71	.84
Phosphates "	.12	.30	.23
Total alkalinity "	158	244	152
Total hardness "	130	156	137
Calcium "	22.6	25.4	22.1
Magnesium "	17.8	22.7	20.1
Sodium "	79	96	103
Potassium "	1.2	1.2	1.6
Sulphates "	25.7	9.0	11.5
Chlorides "	100	94	113
Silica "	18.8	19.5	17.0
Iron "	-	0.3	-
Fluorides "	-	-	0.1
Free carbonic acid (as ppm carbon dioxide)	3.4	3.3	4.7
Temperature ^{o}C	25.0	13.8	13.5
Turbidity (ppm silica scale)	-	25	22
Appearance	Good	Fair	Fair

* Values underlined significant of disturbance.

Public health aspects

Since the lagoon lies outside the Borough of Umhlanga, the local authority is not particularly concerned about the quality of the lagoon from the point of view of public health.

Bacteriology. No information on the bacteriology of the lagoon is available. Considerable leakage from the old trunk sewer directly into the lagoon, was observed in January 1977 (pers. obs.).

In 1964 the river was found to exhibit only slight organic enrichment ([43]) and faecal pollution was noticeable (see Table **32**) above the sewage works. This seemed traceable to small villages in the catchment. Squatters presently encamped in the dune forest south of the lagoon may also be responsible for some contamination of its waters.

Table 32. Bacteriology of the Mhlanga river (2,5 km above the lagoon).

Date	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml
	5 days @ 32°C	Confirmed
21 April 1964	**350**	300
4 August 1964	50	**7 900**
7 December 1964	—	1 900

Values in bold significant of disturbance.

Bilharzia. *Physopsis* snails were collected in the upper reaches of the Mhlanga river in 1964 ([43]), and Jackson (pers. comm.) found *Physopsis* at several localities in the catchment on 29 July 1970. Staff of the Institute of Parasitology have recovered bilharzia snails from the reeds within the confines of the lagoon itself (Berry, pers. comm.). The discharge of a sewage effluent into the river above the lagoon probably makes conditions particularly favourable for these snails. Consequently one can assume that the Mhlanga lagoon is not bilharzia free.

BIOTIC CHARACTERISTICS

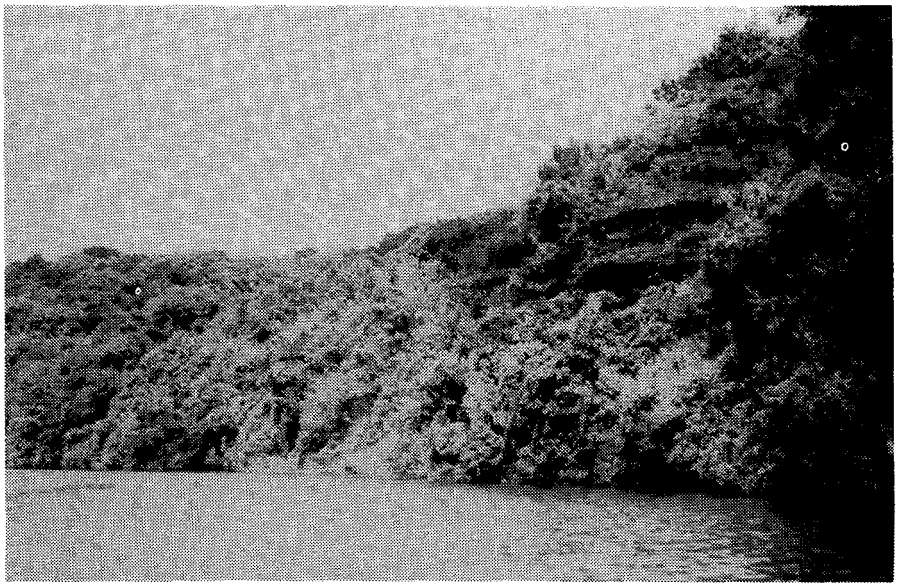
Flora

Algae. During the course of a third-year student project (over the period 12 March 1968 to 22 May 1968) students from the Botany Department, University of Natal, conducted a survey of the phytoplankton of the Mhlanga lagoon under the direction of Prof. R. Pienaar. Their unpublished results revealed details regarding the composition of the phytoplankton and the relative abundance of each species (Pienaar, pers. comm.). Further work of this nature is planned.

Forests. Of major significance alongside the Mhlanga lagoon, is the 50 ha to 60 ha expanse of the Hawaan forest. This is a relic patch of climax coastal forest in which a wealth of plant life occurs, some species of which are exceptionally rare. The Hawaan is the only forest in South Africa to have *Cavacoa aurea* and *Cola natalensis* as dominants ([26, 227, 228, 324]). Within the Hawaan are over 60 species of forest plants, 20 of which are lianes ([26]). It is an area of prime botanical value and has, in the past, been threatened in a variety of ways, including road construction, trunk sewers, salt spray, floods and to a lesser extent fire and tree cutting. Water skiing has been said to cause the erosion of the steep banks below the Hawaan forest.

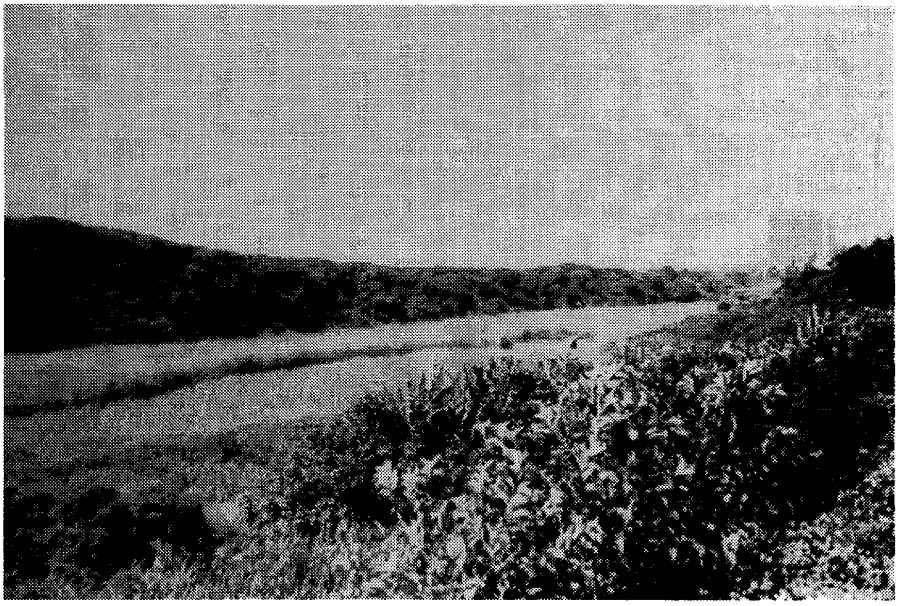
At the coast, the Mhlanga lagoon adjoins a strip of dune forest which runs both south towards Umhlanga Rocks and for 2,5 km north towards Umdloti. Within the latter are situated Meadowbank and Peace Cottage. In this forest community the Red Milkwood *(Mimusops caffra)* is considered important ([324]). Both of these stretches of forest have been threatened by proposed developments. Orme ([260]) came to the same conclusion after surveying the area using colour infra-red techniques.

The lagoon and its surrounds have on a number of occasions been the subject of studies in environmental planning undertaken by the School of Architecture, Natal University. Studies by Phillips (in 1975) and Sheppard *et al* (in 1977) are available.



An impression of the edge of the Hawaan forest alongside the southern bank of the Mhlanga lagoon.

Swamps. Along the edges of the lagoon, a fringe of reeds *(Phragmites mauritianus)* has become an important component of the system. The reeds stabilize the banks as well as act as a buffer in preventing rapid changes in salinity taking place at the base of the Hawaan forest ([227]). They are also an important detritus forming component of the system ([178]). A small colony of mangroves have established themselves, both above, and below the road bridge (Cooper, pers. comm.).



A view of the coastal dune forest in the background, and some of the reedswamps which surround the water's edge.

Fauna

Lower trophic levels.

Zooplankton: Grindley took zooplankton samples from the Mhlanga in 1968, the examination of which has still to be carried out. Whitfield sampled the plankton in May 1977 and showed that densities of plankton in the Mhlanga system exceeded figures obtained from St. Lucia (pers. comm.).

Benthos: Cockcroft ([86]) conducted a study on the sand prawn *Callianassa kraussi* in the lagoon in 1975. It is significant that these animals were confined to a sand bank on the western shore. Whitfield considers the presence of this population to be an indication of low silt volumes. 2,5 km above the lagoon the benthic community was (in 1964) not particularly diverse or numerous, and dominated by Chironomid larvae ([43]).

Fauna of marginal vegetation: This niche was dominated by *Simulium* 2,5 km above the lagoon in 1964 ([43]). Bilharzia snails have been collected amongst reeds in the lagoon and crab life is prolific (pers. obs. 19 April 1977). In earlier days Campbell recalls taking swimming prawns in hand nets at night ([324]).

Higher trophic levels.

Fish: In 1975 Wallace ([329]) showed by netting that juveniles of eight of the main species of estuarine fish in Natal were present in the Mhlanga lagoon. In May 1977 Whitfield (pers. comm.) showed there to be a minimum of 15 species present and also drew attention to the large number of juveniles. Much earlier than this Campbell recalls that "all types of fish were plentiful" and specifically mentions bream, grunter and rock salmon ([324]). Campbell periodically seine nets in the lagoon and on 17 May 1977 caught a few small kingfish, pouters and mullet (*Strializa caniculata*) (pers. comm.). Whitfield (pers. comm.) undertook a food web study of the fishes in the Mhlanga lagoon in 1978. His results are in preparation.

Birds: Fish eagles, ospreys and several other piscivorous birds have been reported as present by Whitfield (pers. comm.), and Bainbridge ([26]). The latter also reported the presence of "a variety of waders, waterfowl and seabirds . . .". Campbell recalls that flamingo were often seen in earlier years, and that the birdlife on the mud flats and edges of the bush were prolific ([324]). Cowden (pers. comm.) has noted that migrant swallows roost in their thousands in the reedbeds of the Mhlanga lagoon at certain times of the year. On 19 April 1977, Malachite kingfishers, Little Bee-eaters and Reed cormorants were conspicuous ([178]). In 1947 White backed night heron were reported to breed alongside the Mhlanga lagoon ([288]) and Peter's Finfoot (nesting) and Black heron have been seen in recent times by Starling (pers. comm.).

The birdlife in the Hawaan forest (comprising 105 species ([324])) can be regarded as part of the Mhlanga system. Several species are at their southernmost limits of distribution in the Hawaan ([26]).

Mammals, reptiles, *et al.* An account of some of the mammals (such as the rare red duiker), reptiles (such as pythons) and insects of the Hawaan forest is available ([26, 324]). The snaring of antelope has become evident since squatters became encamped in the dune forest alongside the lagoon (Cowden, pers. comm.).

SYNTHESIS

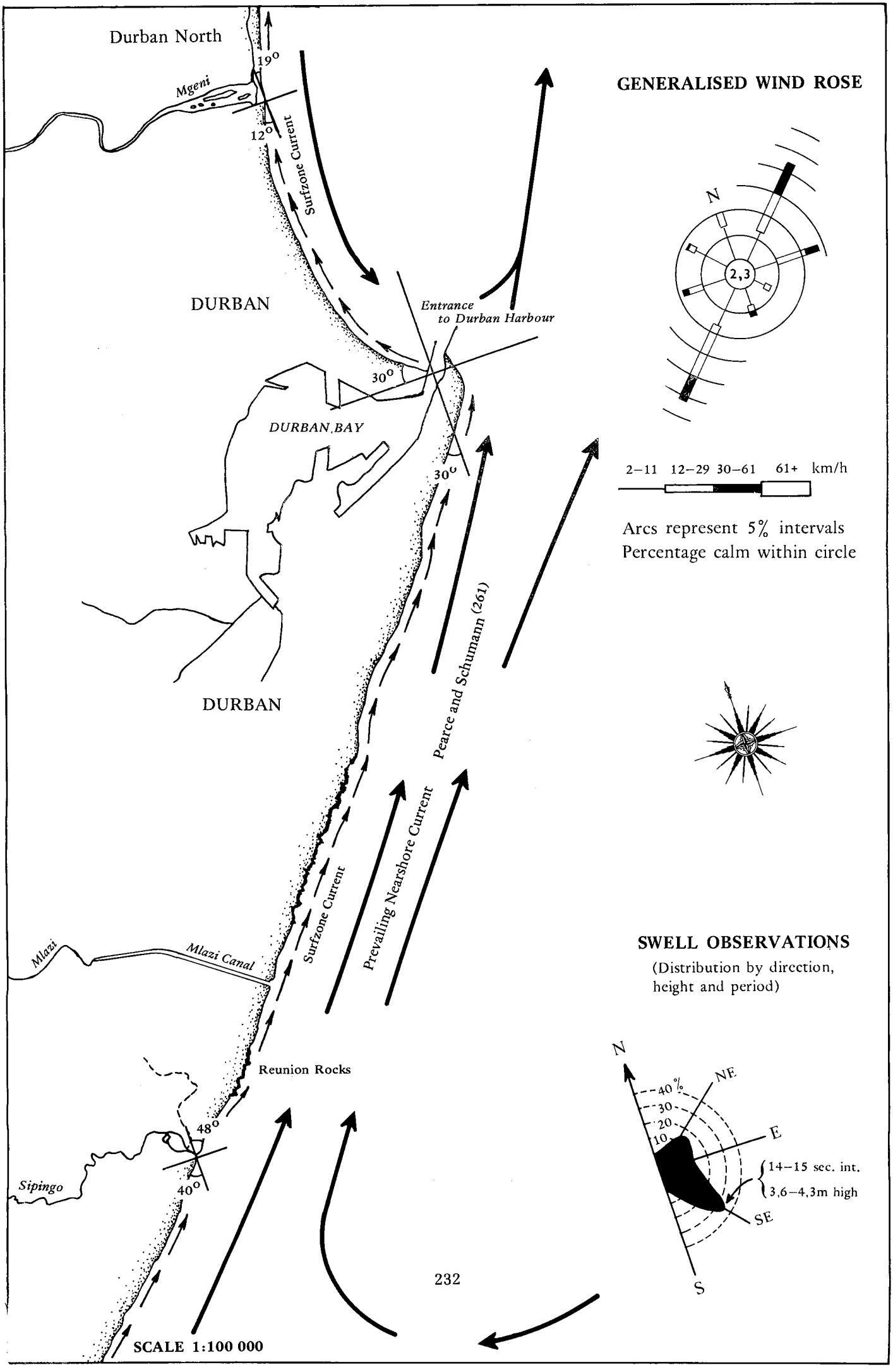
Regrettably our general state of knowledge about the Mhlanga lagoon is rather poor, despite the intense interest shown by conservationists in this area.

When compared to other lagoons in Natal, in its present environmental condition, the Mhlanga is a gem and certainly worthy of a far greater degree of study and protection.

Many people claim that because the environmental condition of the lagoon is already deteriorating, it should be developed before the process continues any further. The logic of such an argument is weak because none of the lagoon's problems are insurmountable and because no-one has made any real effort to control them. These are problems arising from cane encroachment, road construction, sewage effluent, vegetatively unstable areas (on the dunes, the sandbar and the river banks) squatters, and speed boating. However, although development pressures have to date been successfully resisted, they will certainly re-occur in the future.

The recommendation that the lagoon, its floodplain, the Hawaan forest and the dune forests be considered as one ecological unit and set aside as a nature reserve, is endorsed. The area defined would comprise several hundred hectares and form a rare complex found nowhere else within 100 km (either north or south) of Durban. Its value as a "green belt" near Durban must also be considered. By virtue of its accessibility, its potential and the need to understand the lagoon if it is to be administered as a nature reserve, it is recommended that the Mhlanga lagoon becomes a focal point for research activity. Foremost amongst such research should be a study aimed at establishing the marsh functions of a *Phragmites* reedswamp (see also section 4.1).

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																								BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora		Fauna									Food Webs
MHLANGA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids				★	◄	★	►			★	◄	★	►						★			◄			★						►	
Source of Information	Summary of available information																																				
Starling	1952	288																										●								
Brand *et al*	1964	43	●		●			●			○				○										○	○									
Moll	1966	227			●											●			●			●		●											
Moll	1968	228	●	●	●														●					●											
Pienaar *et al*	1968	pers. comm.																					●												
Grindley	1968	pers. comm.																						●											
Midgley & Pitman	1969	223	●		●																														
Chew & Bowen	1971	78	●		●			●																											
Orme	1971	257, 260	●	●						●														●											
Wallace	1975	329																									●								
Cockcroft	1975	86				●																				●									
Bainbridge	1976	26																					●					●	●	●					
Wager	1976	324	●	●						●									●		●		●				●	●	●						
Heydorn	1977	178								●												●		●				●							
Davies	1977	pers. comm.																			●														
Cowden	1977	pers. comm.																					●					●	●						
Duthie	1977	pers. comm.																					●												
Sheppard *et al*	1977	pers. comm.																●	●																
Campbell	1977	pers. comm.																									●								
Whitfield	1977	pers. comm.	●	●						●														●		●	●	●						●	
Aerial photos (Scogings)		No.																																	
1:10 000 Job No. 250	1976	60		●						●														●											
1:25 000 Job No. 251	1976	481	●																																


Durban North
19°
Mgeni
12°
Surfzone Current
DURBAN
Entrance
to Durban Harbour
30°
DURBAN BAY
30°
DURBAN
Pearce and Schumann (261)
Prevailing Nearshore Current
Surfzone Current
Mlazi
Mlazi Canal
Reunion Rocks
48°
Sipingo
40°
SCALE 1:100 000
GENERALISED WIND ROSE
N
2,3
2–11 12–29 30–61 61+ km/h
Arcs represent 5% intervals
Percentage calm within circle
SWELL OBSERVATIONS
(Distribution by direction,
height and period)
N
NE
E
SE
S
40%
30
20
10
14–15 sec. int.
3,6–4,3m high

2.1.8.1 **MGENI**

Synonyms

Umgeni is the most commonly used synonym. The Mgeni estuary is also called the "Blue lagoon" which is most certainly a misnomer.

Zulu meaning

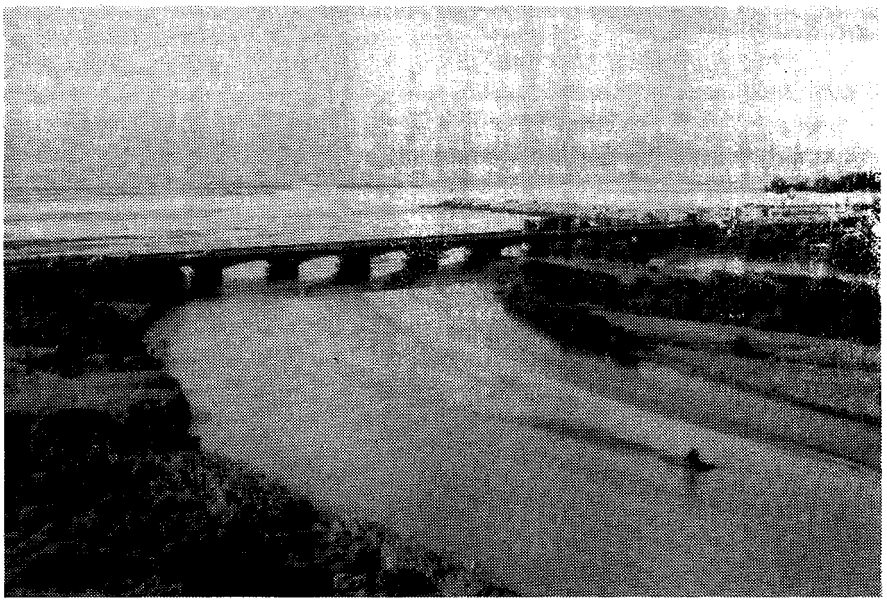
mNgeni means the river that flows through the *Acacia* or thorn trees ([289]).

Location

29°48'S; 30°02'E. The Mgeni estuary is 5 km north of the centre of Durban.

Accessibility

Being surrounded by the northern suburbs of Durban, the estuary is easily accessible. There are roads along both banks, but down to the mouth on the southern bank only.



A view of the freeway bridge over the Mgeni estuary. Notice also the groyne on the southern side of the mouth.

Bridges

There are several bridges across the Mgeni system. These are:

(a) the Ellis Brown viaduct, 450 m from the mouth;
(b) the Athlone bridge, 1,4 km from the mouth (opened in 1927 ([289])).
(c) the Connaught bridge (opened in 1906) ([289]), 2,5 km from the mouth at the head of the estuary. (An old bridge in this position was washed away in 1869).
(d) a railway bridge, 150 m above the Connaught bridge; and
(e) a footbridge over the Beachwood creek.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 4 385 km^2 ([43]); 4 400 km^2 ([257]); 4 639 km^2 ([223]); 5 084 km^2 ([251]); 5 850 km^2 ([85]).

River length. 230 km ([43]) to 235 km ([85]).

Mean annual run-off. 707 x 10^{6}m^3 ([198, 223]).

Flow. Between 1958 to 1961 the mean annual flow was 12,5 m^3/sec. ([257]) to 13 m^3/sec. ([135]). It has also been reported as 15,5 m^3/sec. ([43]). The mean summer flow was 18,4 m^3/sec. and the mean winter flow 6,5 m^3/sec. The highest recorded flows are 532 m^3/sec. and the lowest 4,5 m^3/sec ([43]). Tidal flow rates in the mouth of the Mgeni estuary ([226]) and in the Beachwood creek ([315]) have been studied.

Flood history. Actual flood discharge figures are lacking, but flows in excess of 500 m^3/sec. have been recorded ([43]). A sugar mill built on the bank of the Mgeni river at Springfield, was totally destroyed by a flood in 1856 when 675 mm of rain fell in four days, causing the river to rise 6 m ([324]). 11 m deep scour troughs in sediments are evident ([257]).

Level fluctuations. In the estuary a tidal range of 0,4 m has been reported ([128]). Moes ([226]) provides details of sediment balance, velocity, flow and water levels in the Mgeni mouth over one tidal cycle.

In the Beachwood creek, tidal fluctuations were formerly restricted to a few centimetres, by sand that had blown into the creek from unstable dunes and through interference by a concrete causeway ([229]). At this stage the mangroves were reported to be flooded only at high spring tide ([54]). Once the causeway was removed (in August 1975) by the Durban Corporation, tidal fluctuation was restored to a range of $\pm$1,1 m ([315]). It is considered insufficient only north of the road leading to Rocket Hut beach (Ward, pers. comm.). However, it is interesting to note that despite this, the mangrove community in this area is in remarkably good condition.

Dams.

Existing: (Munroe, pers. comm.)	**Built in**	**Total capacity**
Henley Dam	1942	?
Nagle Dam	1950	20,8 x 10^6 m^3
Midmar Dam	1963	172 x 10^6 m^3
Albert Falls Dam	1975	261 x 10^6 m^3

The Mgeni is the most important water supply for both Durban and Pietermaritzburg.

Proposed: Of the various dams proposed, only the Inanda dam is considered to be a feasible proposition.

Siltation. Soil erosion in the catchment is reported to be severe ([43]) and the silt load carried by the Mgeni considerable. During the period 1958 to 1961 it was estimated to be 70 000 (,07 x 10^6) tons/year ([257, 316]). At the Connaught bridge the mean monthly suspended solids figure was 165 ppm ([43]). Values varied from a minimum of 14 ppm to a maximum of 1 632 ppm.

Land ownership/use. Intensive farming of sugar, fodder crops, tropical fruits and beef and dairy cattle is undertaken in the Mgeni catchment. 24% of the catchment, comprising the Inanda Location, is destined to be incorporated into KwaZulu.

Just upstream of the estuary is the industrial area of the Springfield Flats. On the southern bank of the estuary is a golf course and a model yacht pond, as well as a restaurant and other amusement facilities.

The northern bank of the estuary has not been developed to the same degree. Near the mouth a tidal creek called Beachwood was declared a nature reserve in May 1977. However, on the western bank of Beachwood, the Department of Defence have established a rifle range which they intend improving in the future by building a caretaker's flat, target sheds, rail system and a canteen. At the southern end of the reserve, the Durban Corporation would like to develop a caravan park. An investigation by NRIO is presently in progress which is designed to ascertain whether the estuary can be improved for water recreation (Davis, pers. comm.) ([240, 241]). Although flood prone, the large islands which occur within the estuary would be very suitable for water related development of this nature.

Local authority. The estuary is controlled by the Durban Corporation. The Beachwood nature reserve is under the joint control of the Natal Parks Board and the Department of Defence.

Estuary uses. The Mgeni estuary is a popular recreational centre ([43]) used for angling, bait collection and the occasional water sport event (such as the Mgeni raft race and the 'Duzi canoe marathon). Sand mining may feature as a use to which the estuary is put in the future. The estuary also functions as a means for effluent and storm-water disposal.

The Beachwood nature reserve serves as a scientific and educational facility ([30, 128]) and nature trails through the swamp are planned.

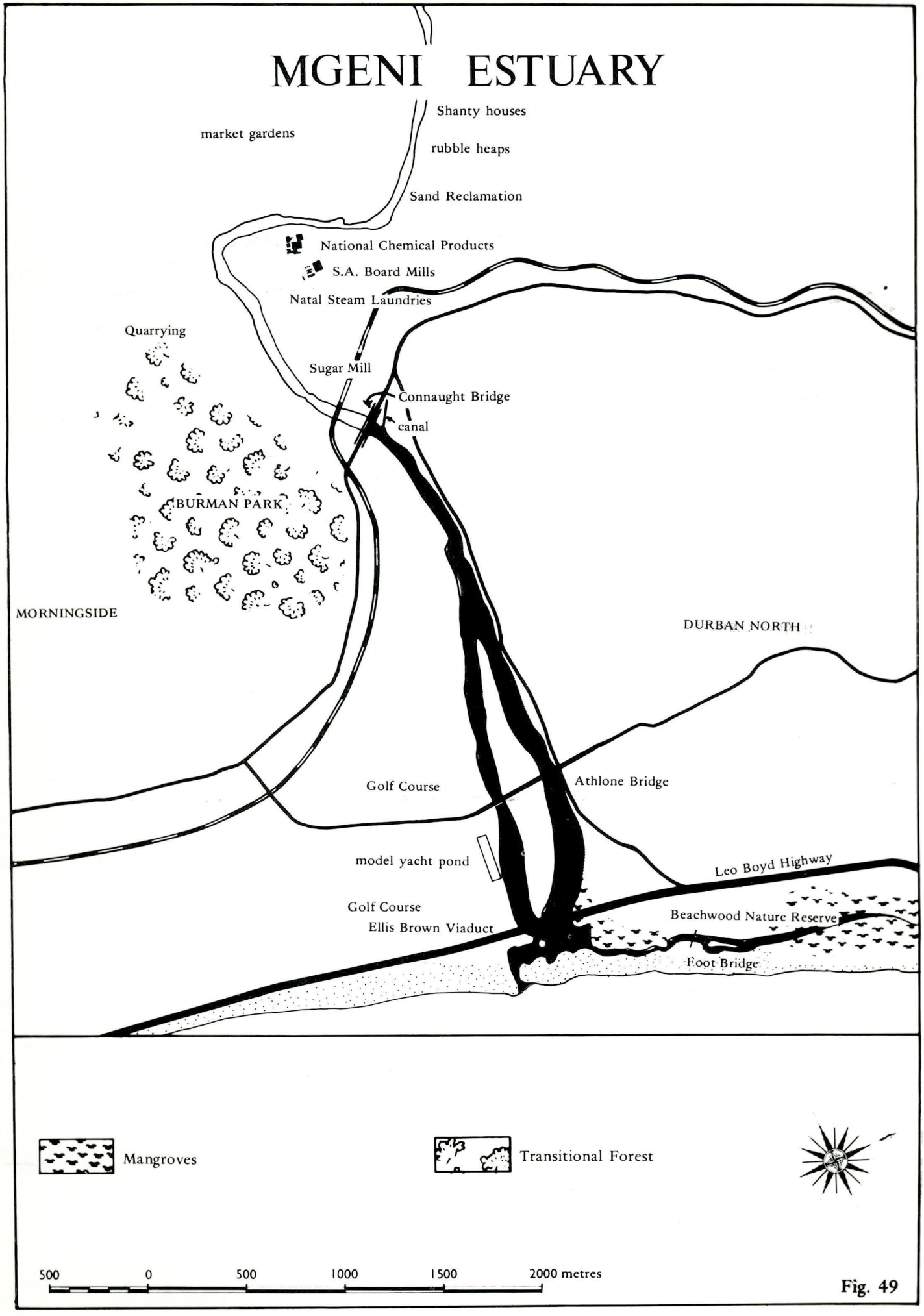

MGENI ESTUARY
Shanty houses
market gardens
rubble heaps
Sand Reclamation
National Chemical Products
S.A. Board Mills
Natal Steam Laundries
Quarrying
Sugar Mill
Connaught Bridge
canal
BURMAN PARK
MORNINGSIDE
DURBAN NORTH
Golf Course
Athlone Bridge
model yacht pond
Leo Boyd Highway
Golf Course
Ellis Brown Viaduct
Beachwood Nature Reserve
Foot Bridge
Mangroves
Transitional Forest
500 0 500 1000 1500 2000 metres

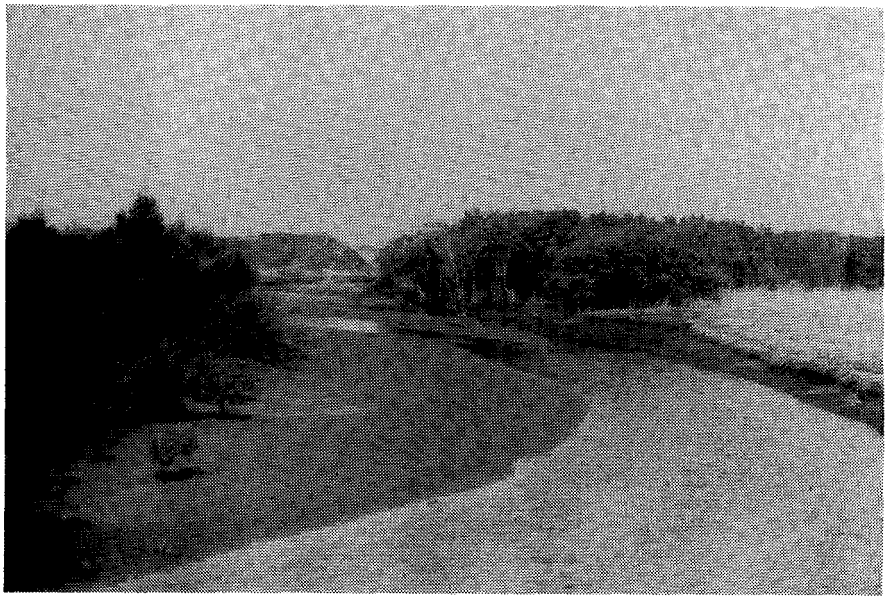
Fig. 49

Morphometry of the estuary (see Fig. **49**).

Area. On a spring tide the total extent of the estuary (including Beachwood) is 48 ha.

Axial length. Although said to be less than 1,6 km ([43]), the axial length of the estuary is actually 2,5 km, this limit having been established after a salinity survey which was conducted on an incoming spring tide on 26 July 1972 ([280]).

The Beachwood creek is 3 km long ([257]).



The Beachwood creek, extending northwards of the Mgeni estuary.

Shoreline length.
Estuary: 8,2 km (including the perimeter of a large centrally situated island).
Beachwood: 6 km.
Total: 14,2 km.

Width.
Maximum. At spring tide the estuary is 600 m wide near its mouth. In the Beachwood creek the entrance of the channel is 20 m wide ([315]) — above which it varies from 2 m to 5 m in width. In places it splits into a series of channels, low islands and mud flats, where the overall width is 30 m to 40 m.
Channel: Normally 100 m wide.
Floodplain: In places over 1 km.

Shape. The main channel of the estuary splits around a large central island which is almost 2 km long and in places 300 m broad. The Beachwood creek runs in a northerly direction, at right angles to the Mgeni estuary itself.

Bathymetry. At spring tide the estuary is 2,5 m deep. On an outgoing neap tide depths vary from 0,75 m to 2 m ([280]). In the Beachwood creek the depth is said to be 0,5 m ([54]) — but more specific details ([315]) have shown that, depending on the tide, depths at the entrance of the creek may range from 0,15 m to 1,25 m.

Geomorphology

Geology. In the catchment, the river traverses a whole variety of rocks of different geological characteristics. The Archaean granites (in the Valley of a Thousand Hills) are said to be the source of the pink sands in the estuary ([257, 259]) (see Fig. **50**).

Orme described bedrock below the estuary as shale which was "fractured and weathered towards the surface with some dolerite intrusions . . .". At the Athlone bridge, bedrock was found to be 52 m below mean sea level ([257, 259]), although reported to be at 67 m below mean sea level at another locality ([219]). At the Connaught bridge bedrock lay at a depth in excess of 28 m below mean sea level.

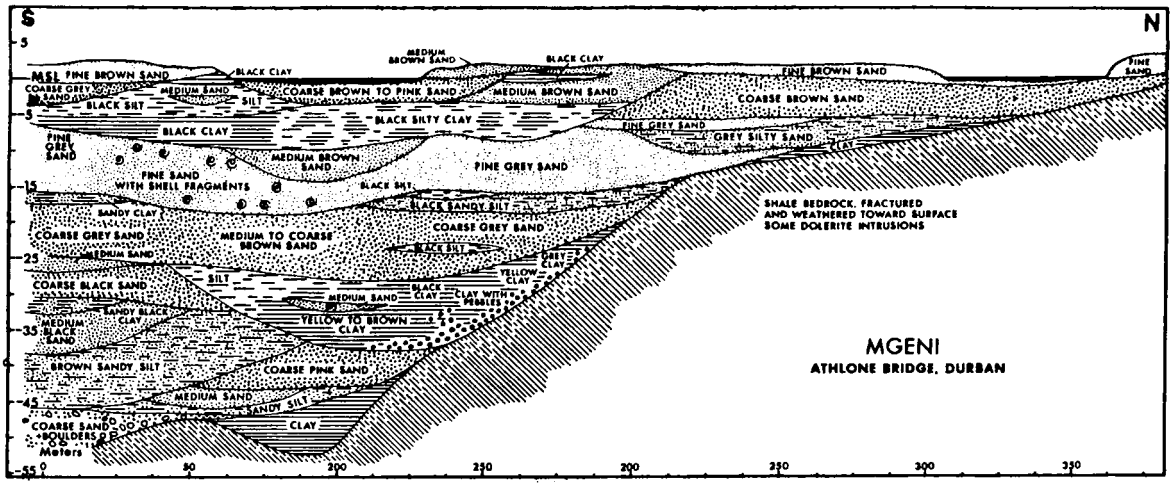


Fig. 50. A cross section through the Mgeni estuary, after Orme ([257]).

Nature of bottom materials. It is confusing to find that the nature of the Mgeni sediments was reported in 1969 to "vary a good deal at different places" as well as "not to alter greatly in any particular area" ([251]). However, organically rich sediments were apparently confined to the northern bank and only near the mouth became evenly spread across the estuary due to turbulence and exchange with the sea. Low flow rates allow deposition and consolidation and the changing salinity causes coagulation of suspended material. From the oxygen absorbed, nitrogen, phosphorus and sulphide values, industrial wastes were considered to be reaching the system. When the sediments were re-examined in 1972 ([280]), improved conditions were revealed (see Table **33**). The nature of the bottom was described as:

near the head of the estuary — fine sands;
near the middle reaches — sandy to gravelly substrates;
near the lower reaches — black anaerobic silt beneath deposits of sand or silt;
in the Beachwood creek — sand of uniform composition; and
in the mouth — sand.

Table 33. Average analysis of sediments from the lower reaches of the Mgeni estuary ([280]).

	1969	May—August 1972
Particle size (%)		
> 1 000 microns	—	6,9
1 000 to 500	—	7,3
500 to 250	—	12,7
250 to 125	—	8,4
125 to 63	—	7,0
< 63	—	57,7
Volatile @ 600°C (% dry weight)	—	7,63
Oxygen absorbed (mg/g dry weight)	25,8	13,3
Kjeldahl-nitrogen (µg/g)	2 304	1 865
Total phosphorus (µg/g)	577	252
Sulphide (mg/g)	3,69	1,20
Surface area per cm^2 (cm^2)	—	8 750

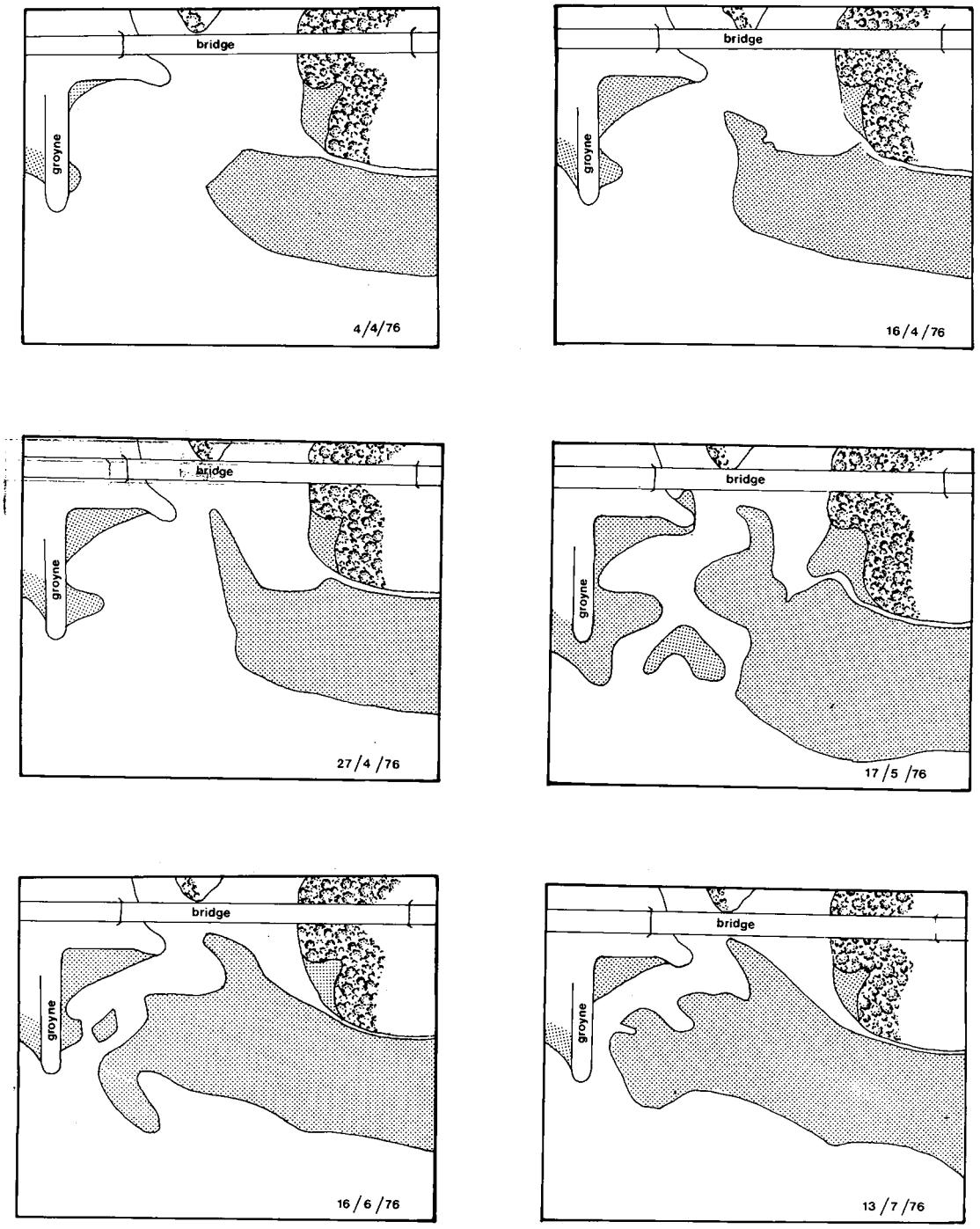
Interstitial water in the Mgeni sediments was reported to be low in oxygen content ([280]). In the Beachwood area, bottom materials were described in 1971 as "fine textured dark muds with the surface substratum composed largely of the faecal pellets of snails . . ." ([54]). More recent information on the substrate composition in the Beachwood area has become available since the studies of Chrystal ([81]).

Sandbar characteristics. Under normal circumstances, the Mgeni sandbar is a south extending spit, or a "southward accreting northern spit" according to van Heerden, after his

studies on spit growth at the Mgeni in 1976 ([316]). However, under certain circumstances (such as the influence of an onshore swell) north directed spit growth can occur (see Fig. **51**). Normally spit growth occurs as a result of beach drift and washover associated with southerly swells, the sediments being provided by the longshore current ([316]). Tidal deltas, bars and sandbanks also form in the mouth ([316]). A groyne has been built on the southern bank at the mouth.

It is of interest to note from maps in the Natal Archives, that historical evidence suggests the Mgeni used to run behind a sand barrier all the way into Durban Bay ([257]). In a Mercury Pictorial (dated 9 September 1909) the mouth was reported to be "three miles" from its present position at which stage much concern was expressed about flooding, malaria risks and damage to reclamation works. On such occasions the City Engineer used to breach the bar manually at the position the mouth assumes today.

Fig. 51. Movement of the sandpits and bars at the mouth of the Mgeni estuary between April and July 1976 (after van Heerden, 1976)



The Durban Corporation ensures that the mouth never closes (to safeguard against flooding upstream) by using a drag-line (when necessary) to keep it open. Physical modelling of the Mgeni mouth has been undertaken by NRIO ([240, 241]). Sand grain sizes on the bar have been measured. The ebb tide was found to deposit finer material than the flood tide ([316]).

Configuration of the adjacent shore. Open, sandy beaches extend both north and south of the estuary.

Surf zone currents. Rip currents are reported as present ([316]) in the near vicinity of the estuary mouth. The longshore current direction is apparently set northwards ([120, 316]), but liable to run in a southerly direction as well according to Pearce ([261]). Old maps in the Natal Archives dated 1884/1885 showed that silt plumes from the Mgeni (then referred to as the "Umgeni freshet") moved both northwards along the coast as well as southwards on some occasions.

Physico-chemical characteristics

Whilst the Mgeni river system is of reasonably good water quality, conditions deteriorate markedly in the estuary due to sources of pollution in the lower Mgeni ([275]) (see Table **34**).

Van der Riet ([315]) has recently studied certain aspects of the chemistry of the Beachwood creek, mainly to investigate the exchange of suspended and dissolved material between the estuary and the mangroves, over a full (both spring and neap) tidal cycle. The results obtained reveal the net gain or loss of such materials with each tide. On three of the four tidal cycles studied, there was a net export of particulate organic matter, nitrite and total phosphorus from the mangrove swamp into the estuary (see Table **35**).

Table 35. Tidal transport between the Beachwood mangrove swamp and the Mgeni estuary over a 12 hour tidal cycle (Spring tide 16 April 1976), after van der Riet ([315]).

Locality: Mgeni/Beachwood	Entering swamp	Leaving swamp	Difference
Volume of water (m^3)	82 679	83 493	814
Particulate matter (kg)	8 505	6 921	1 584*
Particulate organic matter (kg)	78	126	48
Total phosphorus (g)	341	374	33
Reactive phosphorus (g)	240	281	41
Nitrite (g)	43	67	24
Nitrates (g)	7 841	7 463	378*

* net gain by the swamp

Water clarity. The water in the estuary is rarely clear ([128]). Dredging at the Umgeni Sandworks upstream is constantly stirring the bottom ooze. Only in winter, with low river flows, and on a high spring tide can the water be considered as clear.

Salinity. At spring tide, salinities of 31‰ can be recorded at the bottom of the estuary, 2 km from the mouth ([280]). Distinct stratification becomes evident ±1 km from the mouth, but at the mouth itself salinities are high (35‰) and evenly distributed from top to bottom. During high flow periods, salinities naturally fall dramatically and the system assumes 'river mouth' characteristics. In May and August 1972 salinities of 4,6‰ and 3,3‰ respectively were recorded from near the mouth of the estuary ([280]).

Information on salinities in the Beachwood creek are available for three months of 1976 ([84]). At low tide the creek carries water which is almost fresh ([54]).

Pollution. Industrial areas on the Palmiet river have been known to pollute the system, but the chemistry of the estuary is dominated by the overpowering degree of pollution from the Zeekoe (or Piesang) river sewage discharge ([274]). Indices such as a rise in phosphorus from 16 micrograms/litre to 270 micrograms/litre in August 1972 ([85, 280]) are indicative of the magnitude thereof. Industries immediately above the estuary also pollute the system at times. In July 1971 a spill of crude furnace oil ([93]) and on two occasions the release of some respiratory poison, all had disastrous results in the estuary ([128]). Fibre disposal by the S.A.

Table **34.** Physico-chemical characteristics.

Locality: Mgeni	(43) Above the estuary 2.5km	(43) Above the estuary 2.75km	(280) Near the mouth of the estuary 5 May 1972	(280) Near the mouth of the estuary 4 Aug 1972
	Average results July 1965			
Hydrogen ion concentration (pH)	7.26	7.4	-	-
Saturated pH value	-	7.4	-	-
Conductivity micromhos/cm	325	821	-	-
Total dissolved solids ppm (calculated)	-	553	-	-
Dissolved oxygen mg/litre	8.6	6.0	7.15	-
% Saturation	86	59	80	-
Oxygen absorbed mg/litre	-	4.3	3.0	4.0
Biological oxygen demand mg/litre	4.9	1.1	-	-
Kjedahl nitrogen mg/litre	-	-	.85	1.51
Ammonia "	-	nil	.247	1.28
Nitrites "	-	.015	.029	.068
Nitrates "	-	.73	1.30	1.58
Phosphates "	-	.36	.039	.170
Total alkalinity "	-	241	-	-
Total hardness "	-	224	-	-
Calcium "	-	39.5	-	-
Magnesium "	-	30.6	-	-
Sodium "	-	135	-	-
Potassium "	-	2.4	-	-
Sulphates "	-	40.5	-	-
Chlorides "	-	178	-	-
Silica "	-	18.9	-	-
Free carbonic acid (as ppm carbon dioxide)	-	18.5	-	-
Temperature ^{o}C	15.5	13.8	-	-
Turbidity (ppm silica scale)	-	22	-	-
Colour (APHA units)	-	-	5	5
Appearance	dirty, turbid	-	-	-

Values underlined significant of disturbance

Board Mills is a problem. Pollutants are said to seldom enter the Beachwood creek, with the result that this area acts as a reservoir of life to re-populate the estuary ([128]).

Public health aspects

The water of the lower Mgeni were classified as verging on public nuisance levels in 1965 ([43]).

Bacteriology. Bacteriological results ([43, 274, 280]) have indicated that the estuary is both organically enriched and faecally polluted (see Table **36**). The Sea Cow lake discharge is said to be "by far the greatest single source of contamination" ([43]) being typical of a diluted sewage works outfall. Below the Zeekoe (or Piesang river) entry, *E. coli* levels increase by about 100 times and *Salmonella* are recovered ([280]). Details of the bacteriological characteristics of board and paper mill effluents entering the Mgeni estuary in October 1964 are available ([42]).

Table 36. Bacteriology of the lower Mgeni.

Date		Total Plate Count per ml x 10^3	*E. coli* I per 100 ml	Total Coliforms per 100 ml	*Salmonella*	
		5 days @ 32°C	Confirmed		per .25 ℓ	per 4 ℓ
7 December 1964	(42)	—	**6 200** to **17 600**	—		
7 July		**425**	**8 120**	—		+
12 July 1965*	(43)	**265**	**6 300**	—		
19 July		**495**	3 000	—		+
1 August 1972**	(280)	—	241 to 1 900	13 000 to 34 000	+	

+ and values in bold are significant of disturbance.
* 2,5 km above the estuary.
** range between bacteriological stations 5 to 8.

Bilharzia. Sampling amongst marginal vegetation at the Palmiet river confluence (2,75 km above the estuary) revealed the presence of *Biomphalaria* ([43]) and *Bulinus (Physopsis) africanus* has also been shown to occur in the catchment. Consequently, the likelihood of bilharzia near the headwaters of the estuary exists. Near the mouth, where high salinities are encountered, this is probably not the case.

BIOTIC CHARACTERISTICS

Flora

The mangrove community of the Beachwood nature reserve, is the only feature of real botanical significance which remains around the Mgeni estuary. This is largely as a result of urban encroachment in the form of recreational facilities on the southern bank. A fair proportion of the reserve itself is a shooting range. The islands in the centre of the Mgeni estuary are as yet undeveloped.

Halophytes. Of the 50 ha set aside as the Beachwood nature reserve, 12,14 ha are under mangroves ([54, 91]). The two common species are the White (*Avicennia*) and Black (*Bruguiera*) mangrove ([231]). Transplantation of specimens of the Red (*Rhizophora*) mangrove from Durban Bay and *Ceriops* from Kosi Bay have been made. The introduction of *Lumnitzera* is envisaged (Steinke, pers. comm.). The fresh water mangrove (*Barringtonia*) has also been introduced into the reserve. Amongst the mangrove community, are various salt tolerant species of grasses, reeds and rushes. The plant community as a whole supports a very characteristic and interesting estuarine adapted fauna ([30]), dependent on the rich supply of organic detritus which the swamp provides. Because of the educational value of this area (by virtue of its proximity to the main centres of education in Natal) it has been set aside as a nature reserve, to protect the area from the pressures which formerly threatened it (such as reclamation, "Disneyland" development, uncontrolled public access, sand removal, etc.).

The Natal Parks Board, presently in control of the area, are restoring the swamp. This involves among other things, the construction of gabions, dune stabilization, fencing, dredging and debris removal. Other suggestions have included the building of a weir which could be closed when necessary to exclude the Mgeni should it be polluted, excessively silt laden or in some other way a threat to the nursery function of the reserve ([128]). The use of high pressure hoses to wash away sand which has accumulated amongst the root masses of the mangroves has also been suggested (Ward, pers. comm.).

Aquatic flora. Conditions are reported as too turbid for the development of *Zostera* and *Ruppia* ([128]), however blooms of sea-lettuce (a large marine alga named *Ulva*) have been reported in winter. Water hyacinth (*Eichornia*) has been reported amongst the mangroves in the past, and in the extreme north of the reserve, water conditions are sufficiently fresh for *Vallisneria* (eelgrass) and *Salvinia* (Kariba weed) to develop.

Fauna

Lower trophic levels.

Zooplankton: Grindley took samples from the Mgeni in 1963, the analysis of which has not yet been undertaken. Cliff ([84]) studied the zooplankton of the lower reaches of Beachwood and concluded that conditions in the creek did not favour the survival of estuarine and marine forms of zooplankton. Fresh water forms of zooplankton were dominant. Crab, fish and prawn larvae were the most abundant meroplankton forms.

Benthos: In 1972 ([280]) 16 species of benthic animals were found to be present in the estuary, dominated by the polychaetes *Ceratonereis* and *Desdemona* (both being tolerant of low oxygen conditions). The lack of amphipods, isopods and tanaids was considered to be striking, since these forms normally comprise a considerable part of the biomass in Natal's estuaries. This is because they are probably less tolerant of pollution. Production was limited to the top two centimetres of sediment, below which the sediment was anaerobic ([280]). At the head of the estuary, some oligochaetes and entomostraca (*Pseudodiaptomus* and *Cyclops*) occur, indicating the influence of fresh water.

Attention has been given to the distribution and occurrence of fiddler crabs ([81]) (four species of *Uca*) and gastropod molluscs ([54]), in the Beachwood swamp. In 1964 Brown ([54]) found 10 species of gastropods (out of the 13 species listed as occurring in South African mangroves) present. This represented the richest assemblage known at any one locality. The greatest densities were 370/sq metre. Brown concluded that the area might support populations ranging from 200 000 *Cassidula* to 8 million *Assiminea* ([54]). Beachwood is the type locality for *Neritina natalensis*. Gastropod densities varied according to texture and moisture content of the substrate as well as the amount of shade. The same sort of factors govern the distribution of fiddler crabs ([81]). The mangrove whelk (*Terebralia*) has since been introduced from Durban Bay (Forbes, pers. comm.).

Epifauna: In the estuary, animal communities of the marginal vegetation were poorly developed. Thirteen species typical of estuarine conditions were found, these being markedly different in May (when fresh water influenced) and in August (when more typical of brack water forms). Above the estuary the fauna of the marginal vegetation is slightly better developed, with 18 species listed as present 2,5 km above the estuary in 1965 ([43]). Of the larger crustacea in the Beachwood swamp, shrimps (*Caridina*) are said to be dominant ([128]), particularly in spring when thousands of juveniles are said to be present. Two species of prawns occur in the estuary, but they are not common ([128]).

Higher trophic levels.

Fish: Of the 30 species of fish reported as present in the Beachwood creek a striking proportion belong to the gobioid family ([128]). Mullet, followed by "glassies" (*Ambassis*) are the dominant species, the ratio of juvenile mullet to all other species being in excess of 20:1. Juveniles 1,5 cm in length representing fishes only a few weeks old, have been caught after coming into the estuary from the sea.

The Beachwood population of *Periophthalmus* (the mudskipper) is one of the most southerly in terms of its distribution. Five species of fish are reported to breed in the estuary ([128]). *Therapon* (tigerfish), *Rhabdosargus* (stumpnose) and *Acanthopagrus* (perch) are present, as well as fresh water species such as "guppies" (introduced for mosquito control) and mud bream (*Sarotherodon mossambicus*). From the results recorded in ([280]), eels (*Anguilla*) occur at times. Heydorn considers the excellent fishing in the Mgeni estuary to be due to the influence of the mangrove swamps of Beachwood (pers. comm.).

Birds: From the various sources of information available ([30, 128]) and from Sinclair and Nicholls (pers. comm.), the list of birds that have been seen to occur around the Mgeni/Beachwood complex comprises 71 species. In this respect the sandbar of the Mgeni is a very important part of the complex — particularly as a roost for terns and gulls. On the 16 February 1975, 18 000 common terns were present on the bar. Amongst this assemblage rarities such as Bridled terns occur at certain times ([243]). The occurence of White-winged black terns is also noteworthy, since the Mgeni is virtually the only estuarine system in Natal to which these birds appear to be regularly attracted for roosting purposes. Amongst the 23 species of waders recorded as present, Sanderling, Common and Curlew sandpipers are dominant. On occasions rarities such as the Crab plover occur.

Fish eating birds (such as various cormorants, herons and egrets) are common.

As far as birdlife is concerned, the major limiting factor throughout the system is human disturbance.

Miscellaneous: Casual references to various other forms of animal life in the Beachwood nature reserve have been made. These mention vervet monkeys, grey duiker, banded mongoose, leguaans, lizards, geckoes, skinks, snakes, frogs and toads ([128]) as well as various insects ([30]). Recently the presence of a Cape clawless otter has been reported. Records of crocodiles in the Mgeni estuary in 1908 are of interest (Mercury Pictorial, January 30th, 1908).

SYNTHESIS

As one of the better studied systems in Natal our general state of knowledge of the Mgeni estuary, including the Beachwood area, is good. This is largely because the Mgeni estuary is on Durban's doorstep and because the Beachwood area has received so much attention from conservationists.

In their present degraded environmental condition neither the estuary nor the Beachwood nature reserve can be regarded as important estuarine resources. However, there is a distinct likelihood that the Beachwood area will recover in the future and become increasingly important in this respect. Its primary value will always be its educational value as a mangrove swamp, by virtue of its location. The ecological recovery of Beachwood should be monitored, and the introduction of plant and animal species foreign to the system, carefully vetted.

There is little chance of the Mgeni estuary becoming anything but the polluted system which it is; however every effort should be made to keep such pollution at a minimum:

(a) because of the possible effects thereof on the success of the Beachwood venture and
(b) because of the steadily increasing use that is likely to be made of the estuary by the public through various forms of water sports.

It is surprising to find that no information exists on the levels of heavy metals or pesticides in the Mgeni estuary.

The various problems apparent in the system are listed below:

In the estuary — industrial pollution;
sewage pollution;
siltation; and
urbanization.

In Beachwood — beach erosion; and
development/conservation conflicts.

Utilization of the area as both a nature reserve and a shooting range are not the most compatible of uses. Dual ownership of the area seems to create considerable complications in terms of management. The only compromise (after obtaining the necessary guarantees) would be to relinquish the southern part of the Beachwood area for caravan park/shooting range development and to protect the northern part of the system as an educational reserve.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora			Fauna								Food Webs
MGENI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids													←★→																			
Source of Information	Summary of available information																															
Schoonbee	1962 to 1963	274, 275									●	●			●										●	●						
Oliff *et al*	1964	249				●				●	●	●			●											●						
Brand *et al*	1965	42,43	●	●	●		●	●		●	○	○			○										○	○						
Maud	1968	219						●	●	●																						
Midgley & Pitman	1969	223	●		●																											
James & Pegram	1969	198	●		●																											
Oliff *et al*	1970	251								●																						
Orme	1971	257,259	●	●	●			●	●	●											●											
Cooper	1972	72									●																					
Simpson *et al*	1972	280	●	●	●	●	●			●	●	●			●										●	●						
Nicholls & Sinclair	1972 to 1977	pers. comm.																										●				
Godbold	1974	135								●																						
Moes	1975	226			●		●			●																						
Cloete & Oliff	1976	85	Summary of NIWR contribution to date																													
NRIO	1976	240,241	●	●	●		●			●								●														
van Heerden	1976	316								●																						
Wager	1976	324			●																											
Nicholls	1977	243																										●				
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 250	1976	48-49		●						●													●									
1:25 000 Job No. 287	1977	96	●	●																			●									

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other							Flora		Fauna							Food Webs
BEACHWOOD CREEK			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																					★				←★→							
Source of Information	Summary of available information																															
Brown	1964	54		●	●		●			●											●				●	●						
Cooper	1968	91																			●											
Edwards & Moll	1971	128					●				●					●			●	●	●		●			●	●	●	●	●		●
Moll *et al*	1971	231																			●											
Moll	1972	229																			●											
van der Riet	1976	315		●	●	●	●				●										●											
Cliff	1976	84				●																		●			●					
Chrystal	1976	81								●															●	●						
Berjak *et al*	1977	30														●			●	●	●		●		●	●	●	●				●
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 264	1976	542-546		●						●											●		●									
1:25 000 Job No. 287	1977	96	●																				●									

DURBAN BAY

Synonyms

Natal Bay (1:50 000 sheet 2930 DD and 2931 CC). Since this name is never used locally, it has been avoided. In the past the bay has also been called "Thekwini" by the Zulus, meaning an estuary or lagoon, and "Pescaria" by the Portuguese in the 16th Century (289).

Alternative spellings of the rivers which flow into the bay may also be found. These are Umhlatuzana, Umshalatazani (245) and Mbilo. The Mhlatuzana was once known as the Umhlatusi according to a map of the bay drawn in 1842 (Mercury Pictorial, 13 August 1908).

Location

A land locked bay occupying a position between 29°51' to 29°54'S and 31°00' to 31°03'E.

Accessibility

Being surrounded by the city of Durban, the bay is accessible at almost any point of its margin. Access is restricted by the normal security measures imposed by harbour authorities.

Bridges

The only bridges are those across the inflowing rivers — the Umbilo and Mhlatuzana.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. Umbilo — 67 km²
Mhlatuzana — 113 km²
} in total 180 km² excluding that area draining Durban Durban central and the Bluff, i.e. ±30 km².

Historical records suggest that in the past, both the Mgeni (diverted south by a beach barrier) (257) and the Mlazi (120) flowed into Durban Bay. However it is also known that the Mlazi flowed into the Sipingo lagoon (335).

River length.

Umbilo — 35 km
Mhlatuzana — 50 km
} Both are canalized in their lower reaches.

Mean annual run-off. No record.

Flow. No record, because neither river has any gauges from which such determinations could be made.

Flood history. Other than mention of severe floods from the Umbilo in 1905 (Mercury Pictorial, 10 December 1908) no information of floods from the Umbilo/Mhlatuzana catchment could be found.

Level fluctuations. Water movements in the bay are due to both the tides and wind. The tidal range is normally about 1,8 m, increasing to ±2,1m over equinoctial springs (120). At neap tide the range is 0,3m.

Due to the hydraulic gradient, there is a lag in the time at which the tide reaches low or high water at the back of the bay. More specific details are provided by Day and Morgans (120).

Dams.
Existing: Nil.
Proposed: Nil. (Munroe, pers. comm.).

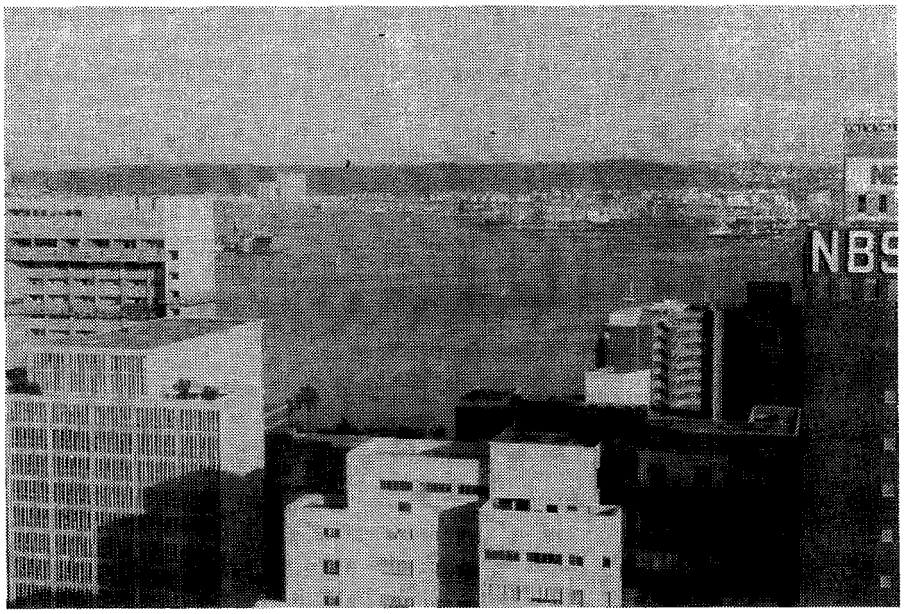
Siltation. No record. The Umbilo and Mhlatuzana deposited silt in an area formerly known as the "sanctuary area" in the south west corner of the bay. It was in this area that mangroves developed to their greatest extent (see under Flora).

Land ownership/use. Draining several suburbs of Durban, the Umbilo/Mhlatuzana catchment is particularly densely urbanized.

The bay however, is surrounded by industrial development. Industries include two oil refineries, a large sugar terminal, chemical, textile, food processing, footwear, tyre manufacturing and printing industries, paper and board mills. The city of Durban with a population of over 1 million, has developed around the bay.

Local authority. South African Railways and Harbours.

Estuary uses. Being one of the finest natural harbours in the world, and the busiest port in South Africa, the principal use made of Durban Bay is shipping. The bay is also a mecca for yachting and fishing ([171]). The discharge of effluents represents a use to which the bay is subjected because, in many respects, it has come to function as a "giant stormwater sump" for the city of Durban.



An impression of the urban and industrial encroachment around Durban Bay (photo from 24th Floor, 320 West Street — 9 June 1978).

Morphometry of the bay. (See Fig. **52**)

Area. 1 060 ha ([170, 231, 328]).

Axial length. 5,6 km ([202, 328]) to 8 km (pers. est.).

Shoreline length. ±27 km.

Width.
Maximum: 3 km ([328]) to 3,3 km (pers. est.).
Mouth: 300 m between north and south piers.

Volume. Unknown, but the amount of water exchanged at each tide (as in Richards Bay) must have increased dramatically in Durban Bay once the bar at the mouth was removed and the entrance deepened.

Bathymetry. The maximum depth in the bay recorded by Day and Morgans was 13,7 m ([120]) — this being representative of the **dredged** depth of the bay. Old maps produced at the turn of the century (a copy of which is reproduced as Fig. **53**) are of interest in that they suggest very little of the bay was, in its pre-developed state, deeper than 2 m at high water on spring tide.

Geomorphology

Geology ([257]). Bedrock is composed of strongly dipping and faulted Karoo sediments of the Dwyka and Ecca series. These are overlain by a veneer of cretaceous rocks which thicken

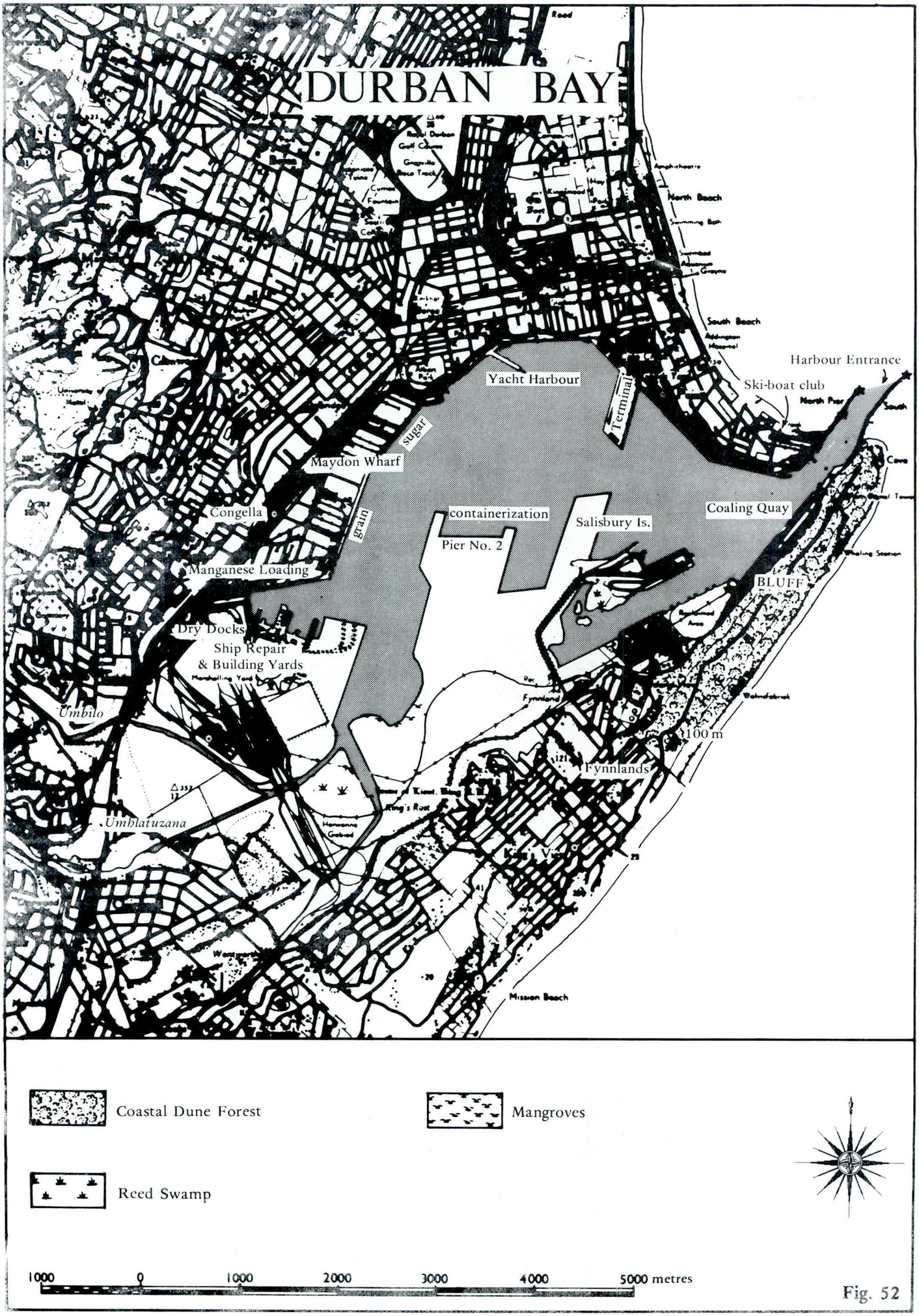

DURBAN BAY
Yacht Harbour
Terminal
sugar
Maydon Wharf
grain
containerization
Pier No. 2
Salisbury Is.
Coaling Quay
Harbour Entrance
Ski-boat club
North Beach
South Beach
Congella
Manganese Loading
Dry Docks
Ship Repair
& Building Yards
BLUFF
Umbilo
Umblatuzana
Fynnlands
100 m
Mission Beach
Coastal Dune Forest
Mangroves
Reed Swamp
1000 0 1000 2000 3000 4000 5000 metres

Fig. 52

FIG 53

PORT NATAL.

PLAN
OF
THE BAY OF DURBAN.

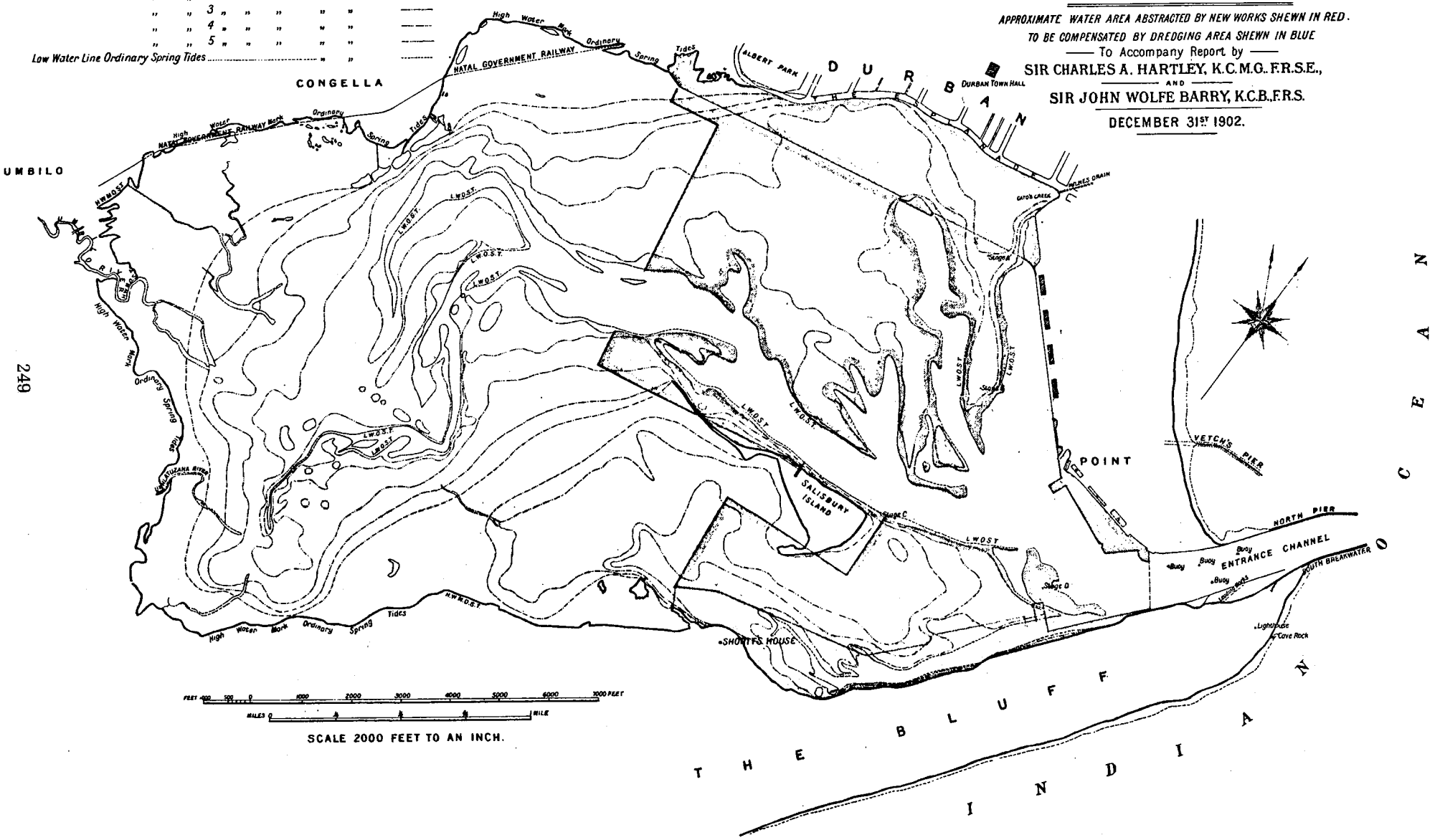
APPROXIMATE WATER AREA ABSTRACTED BY NEW WORKS SHEWN IN RED.
TO BE COMPENSATED BY DREDGING AREA SHEWN IN BLUE

To Accompany Report by

SIR CHARLES A. HARTLEY, K.C.M.G., F.R.S.E.,
AND
SIR JOHN WOLFE BARRY, K.C.B., F.R.S.

DECEMBER 31ST 1902.

High Water Line Ordinary Spring Tides (6 Feet above L.W.O.S.T.) shewn thus ——
Contour Line 1 Foot below H.W.O.S.T. ,, ,, ——
,, ,, 2 Feet ,, ,, ,, ,, ——
,, ,, 3 ,, ,, ,, ,, ,, ——
,, ,, 4 ,, ,, ,, ,, ,, ——
,, ,, 5 ,, ,, ,, ,, ,, ——
Low Water Line Ordinary Spring Tides ,, ,, ·····



SCALE 2000 FEET TO AN INCH.

eastwards beneath the Bluff. The Bluff (see Fig. **52**) is composed of calcareous sandstones (a Pleistocene barrier dune complex) while the hills west of Durban Bay are mantled in Berea red sand ([215]). Deposition during the Flandrian transgression, resulted in the formation of "the harbour beds" ([207]) which consist of ±30 m of unconsolidated sands, silt, clay and shell material overlying cretaceous rocks ([257]).

Nature of bottom materials. Substrate type plays an important role in the distribution of the biota ([120]). There are essentially two major types:

(a) hard substrata (rocky embankments, quays, walls, piers and buoys); and
(b) soft substrata (sands and muds).

The bottom of the entire bay is principally covered by estuarine clay or sand. For more detailed descriptions thereof, reference should be made to Day and Morgans ([120]), Maud ([219]) and Mason (pers. comm.).

Sandbar characteristics. Before piers were built, a shifting sandbar, over which the water was seldom deeper than 2 m, lay across the harbour entrance. The south breakwater was begun in 1882 and completed in 1893. The north pier was begun in 1854 and completed in 1894. A channel developed through this bar as pier construction proceeded. Dredging at the mouth of the harbour is undertaken so as to prevent the sandbar from reforming.

Configuration of the adjacent shore. Due to pier construction, the littoral transport of sand along the coast has been interrupted. Consequently the beaches north of the harbour mouth are starved of sand. However it is interesting to note that Orme considers "the Point" (see Fig. **53**) to be built out of materials which drifted south from the Mgeni ([257]).

The adjacent shoreline departs from the north north-east to south south-west trend of the Natal coast and begins to project eastwards into the Indian Ocean. The Bluff is orientated north-east/south-west at an angle of 15° to the principal shoreline trend ([257]).

Beach type: On the seaward side of the Bluff, the coast is rocky with steep narrow beaches.

Surf zone currents. North flowing ([120]). Strong rip currents and sidewash are characteristic on the seaward side of the Bluff ([132]). Current speeds of 3,5 to 4,5 knots have been recorded near the entrance at spring tide ([120]).

Physico-chemical characteristics

Being a landlocked embayment, the transition of chemical characteristics that normally occur in an estuary (*sensu stricto*) are lacking.

Temperature. Durban Bay is slightly warmer than the open sea in summer and cooler in winter ([120]). In the vicinity of the power station, warm water is detectable. Solar radiation accounts for increased seasonal variations in temperature in the shallower western parts of the bay.

Salinity. Salinity increases rapidly from ranges of ±27‰ near the incoming rivers in the south west, to ±35‰ in the remainder of the bay and near the harbour entrance ([202]). Consequently the water in the bay is markedly marine in its characteristics. Salinity layering has not been reported but presumably does occur.

Turbidity. In the 1950's the turbidity of the open bay (as measured by a Secchi disc), was in the order of 3 m ([120]), but varied markedly with the strength of the wind. The tides generally bring clearer water into the eastern part of the bay.

Acidity. Acidity (pH) in the open bay varied from 8 to 8,5 ([120]). In 1972 the discharge of some lethal acidic effluent into the bay lowered the pH sufficiently to cause "the biggest mass mortality of fish in living memory" ([171]).

Heavy metals. Samples from the Maydon channel in 1975 contained 0,126 to 0,159 micrograms/litre of mercury. These values were considered to be abnormally high ([85]). Copper, lead, cadmium and chromium results were satisfactorily low.

Pollution. Industrial pollution is evident, generally where rivers flow into the bay, although storm water drains from the city also carry industrial effluents ([120]). The lower reaches of both the Umbilo and Mhlatuzana are polluted and are considered to make a major contribution to pollution in the Bay. The Umbilo river is said to be polluted near its source, by industries of Pinetown ([43]). Oil pollution is a constant problem, counteracted by the use of dispersants and spray booms. Like refuse collectors, a pollution squad is constantly removing flotsam and rubbish floating in the bay, and since 1972, 87 ships have been fined for contravening the port's pollution control laws (Daily News, 30 September 1976). Pollution from the Bluff whaling station led to many complaints in the early 1900's (Mercury Pictorials).

A complex of pipes on the North pier used to discharge industrial wastes and 80 million litres of untreated domestic sewage, into the sea each day at the harbour mouth on the outgoing tide ([85, 120]). These materials were then distributed by currents along the coast. These discharges ceased on 22 November 1968 when the submarine pipe at Umlaas was put into service and in November 1969 when a submarine outfall at the Bluff came into operation ([85]).

Public health aspects

At one stage (1890) the mangroves of Durban Bay were considered to be detrimental to health, because of malaria mosquitoes being harboured within the swamp ([13]).

Bacteriology. Before the submarine pipes became operational (1968/1969) *E. coli* counts in the harbour mouth used to exceed 5 million/100 ml and *Salmonella typhi* was frequently encountered ([85]). A dramatic decrease resulted when discharges into the harbour mouth ceased, so that conditions in the surf both north and south of the harbour entrance, improved to Class I standards by 1971.

In 1974 the rivers entering the bay (mistakenly referred to as the harbour waters) exhibited gross faecal pollution ([85]). This situation is, once again, suggestive of pollution sources in the Umbilo/Mhlatuzana catchment.



The process of infilling and reclamation has gradually eliminated what was once the most extensive mangrove community in Natal.

BIOTIC CHARACTERISTICS

Flora

Twenty years ago Durban Bay supported ±200 ha. of mangroves, which was the most extensive mangrove swamp in Natal. The swamp occupied about a quarter to one-fifth of the bay, and was confined to its southern and western margins. Almost all of these trees have been destroyed by infilling and reclamation during the course of harbour and industrial development ([30, 231]). A pitiful remnant of *Avicennia*, *Bruguiera* and *Rhizophora* remains. Elsewhere quays and wharfs have replaced marginal vegetation and dredging has eliminated beds of *Zostera* which once grew in the bay ([202]). Without marginal vegetation, mangroves and *Zostera*, a major portion of the original fauna have been unable to maintain themselves in the Bay ([170]). The gradual destruction of the mangroves has received resistance from the public from as long ago as 1890 ([13]).

Some attention has recently been given to the blue green algal communities growing on the surface of the bay sediments directly opposite the remaining mangroves, by the Geology Department of the University of Natal (Mason, pers. comm.). It has become clear that the algae and diatom associations on the mud surface play an important pioneering role in stabilizing these sediments. There are seasonal outbursts of the sea lettuce (*Ulva lattica*) in the bay during June to September ([202]).

The last 3,5 km of the Bluff is still reasonably well covered by coastal forest.

Fauna

Surveys during the 1950's revealed a tremendously productive bay supporting a very diverse fauna. 563 species were listed ([120]), excluding bird life and animals considered as unidentifiable. 186 of these were fish. Day and Morgans ([120]) considered the absence of surf and strong currents and the nature of the substratum as determining factors. Bearing in mind that 50 years prior to this survey, the basic productivity of the bay must have declined after the increase in tidal exchange associated with bar removal and channel deepening, the bay in its predeveloped form must have been almost unbelievably rich in estuarine life.

By the 1950's the effects of dredging on the fauna of the sand and muddy substrates of the bay were apparent. Undisturbed areas had naturally remained the richest in this respect. With the continuation of dredging over the last two decades, hardly any undisturbed areas remain.

Although utilization of the bay is still made by juvenile and larval forms of marine organisms, as well as adult forms seeking food, their existence and growth is jeopardised by effluent releases. The effects on life in the bay after such a release has been described by Heydorn ([171, 172]). It is also not uncommon to catch fish in the bay which are in a diseased or emaciated condition.

Nevertheless in the absence of these intermittent periods of pollution, the bay still appears to continue to serve as an important nursery area for marine life (Ballard, pers. comm.) when what lives in Durban Bay is compared with what lives in nearby lagoon systems. A surprisingly rich fish fauna persists ([328]) many of which are typically euryhaline estuarine forms and juveniles of those species that normally abound in "true" estuaries. The juveniles of 12 of the main species of estuarine fish in Natal, were recorded as present by Wallace in the early 1970's ([329]). Molluscs (such as *Terebralia* and *Cerithidia*) still survive where mangroves occur in the bay. Barnacles are also conspicuous, growing upon every conceivable object, as is the tiny maritime insect (*Anurida maritima*) which may be found all over the mudflats at low tide (pers. obs.).

Birds. During the course of 36 counts over the period 27 January 1974 to 28 October 1977, Sinclair and Nicholls (pers. comm.) have demonstrated the presence of 50 species of estuarine birds in Durban Bay. Amongst these, certain waders such as the Broad billed sandplover, Mongolian and Grey plovers are noteworthy because of their rarity elsewhere. The numbers of certain species such as the Greater flamingo, Knot and the two plovers already mentioned, have been dwindling during the study period. A small colony of Pink-backed pelican occurs, and gulls, especially the Greyheaded, are abundant. Durban Bay is a stronghold of the Curlew sandpiper, being second only to Richards Bay in this respect.

SYNTHESIS

Our state of knowledge of Durban Bay is poor and outdated. This is a situation that should be rectified because, when one considers the productivity of the Bay even in the 1950's ([120]) and various statements made since then ([328]), it would be of great value to establish to exactly what degree estuarine organisms utilize the bay in its present condition. Such a study would serve not only as an index as to what ecological value can still be attributed to Durban Bay, but also would illustrate what the effects of 25 intervening years of continued harbour development have been.

Nevertheless, irrespective of what the bay still supports, in its present environmental condition, the system has become severely degraded as a result of harbour development. This situation can be attributed to four major influences:

- the gradual elimination of marginal vegetation;
- the disruption of suitable substrates as feeding grounds;
- industrial pollution, which, more often than not is toxic; and
- the increased tidal exchange.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC									
			Physio-graphy	Physics				Geomor-phology			Chemistry						Other								Flora			Fauna							Food Webs
DURBAN BAY ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles				
Data Voids																									◄	★	►						
Source of Information	Summary of available information																																	
Stebbing	1914 to 1917	un-cited																								●								
Day & Morgans	1950 to 1952	120		●		●	●			●										●		●				●	●	●						
Joubert	1963	202		●		●																●					●							
Brand *et al*	1964	43									○																							
King & Maud	1964	207						●	●																									
McCarthy	1967	215						●																										
Moll *et al*	1971	231																				●												
Orme	1971	257						●	●	●																								
Heydorn	1971	170, 171		●							●									●		●						●						
Heydorn	1974	172									●																	●						
Sinclair & Nicholls	1974 to 1977	pers. comm.																											●					
Wallace	1975	328, 329																										●						
Cloete & Oliff	1976	85									●		●		○																			
Berjak	1977	30																				●				●								
Mason	1978	pers. comm.						●	●	●													●											
Aerial photos (Scogings)		Nos.																																
1:25 000 Job No. 141	1973	174		●																●		●												

2.1.8.3 **SIPINGO**

Synonyms

This lagoon is most commonly referred to as the Isipingo.

Zulu meanings

uMpingo is a spear with a loose fitting blade, used for killing elephant. Other meanings given ([269]) are:

(a) the river that twists;
(b) a long narrow penetrating channel of water, reminiscent of the "ipehngele wattle" used for holding down thatch on a hut; and
(c) the place of adultery.

Location

30°00'S; 30°57'E.

Accessibility

By road the Sipingo lagoon is 21 km south south-west from the centre of Durban. Various roads provide access to both banks of the lagoon, the most convenient being those leading to the southern bank.

Bridges

On the entrance to the southern limb of the lagoon, there is a small road bridge, providing access to the Isipingo Hotel.

At the head of the lagoon (on the northern limb) a major road bridge crosses the system.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 29 km^2 ([98]); 37 km^2 (NTRP); 44 km^2 ([245]) and 46,6 km^2 ([43, 335]).

River length. 27 km ([245]).

Mean annual run-off. 3,34 x 10^6 m^3 ([245]).

Flow. Flow from the Mlazi river, previous to 1952 (see appendix to this report) was sufficient to prevent the mouth from closing. Prior to the diversion of the Sipingo river in 1969, the average flow was given as 1,7 m^3/sec. (range ,28 m^3/sec. to 2,8 m^3/sec.) ([43]).

Flood history. Orme ([257]) has shown the highest recorded flood level to be 2,5 m above sea level, presumably prior to the diversion of the Mlazi and Sipingo rivers. Floods of this magnitude probably inundated the whole of the Isipingo flats. 1:100 year floods from the Sipingo river have been calculated to discharge 325 m^3/sec., while 1:10 year floods are said to discharge 159 m^3/sec. ([98]). Details of the more destructive floods since 1856 are available ([335]). The last severe flood was in 1935 — but since diversion/canalization of the Mlazi river (in 1952) and diversion of the Sipingo river into the Mbokodweni (in 1969), flood dangers have been reduced. Simultaneously the ecological benefits of flooding have been reduced (see Figs. **54** and **55**).

Dams. There are no suitable dam sites on the Sipingo river. In addition the quality of the water is considered to be unsuitable and the quantity of water inadequate ([245]).

Siltation. Ward ([335]) has expressed concern about siltation of the Sipingo lagoon resulting in the extreme shallowing of the system. Apart from the silt load of the Mlazi river (pre-diversion), the opening of a canal between the southern and northern arms of the system in 1906 (for boating purposes) accelerated the process. Much siltation also took place apparently during the development of Prospecton (Jackson, pers. comm.). On the other hand, Orme considers "comparatively little sediment input . . ." to be characteristic of the Sipingo system ([257]).

Land ownership/use. 37,2% of the catchment is Bantu influenced and destined to become incorporated into KwaZulu. Particularly influencial are the industrial areas of Isipingo Rail and Prospecton, and sugar cane areas within the catchment.

On the southern bank of the lagoon there is a hotel and a new township is under construction. The lagoon is overlooked by the township of Isipingo Beach and there is a tearoom at the mouth.

A sand removal company (Isipingo Sand) operates on the northern bank. Sugar cane surrounds the head of the lagoon.

Local authority. The northern bank is under the control of the Borough of Amanzimtoti. Control of the southern bank was given to the Indian Borough of Isipingo in 1972.

Estuary uses. Although formerly a very popular boating and angling venue, utilization has been limited by pollution. Locals (an Indian community) can still be found angling in the lagoon.

Morphometry of the lagoon. (see Fig. **55**).

Area. 6,8 ha.

Axial length. The lagoon is 1,25 km along its northern arm.

Shoreline length. 4,2 km.

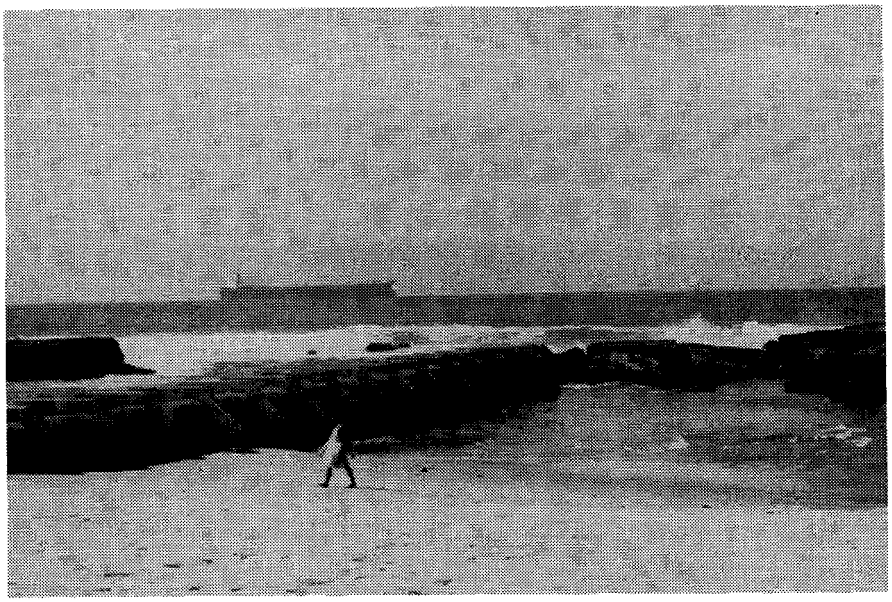
Width.

Maximum: At its widest, the southern arm of the system is 100 m.

Mouth: The mouth of the Sipingo lagoon comprises two concrete pipes (each 1 m in diameter) which were laid in 1961 ([335]).

Floodplain: ±250 m.

Shape. The Sipingo lagoon is roughly V shaped. Ward ([335]) considers the southern extension of the system to be a lagoon and the northern extension an estuary.



A piped outlet came to function as the mouth of the Sipingo lagoon after the diversion of the Mlazi river in 1952.

Bathymetry. Depths of 7,5 m were reported in 1910 ([335]) and one spot in the southern arm is still in excess of 6 m deep (pers. obs. 28 April 1977). Elsewhere the lagoon is less than 3 m deep. It is particularly shallow (0,15 m) near the mouth.

Geomorphology

Geology. Outcrops of Table Mountain Sandstone and Dwyka rocks occur in the Sipingo catchment, whilst Tertiary and recent sediments occur nearer the coast ([43]).

The lagoon is surrounded by alluvium, modern dunes and weathered red sands ([335]). Bedrock lies at a depth in excess of 22 m ([257]). Sand mining takes place immediately north of the lagoon.

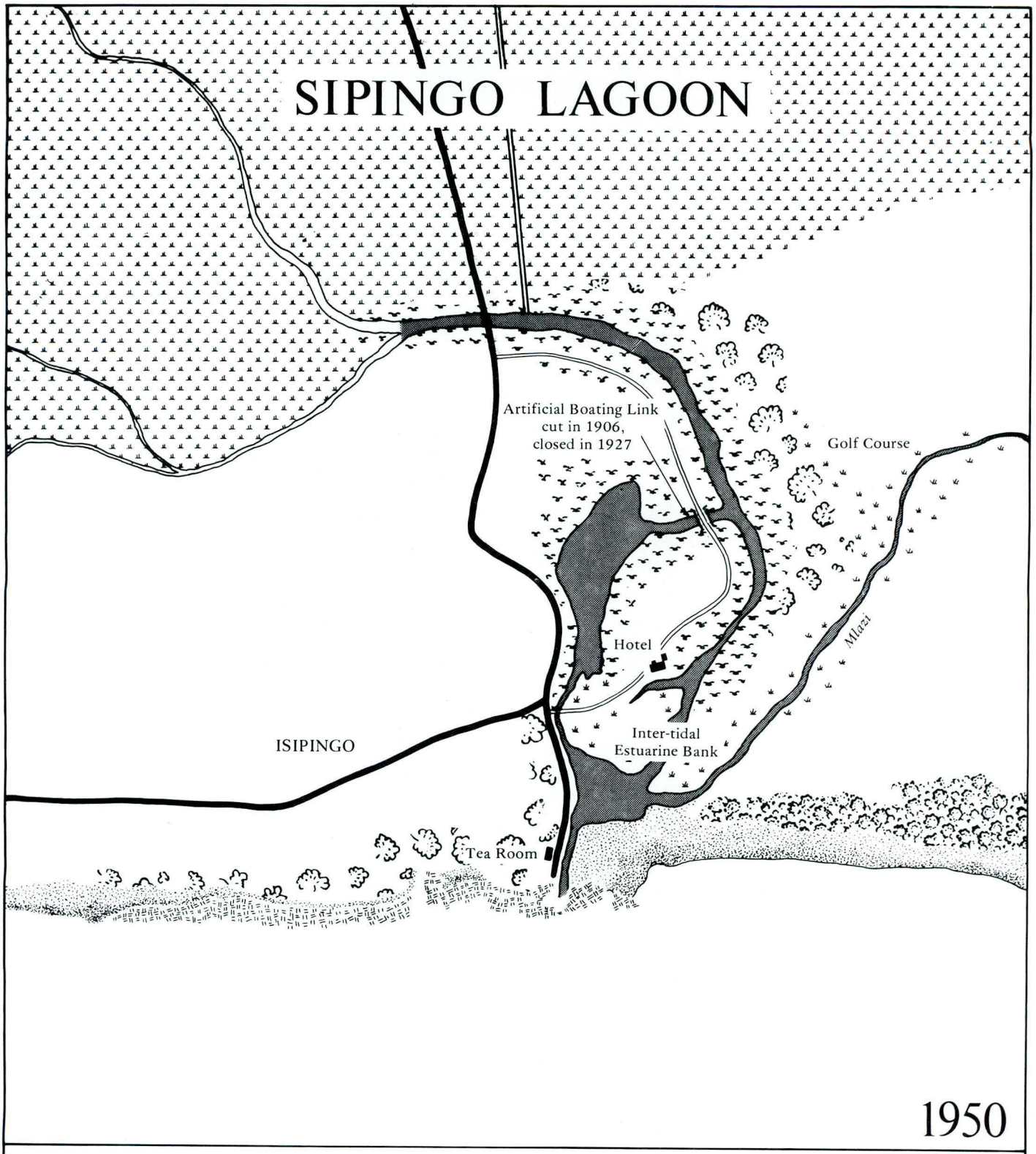

SIPINGO LAGOON
Artificial Boating Link
cut in 1906,
closed in 1927
Golf Course
Hotel
Mlazi
ISIPINGO
Inter-tidal
Estuarine Bank
Tea Room
1950
Coastal Dune Forest
Mangroves
Transitional Forest
Reed Swamp
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 54

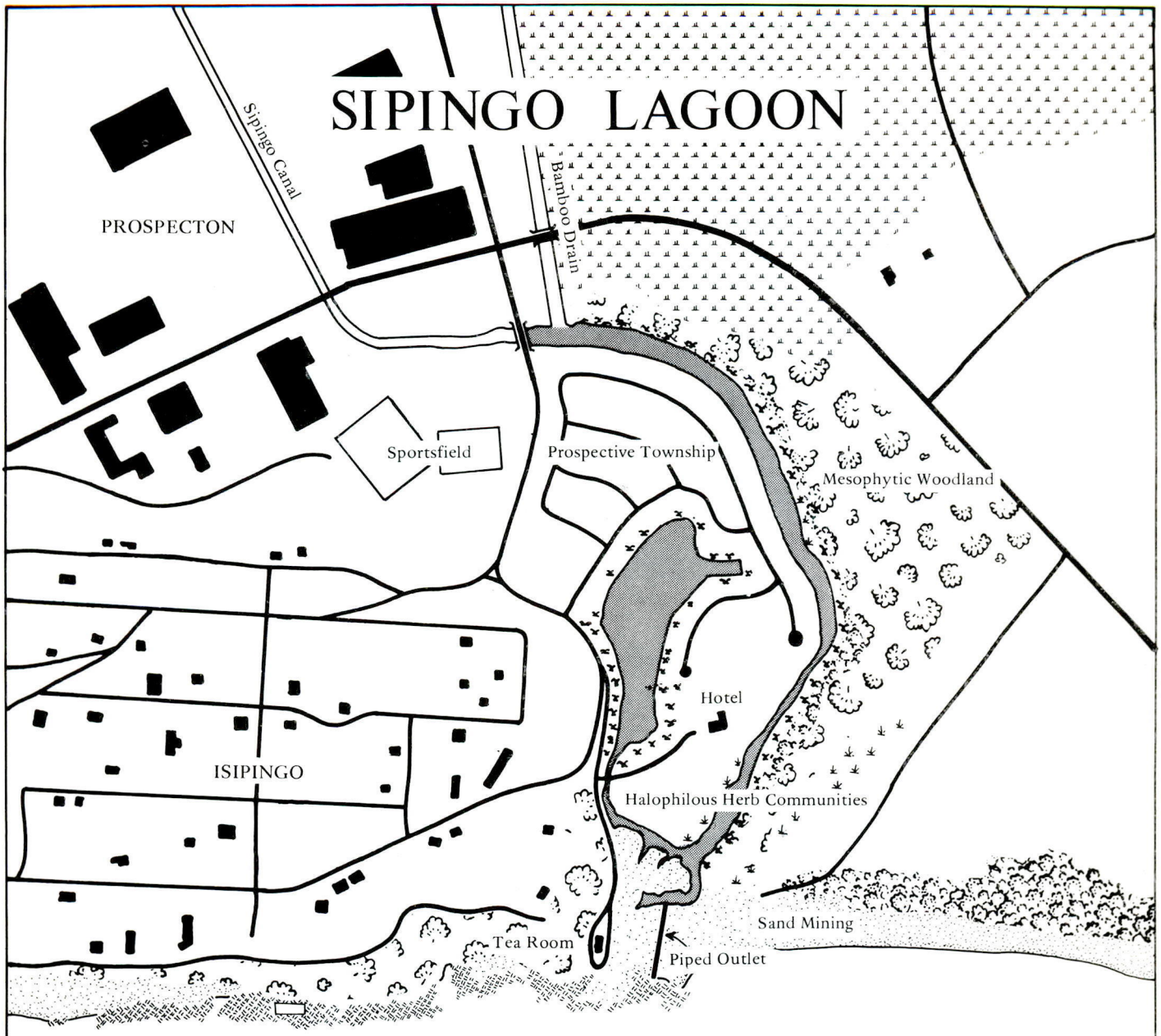
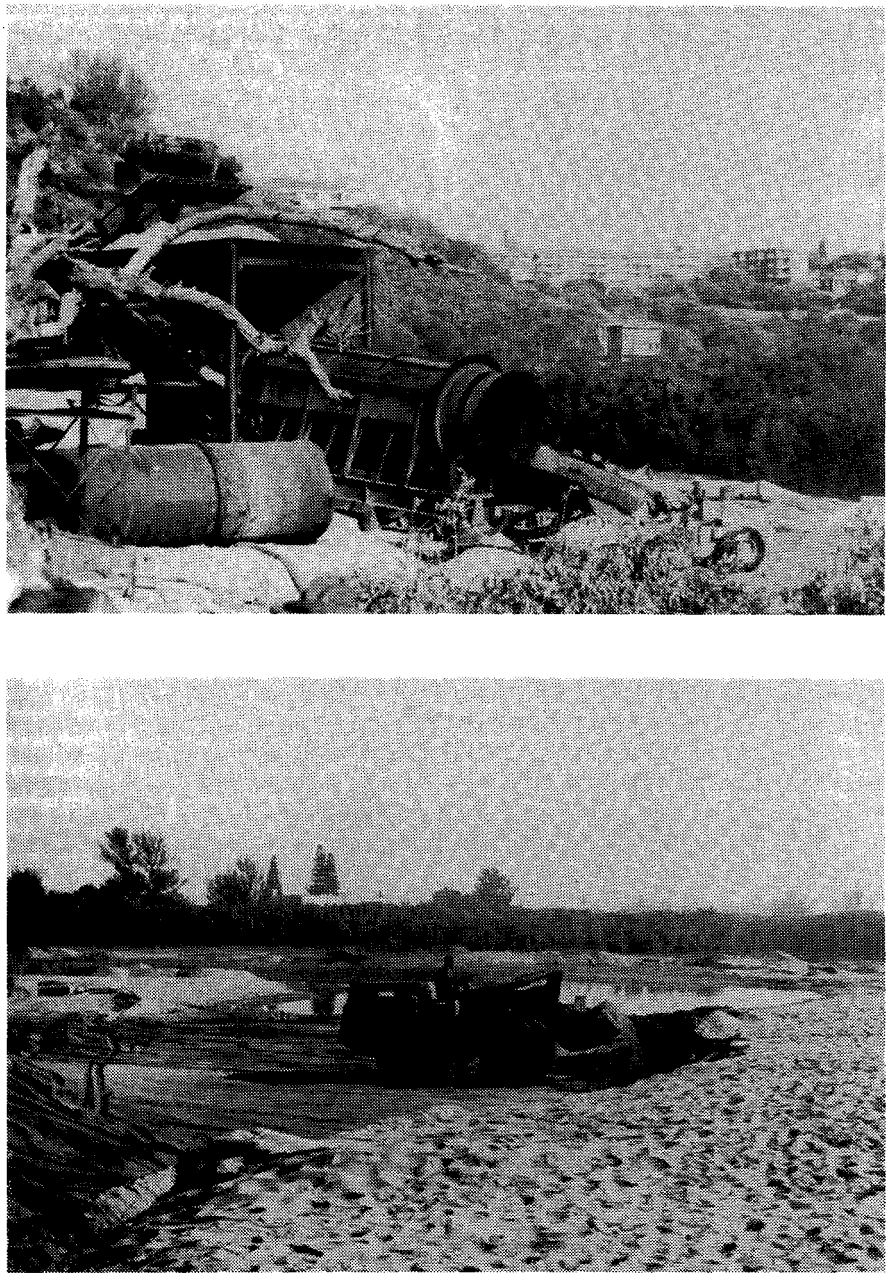

SIPINGO LAGOON
Sipingo Canal
Bamboo Drain
PROSPECTON
Sportsfield
Prospective Township
Mesophytic Woodland
Hotel
ISIPINGO
Halophilous Herb Communities
Sand Mining
Tea Room
Piped Outlet
1976
Coastal Dune Forest
Transitional Forest
Reed Swamp
Mangroves
Cane
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 55



The reclamation of sand from the Sipingo sandbar is an activity that, if undertaken at the mouth, could benefit the lagoon considerably.

Nature of bottom materials. (see Fig. **56**). Orme ([257]) describes the Sipingo lagoon as a "tranquil, sedimentary environment . . ." resulting in the deposition of various proportions of sand, silts and clays. The northern bank still comprises a sufficiently muddy substrate to support mangroves. Marine sand is washed into the mouth of the system at high spring tide.

Sandbar characteristics. The Sipingo sandbar was formerly 250 m long and south extending. The mouth position was (and occasionally still is) against the southern bank. Since the diversion of the Mlazi and Sipingo rivers, the mouth has become sealed. Two concrete pipes underneath the bar are the only means of contact with the sea. MacNae ([217]) could have been under the wrong impression when he suggested that they were non-return pipes, which would prevent sea water from coming in, but permit river water to run out. They are open pipes today and the system is considered to be tidal in its lower reaches, because at spring tide "salt water comes upstream almost as far as Isipingo Rail" ([43]).

Mechanical opening of the bar became necessary after the system closed semi-permanently in 1952 ([335]). Since the pipes were laid as an outlet in 1961, breaching has been unnecessary. Sand removal occurs because the bar is composed of materials suitable for fill and construction and because it is easily accessible.

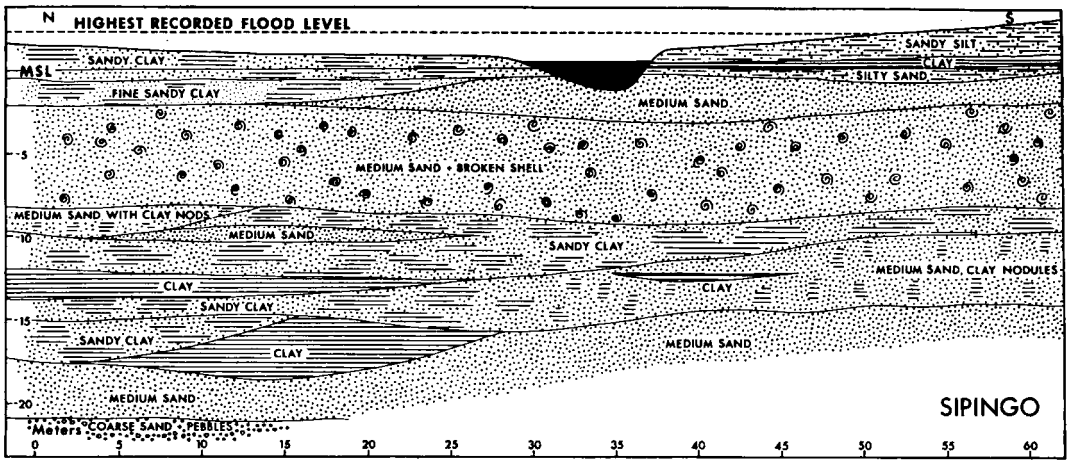


Fig. 56. Cross section beneath the Sipingo flats after Orme ([257]).

Configuration of the adjacent shore ([132]).
Beach type — asymmetrical beach, sheltered from the south and suitable (with reservations) for bathing.

Average beach slope — 7°
Average beach width — 65 m
Average sand grain size — 708 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are apparently absent in the near vicinity of the lagoon.

Physico-chemical characteristics.
In 1964 Brand *et al* ([43]) concluded that the water of the Isipingo river was chemically of poor quality 2,5 km above the lagoon. The anomalous mineralization of the river water was thought to be due to some geological factor, due to excess irrigation run-off or even due to sea water brought up the lagoon at high spring tide (see Table **37**). The seepage and drainage of industrial effluents from the surrounding area of Isipingo Rail, could also account for these characteristics in the river. From the results of Kirk (see Table **37**) who regularly analyses water samples from the system on behalf of the Borough of Amanzimtoti, the lagoon is clearly polluted (Stuart, pers. comm.). The lagoon has eutrophic characteristics because effluents from the Umlazi sewage works enter the river upstream.

It is interesting to note from Kirk's chloride values that salinities as high as 10‰ have been recorded (on 17 March 1975) at the head of the lagoon. This is surprising as not a great deal of sea water enters the system through the piped outlet. It would appear, however, that whatever sea water does enter, remains only semi-diluted because of the minimal fresh water inflow.

In 1974 the lagoon was examined for the presence of heavy metals by Turner *et al* ([303]), and Grindley ([137]) has drawn attention to pollution of the Sipingo by detergents.

Public health aspects

Bacteriology. Once the Mlazi river became diverted in 1952, pipes had to be installed at the mouth of the lagoon, to prevent the creation of a health hazard ([335]). Harris found the Sipingo lagoon to be polluted by the effluent from septic tanks in 1953 ([145]). From the results of Brand *et al* in 1964 ([43]) and Stuart (pers. comm.) in the 1970's, both river and lagoon were organically and faecally polluted (see Table **38**). This is hardly surprising because effluent from the Umlazi sewage works enters upstream.

Table 37. Physico-chemical characteristics.

Locality: Sipingo	(43) 2.5km above lagoon 1964		Stuart (pers. comm.)* Station I4 in lagoon 1975		1976		
	Summer	Winter	17 Mar	24 Nov	7 Jun	27 Sep	29 Nov
Hydrogen ion concentration (pH)	7.3	7.7	7.5	7.7	6.9	7.4	7.1
Saturated pH value	9.0	8.5	-	-	-	-	-
Conductivity micromhos/cm	387	650	-	-	-	-	-
Total dissolved solids ppm (calculated)	248	326	-	-	-	-	-
Dissolved oxygen mg/litre	6.2	5.8	-	-	7.8	6.6	6.4
% Saturation	74	54	-	-	-	-	-
Oxygen absorbed mg/litre	-	-	-	-	6.0	6.6	6.0
Biological oxygen demand mg/litre	1.8	1.3	7.0	3.8	7.9	7.5	6.4
Permangenate value (after four hours)	-	-	6.8	6.0			
Kjedahl nitrogen mg/litre	Trace	Trace	-	-	-	-	-
Ammonia "	Trace	Nil	-	-	-	-	-
Nitrites "	0.063	Trace	-	-	-	-	-
Nitrates "	.90	.32	-	-	-	-	-
Phosphate "	.13	.21	-	-	-	-	-
Total alkalinity "	60	116	-	-	-	-	-
Total hardness "	68	110	-	-	-	-	-
Calcium "	7.9	14.6	-	-	-	-	-
Magnesium "	11.8	18.1	-	-	-	-	-
Sodium "	59	75	-	-	-	-	-
Potassium "	2.9	2.6	-	-	-	-	-
Sulphates "	15.5	1.0	-	-	-	-	-
Chlorides "	86	126	5 500	4 700	390	325	476
Silica "	25	15.5	-	-	-	-	-
Iron "	-	1.4	-	-	-	-	-
Free carbonic acid (as ppm carbon dioxide)	5.5	4.1	-	-	-	-	-
Temperature °C	25.0	12.5	-	-	-	-	-
Turbidity (ppm silica scale)	-	27	-	-	-	-	-
Appearance	Dirty	Dirty	-	-	-	-	-

* Stuart obtained information directly from B.N. Kirk Inc.

Values underlined significant of disturbance.

Table 38. Bacteriology of the lower Sipingo.

	Date	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml
		5 days @ 32°C	Confirmed
2,5 km above lagoon (43).	2 April 1964	90	**27 800**
	6 May 1964	**350**	200
	5 August 1964	**3 650**	130
	16 November 1964	—	**54 400***
At Station I4 in the lagoon (Stuart, pers. comm.).	27 November 1973	—	**60 000**
	10 June 1974	—	**35 000**
	9 December 1974	—	**90 000**
	17 March 1975	—	**160 000**
	15 July 1975	—	**35 000**
	6 October 1975	—	**25 000**
	29 November 1976	—	**60 000**

*Membrane count.

Values in bold significant of disturbance.

In conclusion therefore the Sipingo lagoon constitutes a public health hazard. This state of affairs is unacceptable if the Indian community intend to use the lagoon as a recreational amenity in the future. Drainage from the township which is presently under construction on the edge of the lagoon, is likely to make conditions worse. Due to the piped outlet, flushing of the lagoon is presently inadequate.

Bilharzia. *Physopsis* was collected amongst the marginal vegetation in the Sipingo river in 1964, 2,5 km above the lagoon (43). This, together with the low flows, the Bantu influenced catchment and sewage pollution, increases the likelihood of contracting bilharzia in the lagoon.

BIOTIC CHARACTERISTICS

Flora

Day (116) and MacNae (217) provide some of the earliest descriptions of the vegetation surrounding the lagoon in 1950 and 1961 respectively. The area surrounding the Mlazi/Sipingo estuary was originally covered by mangroves, low lying woodland, marsh and scrub communities. Many of these communities were destroyed when the construction of the Louis Botha Airport began in 1946. The process continued during the period 1966 to 1970, with the development of Prospecton. In 1965, virtually all of the mangrove swamp on the southern bank and the central island area of the lagoon was reclaimed for township development (231, 335). The mangroves that remain on the northern bank, are only a tiny remnant of this swamp. Despite this, they are in good condition (231) and exhibit interesting stages in mangrove succession leading to coastal forest (335). MacNae (217) considered that the Sipingo mangroves would disappear within a decade, as *Avicennia* showed signs of dying back as long ago as 1961 (see Figs 54 and 55).

The plant communities in the vicinity of the Sipingo lagoon were studied in great detail by Ward in 1969/1970 (335). Other than mangroves (*Avicennia*, *Bruguiera* and the occasional

Rhizophora) the major elements comprised *Hibiscus tiliaceus* communities, *Phragmites* marsh/reed swamps and halophilous herb communities.

Water hyacinth (*Eichornia crassipes*) has flourished within the lagoon for years, severely limiting any utilization. It is cleared manually. Ward reported the occurrence of *Pistia stratiotes* (another floating plant) in the river in 1969 ([335]).



Blooms of water hyacinth (Eichornia crassipes) completely cover the Sipingo lagoon at certain times (25 March 1977).



The surviving mangroves (Avicennia marina) alongside the Sipingo lagoon suggest restoration of the system is feasible.

Fauna

The earliest information (see Table **39**) available is that from the collections made in 1950 by Day ([116]). He listed 50 different organisms as present, 17 of which were fish.

In 1961 MacNae ([217]) drew attention to the "elimination of fiddler crabs" in the Sipingo and attributed this to the effects of fresh water. It is interesting to note however, that even Day's survey, **prior to closure of the mouth,** failed to reveal their presence. MacNae also attributed the lack of snails to the effects of fresh water, but in 1964 Brown ([54]) collected six species of gastropod snails from the Sipingo. Today, it would appear that, together with *Avicennia* (the hardy, pioneering species of mangrove) certain elements of the fauna (such as

Sesarma crabs) have successfully maintained themselves for the last 25 years, since the mouth closed. The secret to their success must be the inflowing sea water (albeit restricted) and because of the lack of river inflow, no prolonged periods of inundation.

Although *Mugil cephalus* and *Sarotherodon mossambicus* are still present (pers. obs.) angling was once reported to be excellent. The lagoon is by no means devoid of birdlife, although only six estuarine associated species were present on 28 April 1977 (pers. obs.).

Table 39. Fauna of the Sipingo estuary in 1950, after Day ([116]).

Group	Number of species	Details of those species listed as common (c) or abundant (ab)
Polychaete	2	
Tanaid	2	*Apseudes digitalis* (ab) *Tanais philetaerus* (c)
Amphipoda	3	
Cumacea	1	At high tide mark on rocks in
Cirripede	1	Sipingo mouth.
Bivalves	3	
Gastropoda	9	*Cerithidea* on mangroves (c)
Crabs	6	*Sesarma* amongst mangroves (ab)
Prawns	4	*Macrobrachium equidens* (ab) *Metapenaeus monoceros* (c) *Penaeus indicus* (c)
Insects	2	
Fish	17	2 species *Ambassis* (c) *Liza macrolepis* (c)

SYNTHESIS

Whilst outdated in many respects, a fair amount of knowledge has been accumulated on the Sipingo lagoon. However, it is one of the most severely degraded of estuarine systems in Natal. This situation has arisen chiefly as a result of mouth closure, once the inflowing rivers which previously fed into the estuary, were diverted elsewhere. With insufficient tidal exchange, industrial and sewage wastes accumulated and plants such as *Eichornia* (the water hyacinth) and animals such as bilharzia snails, flourished. These have rendered the water body unfit for any purpose, other than becoming a sump into which wastes from the catchment area gravitate. River diversion thus transformed a thriving estuary into a polluted backwater.

Although restoration of the Sipingo lagoon may seem impossible, the following points should be considered:

(a) the incredible resilience of the system has been demonstrated by the survival of mangroves and their associated fauna, despite tremendous modification and abuse by man;
(b) Although obviously no longer in its former condition, it is still the best endowed lagoon along a 30 km stretch of coast between Durban and Illovo Beach and;
(c) it has considerable potential as a recreational/educational facility to the Indian community.

A greater degree of contact with the sea remains as the key to revival of the whole system, i.e. the improvement of water quality, rejuvenation of the mangrove community, the control of hyacinth and an improvement in the fishing.

ESTUARY/LAGOON SIPINGO (and Mlazi River) ○ = denotes river survey	Year (date of information)	Reference number in Text.	ABIOTIC																							BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other							Flora			Fauna								Food Webs
			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles				
Data Voids					←—★—→						←—★—→											←—★—→			←—★—→									
Source of Information	Summary of available information																																		
Day	1950	116		●	●					●												●		●			●	●						
Harris	1953	145									●				●																			
Meinecke	1959	220	●		●																													
MacNae	1961	217	●				●															●		●			●							
Brown	1964	54																				●				●	●							
Brand *et al*	1964 to 1965	43	●		●			●			○	○			○										○	○								
CSIR (NMERI)	1968	98	●		●																													
Ward	1969 to 1970	335	●	●	●		●	●		●									●			●		●										
Grindley	1970	137									●																							
Fromme	1970 to 1975	132								●																								
Moll *et al*	1971	231																				●												
Ninham Shand & Partners	1971	245	●		●					●																								
Orme	1971	257	●		●			●		●																								
Loxton, Hunting & Assoc.	1971	213	●																															
Turner & Livingstone	1974	303											●																					
Serfontein	1975	277								●																								
Stuart	1974 to 1976	pers. comm.									●	●			●																			
Aerial photos (Scogings)		No.																																
1:10 000 Job No. 261	1976	221		●						●												●		●										
1:25 000 Job No. 262	1976	504	●	●																														

MLAZI CANAL
(Appendix to Sipingo Lagoon)

Introduction

The Mlazi canal is artificial and exists for some considerable length of its course as a concrete lined drainage canal. It can hardly be termed an estuary and really falls outside the objectives of this survey. However an understanding of the Mlazi is fundamental to the understanding of the Sipingo lagoon, because until the Mlazi was diverted to its present position in 1952 ([335]), both systems were united.

Synonyms

Umlaas.

Zulu meaning

"The river like whey", because of its colour and stale taste ([289]).

Location

The Mlazi canal opens to the sea 13,5 km south west of the entrance to Durban harbour.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 925 km^2 ([213]); 945 km^2 ([220]); 956 km^2 ([245]); 984 km^2 ([335]).

River length. 300 km ([245]).

Mean annual run-off. 68 x 10^6 m^3 ([245]).

Flow. The annual average flow has been estimated at 19 m^3/sec. ([43]). The normal ranges experienced are a maximum flow of 35 m^3/sec. in the rainy season; and a minimum of 5,9 m^3/sec. in the dry season.

Flood history. Peak flow in the May 1959 floods was estimated at 2 285 m^3/sec. ([220]).

Dams.

Existing: Shongweni dam (or Vernon Hooper dam) ([220]), built in 1927 ([43]).

Proposed: A dam site has been located 113 km from the sea at Welbedagt ([245]).

The Mlazi has served as the source of water for Durban since 1891. The diversion weir (Durban city intake) is 16 km below the Shongweni dam. The city abstracts between 22,7 x 10^6 m^3 ([43]) and 41,5 x 10^6 m^3 ([213]) of water per annum.

Siltation. Annual siltation at the Welbedagt site is estimated to be 0,55 x 10^6 m^3 ([245]). By 1951, 37% of the capacity of the Shongweni dam had been lost through siltation ([277]). The Camperdown dam (which collapsed in 1943) was 72% silted within 22 years of its construction ([277]).

Land ownership/use. In the catchment of the Mlazi river are dairy farming areas, Bantu farmlands, the Umlazi location and Umlazi Mission reserve.

In the immediate vicinity of the outfall is the South African Petroleum Refineries (SAPREF), the Louis Botha International Airport and the Merebank Industrial area.

Local authority. Durban Corporation.

Canal uses. Effluent/stormwater disposal.

Physico-chemical characteristics

From a survey in 1964 ([43]), appreciable pollution is generally evident in the Mlazi canal (see Table **40**).

Samples from the Mlazi were analysed for heavy metals in 1974 ([303]).

Table 40. Physico-chemical characteristics ([43]).

Locality: Mlazi Canal Distance from sea: 1km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	8.1	8.3
Saturated pH value	8.7	8.1
Conductivity micromhos/cm	207	454
Total dissolved solids ppm (calcd.)	130	287
Dissolved oxygen mg/litre	7.3	13.3
% Saturation	9.9	158
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.9	12.0
Kjedahl nitrogen mg/litre	0.9	5.9
Ammonia mg/litre	0.2	1.7
Nitrites mg/litre	0.022	.487
Nitrates "	.51	2.45
Phosphates "	.23	.82
Total alkalinity "	56.8	118.1
Total hardness "	51	87
Calcium "	83	17.5
Magnesium "	7.3	10.6
Sodium "	25.2	64.4
Potassium "	1.9	7.3
Sulphates "	7.7	15.2
Chlorides "	28.4	71.4
Silica "	14.8	14.9
Iron "	0.1	0.8
Fluorides "	0.1	0.4
Free carbonic acid (as ppm carbon dioxide)	0.9	1.2
Temperature °C	32.0	25.0
Turbidity (ppm silica scale)	102	34
Colour (APHA units)	20	120
Appearance	Turbid	Very dirty
Odour	-	-

Values underlined significant of disturbance.

Public health aspects

Bacteriology. Effluent and seepage from sewage ponds at Lamont and Mlazi (both Bantu areas) and Chatsworth (an Indian area) drain into the Mlazi river ([43]). Consequently faecal and organic pollution is evident and *Salmonella* regularly isolated (see Table **41**). It has been suggested that Pietermaritzburg's effluents should be diverted into the Mlazi in order to diminish the load entering the Mgeni (Munroe, pers. comm.).

Table 41. Bacteriology of the Mlazi canal (1 km from the sea).

Date	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml	*Salmonella* per 500 ml
	5 days @ 32°C	Confirmed	
29 June 1964	—	**6 000***	+
27 August 1964	**9 000**	**54 2000**	
15 December 1964	**270**	**8 300**	
19 January 1965	49,5	2 000	
25 January 1965	—	2 080*	

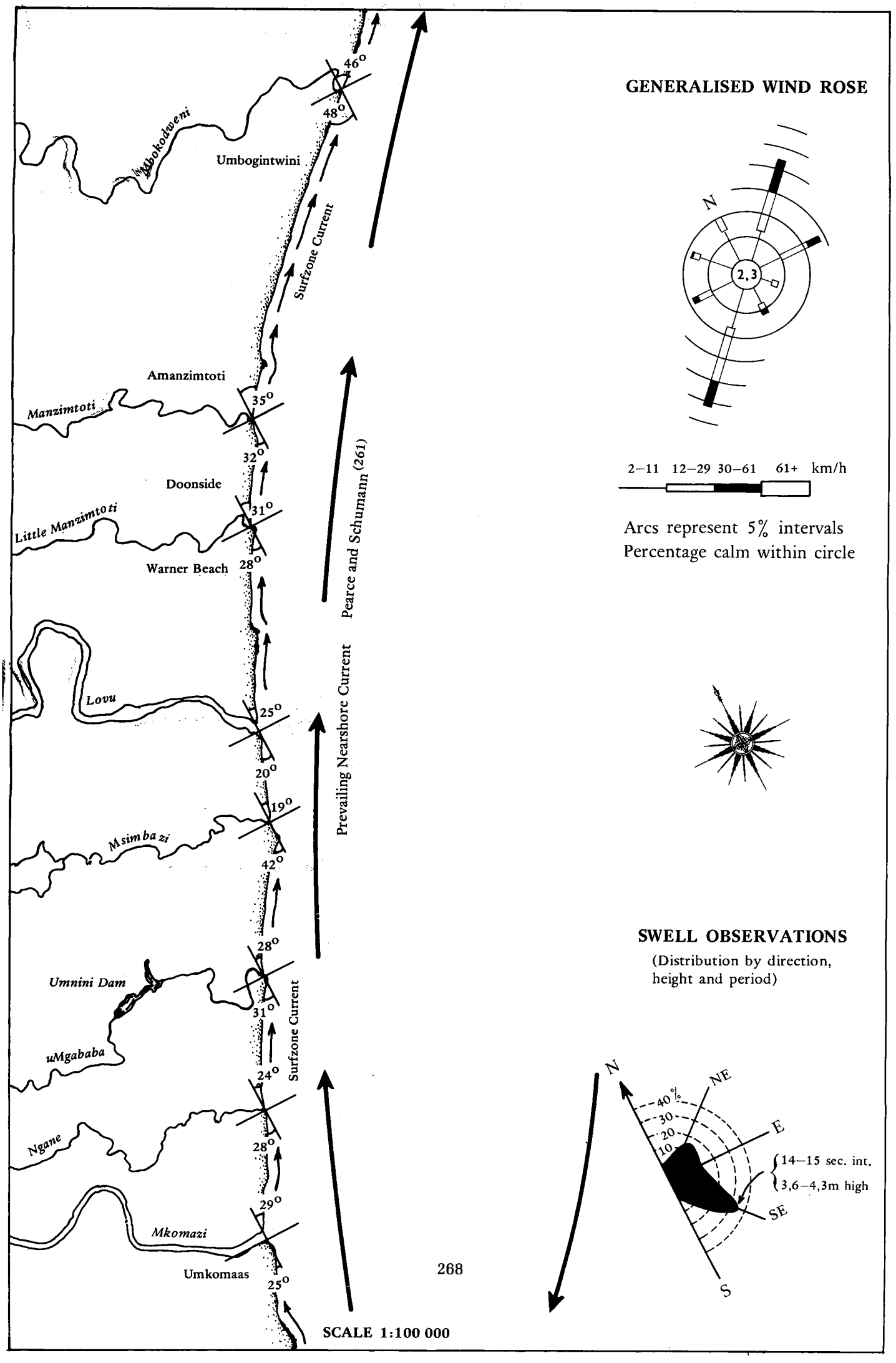
*membrane count

Values in bold significant of disturbance.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Not applicable.



GENERALISED WIND ROSE

2–11 12–29 30–61 61+ km/h

Arcs represent 5% intervals
Percentage calm within circle

SWELL OBSERVATIONS

(Distribution by direction, height and period)

SCALE 1:100 000

2.1.9.1 **MBOKODWENI**

Synonyms
Umbogintwini is the most commonly used synonym, also spelt Umbohodweni [236].

Zulu meaning
eMbokindwini is said to mean "the place of the round stones" [289].

Location
30°01'S; 30°56'E.

Accessibility
By road the lagoon lies 24 km south west of Durban. Golf course development on both banks renders all of the lagoon easily accessible.

Bridges
There are no bridges across the lagoon itself. Three road bridges, a railway bridge and a footbridge traverse the river 500 m to 800 m above the head of the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Before considering the present characteristics of the Mbokodweni catchment, it must be realized that the Sipingo river was purposely diverted along a grass-lined canal into the Mbokodweni in 1969 [98]. Consequently characteristics from the Sipingo catchment may reveal themselves in the Mbokodweni lagoon.

Area. 235 km^2 [213]; 241 km^2 [98]; 243 km^2 [245]; 256 km^2 [43, 145].

River length. 47 km [43]; 71 km [245].

Mean annual run-off. 9,5 x 10^6 m^3 [213, 245].

Flow. In the dry season, African Explosives & Chemical Industries (AECI) abstract the entire flow of the Mbokodweni river [43]. With the floodwaters of the Sipingo river now diverted into the Mbokodweni, the flow below the point of entry has altered considerably.

Flood history. The Mbokodweni was known to flood in 1953, 1957, 1961 and 1967 [98]. A storm in March 1968, resulted in flood discharges of 300 m^3/sec. [99]. 1:100 year floods are estimated to discharge 1 416 m^3/sec. [98]. The northern bank of the lagoon has been protected by stone-cageing to ensure that the industrial area of Prospecton is protected. Floodwaters from the Sipingo river were also diverted into the Mbokodweni to prevent the flooding of Prospecton. A model study was done of the system by the National Mechanical Engineering Research Institute (CSIR) in 1968 [99]. This showed that by creating a new mouth, flood levels would be lowered but water velocities would increase. It is presumably the latter which is causing the alarming rate of bank erosion in the golf course area today. The golf course authorities are trying to develop a scour channel on the opposite bank in order to prevent anymore of the course being eroded away.

Dams.
Existing. None.

Proposed: Although rated very low as an economic proposition, a potential dam site (the Cliff site) has been located 29 km above the lagoon [245].

Siltation. Sediment yield at the proposed dam site was calculated to be 0,10 x 10^6 m^3 [245]. Silt emanating from the Sipingo is considered to be negligible.

Land ownership/use. Wattle estates and dairy farms surround the upper reaches of the Mbokodweni river. Besides these, there is the Umlazi location in the middle reaches and sugar cane near the coast. 70% of the catchment is destined to become incorporated into KwaZulu. The AECI factory is situated 3 km above the lagoon.

On the northern bank is the industrial development of Prospecton and part of the

Amanzimtoti golf course. The latter also extends onto the southern bank. The lagoon is overlooked by the township of Umbogintwini (population ±4 000) which is made up mainly of AECI employees. There are no great influxes of holiday-makers.

Local authority. The lagoon and its surrounds are principally controlled by the Borough of Amanzimtoti. However, the Isipingo Local Authority area boundary runs along the coast in such a way that the latter officially controls the new mouth of the system and part of the now isolated lagoon.

Estuary uses. The lagoon is not used for any purpose other than for effluent and stormwater disposal. Use is made of the golf course immediately alongside the lagoon. Water abstraction above the lagoon amounts to $1,0 \times 10^6$ m^3 per annum ([43]).

Morphometry of the lagoon (see Fig. **57**).

Area. Including the now isolated southern part of the old lagoon (2,84 ha in extent) the Mbokodweni lagoon system is 7,24 ha in extent.

Axial length. The main channel is 650 m to 700 m long and the isolated section of the old lagoon is 350 m long.

Shoreline length. Including the isolated part of the old lagoon (with a shoreline of 850 m), the total shoreline length of the Mbokodweni lagoon system is 2,6 km.

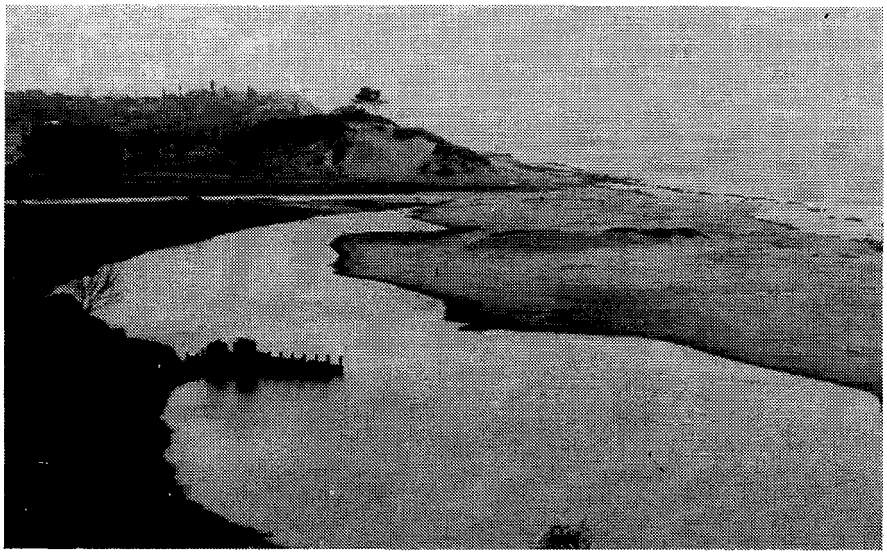
Width.
Maximum: 70 m.
Mouth: 8 m to 10 m during normal flow periods.
Floodplain: 560 m.

Bathymetry. No record.

Geomorphology

Geology. The Mbodokweni river traverses Table Mountain Sandstone and Dwyka tillites whilst flowing to the sea ([43]). In addition to these, rocks of the basement complex and recent deposits also occur ([245]). Dykes (pers. comm.) say that bedrock at the road bridge (comprising Table Mountain Sandstone) lies at depths of 22 m to 42 m. It is overlain by sand, boulders and pebbles and 15 m of very soft black mud. Bedrock at the mouth, is Bluff Sandstone overlain by a cap of beach sand and ilmenite ([99]).

Nature of bottom materials. The bed level grades very rapidly to above mean sea level resulting in steep hydraulic gradients. The adjacent floodplain material is highly erodible and the banks are consequently unstable (Dykes, pers. comm.).



A view of the lower reaches of the former Mbokodweni lagoon, now isolated since creation of the new mouth. The latter can just be seen in the background.

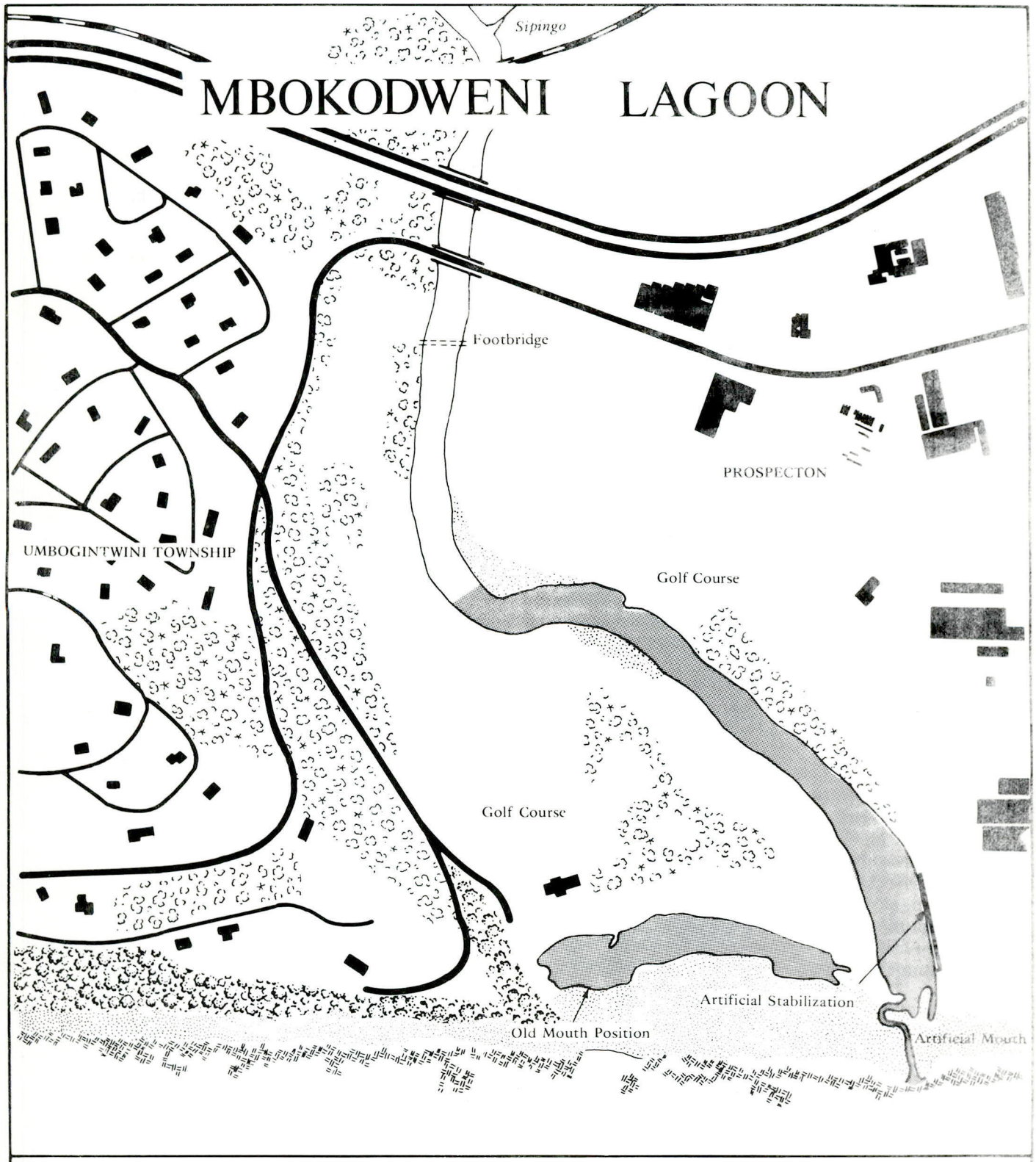

Sipingo
MBOKODWENI LAGOON
Footbridge
PROSPECTON
UMBOGINTWINI TOWNSHIP
Golf Course
Golf Course
Artificial Stabilization
Old Mouth Position
Artificial Mouth
Coastal Dune Forest
Coastal Riverine Forest
100 0 100 200 300 400 500 600 700 metres

Fig. 57

Sandbar characteristics. Prior to any modification, the system was deflected southwards, behind a 400 m long south extending sandbar. The creation of a new mouth, by blasting a channel through the rocks at the coast, became necessary ([99]) because diversion of the Sipingo river into the Mbokodweni, would otherwise have resulted in increased water levels in the golf course area ([98]). Breaching of the new mouth has to be undertaken because of its closure by sand ([99]). The isolated section of what was formerly part of the lagoon, now tends to become stagnant, and itself requires breaching. The suggestion was made to lay pipes between the new mouth and the lagoon, through which it was hoped tidal water could flow when the new mouth was open ([335]).

Configuration of adjacent shore ([132]).

Beach type — open rocky beach, suitable (with reservations) for bathing.

Average beach slope — 7°
Average beach width — 196 m
Average sand grain size — 996 microns
} Indicative of rough surf zone conditions.

Surf zone currents. Rip currents in the near vicinity of the lagoon are reported to be absent.

Physico-chemical characteristics

Data from the lagoon itself is available from the Borough of Amanzimtoti (Stuart, pers. comm.), as they send water samples every three months for sanitary analysis. Some of these results have been expressed in Table **42** and indicate regular signs of disturbance.

The results obtained 2,5 km above the lagoon (see Table **42**) by Brand *et al* ([43]) in 1964 are more informative, but outdated. Nevertheless, in both the dry and the rainy season, enrichment was evident. The main feature was the high degree of mineralization in the dry season (conductivity 1 321 micromhos) and the complete change in inorganic chemistry (sulphate becoming the dominant anion). Although the main effluent from the AECI factory is today piped out to sea ([248]), run-off from dumps of ash and spent chemicals and the effluent from laboratories and from the factory's own sewage treatment plant have been known to enter the Mbokodweni river ([145]). In the past, liquid wastes from the factory and mine washings from the titanium extraction at Umgababa ([145]) used to enter the system from the sea at high tide.

Salinity. From the chloride values expressed in Table **42** the highest salinities recorded in the lagoon (7 November 1975) are in the vicinity of 4‰. The system is probably too shallow for salinity stratification.

Public health aspects

Bacteriology. The final effluent from both the Umbogintwini sewage works and the Amanzimtoti sewage works, discharge into the river above the lagoon. From the results of Kirk (Stuart, pers. comm.) (see Table **43**), faecal pollution of the system is obvious. In 1964 Brand *et al* ([43]) found the river to be both organically and severely faecally polluted, 2,5 km above the lagoon.

Table 43. Bacteriology of the Mbokodweni lagoon*

Date	*E. coli* I per 100 ml
4 March 1974	**16 000**
2 December 1974	**160 000**
3 March 1975	**9 000**
1 March 1976	**60 000**

*selected results from Station U5 at the mouth of the lagoon (Stuart, pers. comm.).

Values in bold significant of disturbance.

Table 42. Physico-chemical characteristics.

Locality: Mbokodweni	(43)		Stuart (pers. comm.)*				
	2.5km above Lagoon		Station U5 (mouth of the Lagoon)				
	1964		1975		1976		
	Summer	Winter	3 Mar	17 Nov	1 Jun	20 Sep	22 Nov
Hydrogen ion concentration (pH)	7.41	6.27	7.1	6.8	6.7	7.8	7.3
Saturated pH value	9.0	8.2	-	-	-	-	-
Conductivity micromhos/cm	231	1 321	-	-	-	-	-
Total dissolved solids ppm (calculated)	162	1 150	-	-	-	-	-
Dissolved oxygen mg/litre	10.2	10.2	-	-	8.8	8.9	7.0
% Saturation	121	120	-	-	-	-	-
Oxygen absorbed mg/litre	-	-	-	-	2.2	4.2	3.8
Permangenate value (after four hours)	-	-	14.0	4.6	-	-	-
Biological oxygen demand mg/litre	3.7	3.2	3.0	2.6	-	7.8	6.3
Kjedahl nitrogen mg/litre	1.6	4.4	-	-	-	-	-
Ammonia "	Nil	1.8	-	-	-	-	-
Nitrites "	.012	.008	-	-	-	-	-
Nitrates "	.56	2.6	-	-	-	-	-
Phosphate "	.42	.21	-	-	-	-	-
Total alkalinity "	34.3	19.4	-	-	-	-	-
Total hardness "	53.5	530.9	-	-	-	-	-
Calcium "	7.3	87.7	-	-	-	-	-
Magnesium "	8.6	75.7	-	-	-	-	-
Sodium "	31.5	138.6	-	-	-	-	-
Potassium "	1.7	9.5	-	-	-	-	-
Sulphates "	21.0	722.5	-	-	-	-	-
Chlorides "	47.2	64.2	300	2 125	145	1 280	75
Silica "	16.1	22.0	-	-	-	-	-
Iron "	4.8	1.1	-	-	-	-	-
Fluorides "	0.3	-	-	-	-	-	-
Free carbonic acid (as ppm carbon dioxide)	2.6	17.6	-	-	-	-	-
Temperature °C	25.0	24.0	-	-	-	-	-
Turbidity (ppm silica scale)	89	18	-	-	-	-	-
Colour (APHA units)	290	10	-	-	-	-	-
Appearance	dirty	very dirty	-	-	-	-	-

* Stuart obtained information directly from B.N. Kirk Inc.

Values underlined significant of disturbance.

Bilharzia. On 27 July 1971 *Physopsis* snails were collected at the AECI weir site above the lagoon (Jackson, pers. comm.). He also reports that the river is known to be infested with *Biomphalaria pfeifferi*. Thus it must be accepted that the chances of bilharzia transmission in the lagoon are good. The sewage/nutrient laden waters of the system (especially if impounded) make conditions particularly favourable for the host snails.

BIOTIC CHARACTERISTICS

Flora

Botanically the Mbokodweni lagoon is unimportant, as a result of golf course development on the floodplain, and industrial development on the northern bank. Ward ([335]) listed seven major types of plant communities around the lagoon in 1970. These included:

(a) Mesophytic woodland
(b) *Phragmites australis* } marsh/reedswamp communities
(c) *Phragmites mauritianus* }
(d) Dwarf salt spray communities
(e) Closed maritime scrub communities
(f) *Mimusops caffra* transitional forest
(g) Halophilous herb communities

Most of the riverine *Phragmites mauritianus* have in the intervening years, been eradicated due to bank erosion and flooding. *Pistia stratiotes* frequently blocks the Sipingo/Mbokodweni diversion canal.

Fauna

There is no information available on the fauna of the Mbokodweni lagoon. Sampling in 1964 (2,5 km above the lagoon ([43]) revealed the effects of toxic pollution in that both the numbers and diversity of animals present were exceedingly low (biotic index — zero).

Birds. Fair sized flocks of Common terns (±300) and Kelp gulls (±25) utilize the lagoon for roosting and bathing (pers. obs. 25 March 1977).

Fish. Jackson (pers. comm.) reports that fish mortalities occur regularly as a result of pollution.

SYNTHESIS

Our general state of knowledge of the Mbokodweni lagoon is fairly good. The lagoon is in an extremely degraded environmental condition as a result of siltation and pollution by sewage and toxic wastes. Should consideration ever be given to using the lagoon for public recreation, precautions will have to be taken to ensure that effluents discharged upstream conform to the necessary standards. It is considered to have no value whatsoever as an estuarine resource.

Having foreseen at the outset that river diversion and the construction of a new mouth would lead to increased water velocities, every effort should consequently be made to combat the bank erosion which is occurring alongside the Amanzimtoti golf course. The situation also illustrates the inadvisability of floodplain development.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other						Flora		Fauna								Food Webs
MBOKODWENI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids										★																							
Source of Information	Summary of available information																																
Harris	1953	145	●								●																						
Oliff & Snyman	1963	248									●																						
Brand *et al*	1964	43	●		○			●			○				○										○	○						
CSIR (NMERI)	1968	98,99	●	●	●		●	●		●								●														
Ward	1970	335						●													●		●									
Fromme	1970 to 1975	132								●																						
Dykes	1970	pers. comm.			●			●		●																						
Ninham, Shand & Partners	1971	245	●		●			●		●																						
Jackson	1971	pers. comm.																							○	○	●					
Loxton, Hunting & Assoc.	1971	213	●		●															●												
Stuart	1974 to 1976	pers. comm.									●				●																	
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	224		●						●													●									
1:25 000 Job No. 262	1976	502	●																													

2.1.9.2 **MANZIMTOTI**

Synonyms

A commonly used synonym is Amanzimtoti, often abbreviated to 'Toti.

Zulu meanings ([87, 289])

"The water is sweet" (from a comment made by Shaka after tasting the water . . . "Kanti Amanz'a mtoti").

Location

30°04'S; 30°53'E.

Accessibility

By road the Manzimtoti lagoon is 31 km south west of Durban. Almost any point of the lagoon is accessible due to the complex of secondary roads on both banks. Access to the northern bank is the easiest.

Bridges

There are five bridges across the lagoon, a railway bridge 300 m from the mouth and four road bridges 350 m, 650 m, 700 m and 1 km from the mouth, respectively.



An aerial photograph of the Manzimtoti lagoon (taken by Prof. Scogings in June 1976) shows the urbanized surrounds and the relationship of the bridges over the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 28 km^2 ([257]) to 33 km^2 ([43, 87]).

River length. 10 km ([23, 212]); 11,3 km ([43, 87]); 14 km ([257]).

Mean annual run-off. 1,0 x 10^6 m^3 ([163]) to 2,0 x 10^6 m^3 ([257]).

Flow. The average flow is said to increase from ,028m^3/sec. ([43]) in the dry season to ,28 m^3/sec. in the rainy season ([23, 212]).

Flood history. No quantitative estimates of flood discharges have been made.

Level fluctuations. Very high flood levels are encountered if the mouth is open and heavy rains coincide with a spring tide. On such occasions, the shopping centre adjacent to the lagoon, becomes flooded. A considerable volume of water may discharge during periods of rainfall, from a large drain that enters the lagoon on the northern bank (Wijnberg, pers. comm.).

Dams.
Existing:
Proposed:
None

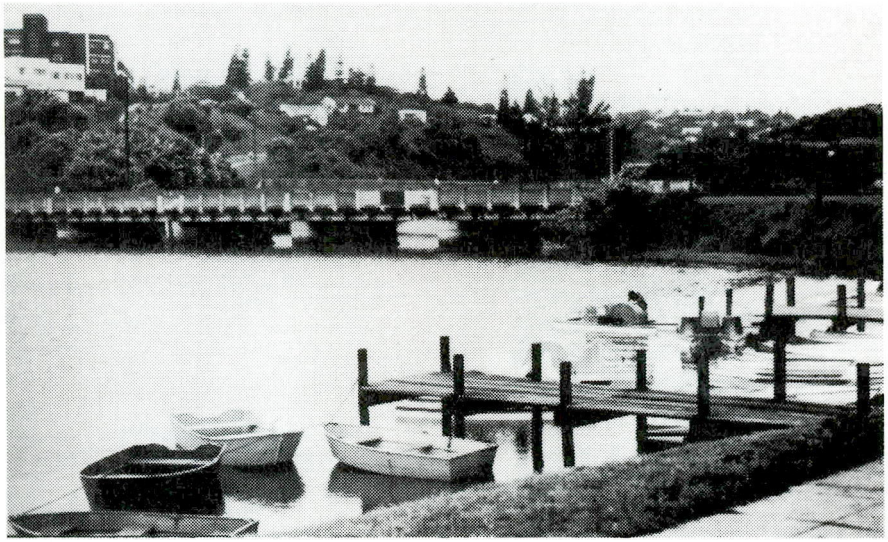
Siltation. No quantitative data is available. Dredging has been undertaken in the past (Maurice, pers. comm.) and depths over the past few decades have decreased considerably due to siltation (see under Bathymetry).

Land ownership/use. 84,2% of the catchment area is Bantu influenced comprising the Umlazi location and the Amanzimtoti Mission reserve. Both are due to be incorporated into KwaZulu. Nearer the coast, the river flows through urban areas.

The lagoon is surrounded by the Borough of Amanzimtoti, with a total permanent White population of 16 000 (Hanlon, pers. comm.). There is an annual influx of 160 000 tourists per annum. Amanzimtoti has also become a dormitory suburb of Durban, to which people regularly commute. The lagoon is surrounded by flats, a business centre, sporting facilities and a civic centre. Doonside spreads southwards of the lagoon.

Local authority. Borough of Amanzimtoti.

Estuary uses. The lagoon is used for paddle boating and the sandbar is a popular bathing beach.



Boating facilities on the Manzimtoti lagoon.

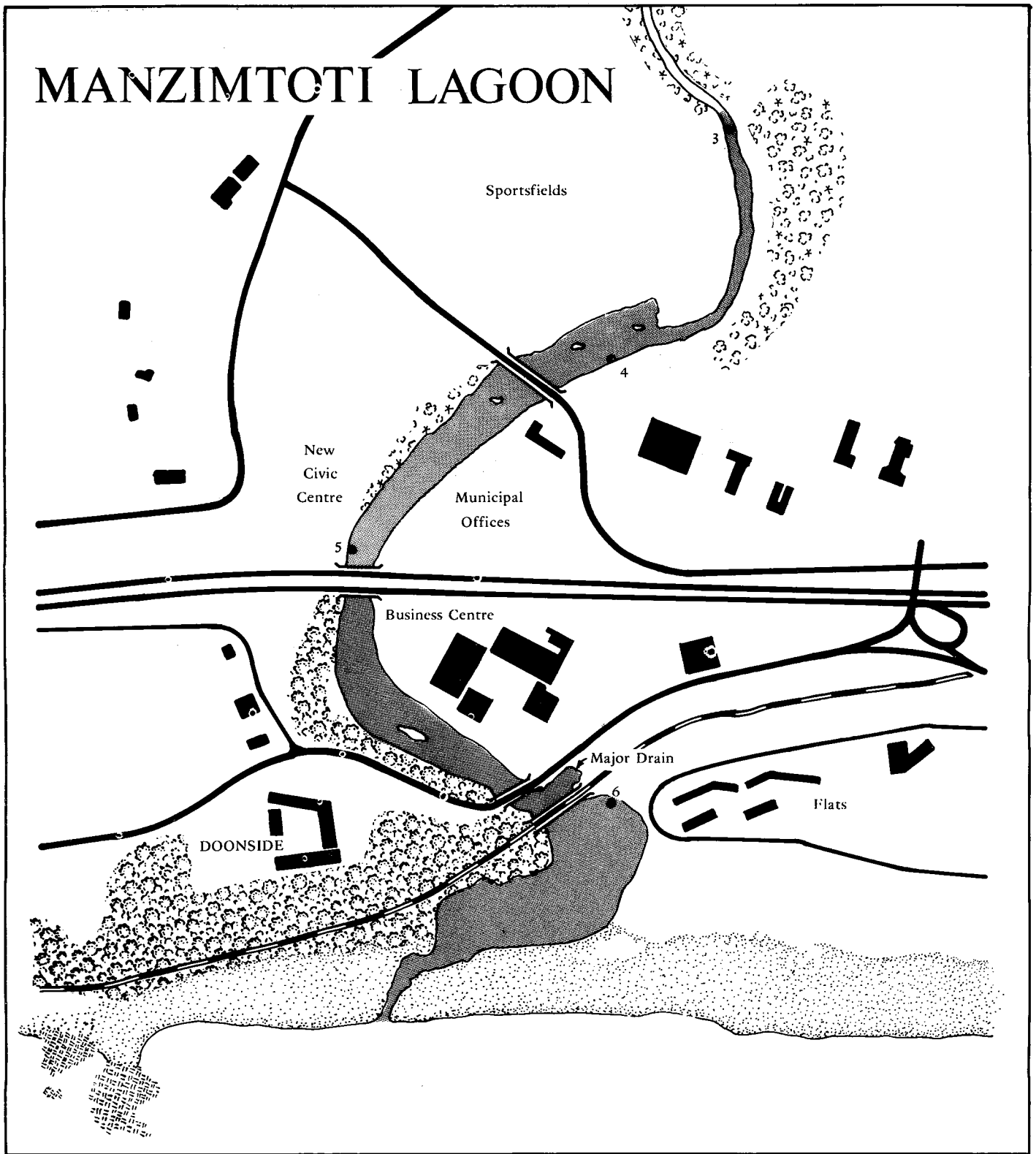
Morphometry of the lagoon (see Fig. **58**)

Area. 6,67 ha.

Axial length. 1,6 km to 2 km ([23, 212]).

Shoreline length. 2,6 km

Width.
Maximum: 110 m
Channel: No record.
Floodplain: 200 m



Station Numbers after Archibald et al 1972[23]

Fig. 58

Bathymetry. Day recorded depths of 1,8 m to 3 m in the lagoon in 1946 ([108]). More recent measurements indicate a maximum depth of 1,65 m and mean depths of 0,79 m ([23]).

Geomorphology

Geology. The geology of the catchment area is complicated due to faulting. Beneath the lagoon, bedrock (black Dwyka shale) lies at 14 m below mean sea level ([257]).

Nature of bottom materials. (see Fig. **59**). Orme has shown the bottom materials of the Manzimtoti lagoon to comprise coarse white sand (with pebbles), underlaid by an extensive layer of black clay at ±2 m to 4 m below mean sea level ([257]).

Chemical analyses of the bottom sediments revealed them to be enriched and in most cases anaerobic, other than in the lower reaches of the lagoon ([304]). The presence of sulphides indicate a rich supply of decayable organic matter and fairly fine sediments. With the mouth closed, percolation of water through the sandbar, prevented sulphide formation in its immediate vicinity. In one particular backwater of the lagoon, very high values for oxygen absorbed, iron and humic acids were recorded.

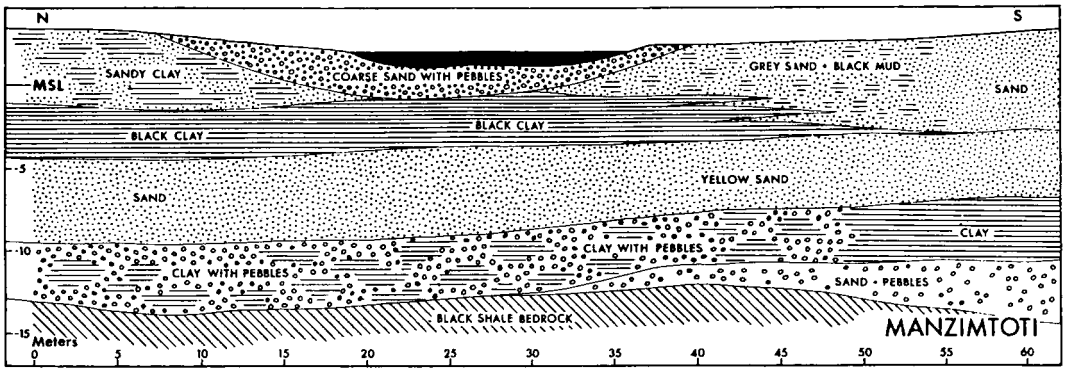
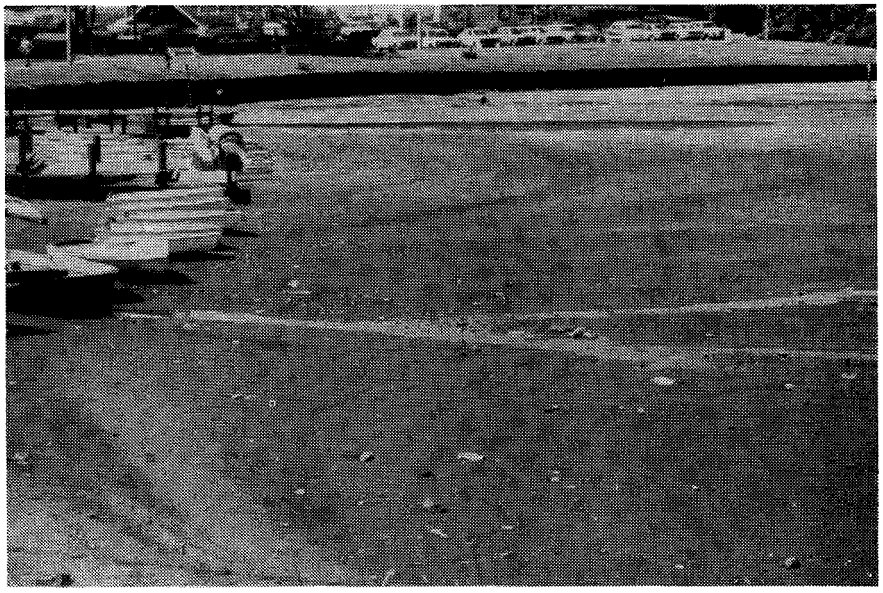


Fig. 59. Cross section through the Manzimtoti lagoon after Orme ([257]).

Sandbar characteristics. The Manzimtoti sandbar is 250 m long and south extending. The lagoon is rarely open to the sea, doing so only after heavy rain ([145]). On such occasions the lagoon virtually empties completely, so that only a very small expanse of water remains. The mouth position is stable, except during times of flood. Overtopping may occur on high spring tides, particularly should there be a storm at sea.

Artificial breaching is undertaken by the local authority if lagoon levels become too high.



An impression of the floor of the lagoon after breaching in March 1977.

Configuration of adjacent shore ([132]).
Beach type — open beach, suitable for bathing.

Average beach slope — 6°
Average beach width — 100 m
Average sand grain size — 539 microns
} indicative of fairly rough surf zone conditions.

Surf zone currents. Rip currents are reported as present in the near vicinity of the lagoon.

Physico-chemical characteristics

There are records of pollution of the Manzimtoti lagoon by chemicals from the Kynoch factory, in Mercury Pictorials dated 18 March and 28 October 1909. However, ever since 1964 the lagoon has received much attention, because of its poor water quality. At one stage, pollution upstream arose from a pig farm, the Bantu location, a sewage works and a zoo ([23, 43, 304]) and in the lagoon, from laundry effluent ([212]). At present the Borough of Amanzimtoti send water samples for sanitary analysis to B. N. Kirk Inc. every three months. Most of this has been summarized and presented as Table **44**. An improvement in water quality is apparent since closure of the sewage works in August 1974, and most problems are presently a consequence of the Bantu influenced catchment.

Thermal properties. In deeper parts of the lagoon, temperature stratification is apparent,

Transparency. The mean percentage visibility from Secchi disc measurements (0,3 m to 0,9 m) is 71% ([23]).

Salinity. Considering the infrequency of contact with the sea, salinities in the lagoon can be surprisingly high. The maximum salinity values recorded on 3 July 1972 were 15,6‰ at the bottom of the lagoon ([23]). Stratification has been apparent on some occasions, whilst on other occasions (e.g. 2 May 1972) salinities were uniform throughout the system. Surface salinities may at times approach zero.

Public health aspects

The safety of the water for bathing, swimming and paddling is questionable in the opinion of the State Department of Health (pers. comm.). This opinion is based upon knowledge of the bacteriological quality of the lagoon and the threat of bilharzia (see below).

Bacteriology. Faecal pollution has been apparent in the lagoon since 1953 ([145]). In 1964, the river 9 km above the lagoon, was shown to be highly organically and faecally polluted ([43]), such that a dry season sample showed visible signs of raw sewage. This situation was confirmed in 1966 by Livingstone *et al* ([212]). Lower down the river, the municipal sewage works also discharged a treated (purposely over chlorinated) effluent into the river (see Table **45**).

Thus it was not surprising to find that in 1970 signs alongside the lagoon read "Keep out — water unfit for bathing. Danger of infection". When closed, the lagoon has no influence on the nearby sea-bathing area ([212]) because the sand-bar is considered to act as a bacteriological filter and indirectly prevents pollution of the sea ([145]).

At present, faecal pollution (see Table **45**) is attributed to Bantu areas in the catchment (Stuart, pers. comm.).

Parasites. Viable tapeworm ova (*Taenia* species) were found in the lagoon in November/December 1966 ([212]) and provided confirmatory evidence of faecal pollution.

Bilharzia. *Physopsis* snails have been located (on 29 July 1971) in the catchment as well as just above the lagoon. The presence of *Schistosoma haematobium* itself has also been established — Jackson (pers. comm.). Warning signs to this effect have been erected alongside the upper reaches of the lagoon. At one stage it was suggested that the lagoon be artificially flooded with sea water to minimize the chances of bilharzia transmission (Shiff, Stuart — pers comm.). Nutrient enrichment naturally aggravates the situation.

Table 44. Physico-chemical characteristics.

Locality: Manzimtoti	IN RIVER			IN LAGOON PROPER									Remarks[23]
	Actual Values			Range in Values		Actual Values							
	9km above the Lagoon			Station 5, 6 & 8	Station 5	Station 8	At Station A3 (National Road Bridge)						
	(43)			(304)	(23)	(87)	Stuart (pers. comm.)*						
	1964			1966	1972	1974	1975				1976		
	Rainy a.m.	Season p.m.	Dry Season	Nov-Dec	May-Aug	June	26 Nov	10 Mar	22 Sep	10 Nov	5 May	9 Sep	15 Nov	
Hydrogen ion concentration (pH)	7.5	7.4	7.4	7.9-8.1	7.3-7.6	6.0	8.5	7.2	7.0	7.6	7.3	7.5	8.0	Alkaline system - pH increasing towards mouth
Saturated pH value	9.2	9.0	8.5	-	-	-	-	-	-	-	-	-	-	No comment
Conductivity micromhos/cm	245	263	455	-	-	(Station 6) 317	-	-	-	-	-	-	-	
Total dissolved solids ppm (calculated)	151	172	209	-	-	6 400	-	-	-	-	-	-	-	
Suspended solids mg/litre	-	-	-	-	-	(Station 7) 200	-	-	-	-	-	-	-	
Dissolved oxygen "	7.7	7.4	2.6	-	1.7-8.0	-	-	-	-	-	8.1	8.1	7.2	Dissolved oxygen and % saturation values show marked changes throughout lagoon. Oxygen statification was evident in deeper parts of lagoon. Evidence of slightly higher values near the mouth.
% Saturation	89	88	26	-	19-88	-	-	-	-	-	-	-	-	
Oxygen absorbed mg/litre	-	-	-	-	-	-	-	-	-	-	4.4	4.6	5.2	
Permangenate values (after four hours)	-	-	-	9.6-14.5	-	-	7.0	8.0	7.0	7.1	-	-	-	
Biological oxygen demand mg/litre	1.9	3.6	26.1	-	-	-	8.2	1.8	5.8	6.4	1.7	2.2	3.7	
Kjedahl nitrogen mg/litre	3.7	2.2	17.6	0.2-1.6	2.9-3.7	-	-	-	-	-	-	-	-	Pre-1974 generally higher than desirable and consistent with concentrations expected in a system receiving sewage effluent (i.e. ammonia values exceed those of nitrates)
Ammonia "	.7	.8	12.1	0.3-5.9	1.6-2.1	1.9	-	-	-	1.2	0.4	0.4	0.3	
Nitrites "	.067	.084	.218	-	-	-	-	-	-	-	-	-	-	
Nitrates "	.49	.42	.11	.12-.32	.78-.98	-	-	-	-	-	2.8	-	0.4	
Phosphates "	Trace	.12	10.05	0.7-2.18	.5-.55	-	-	-	-	-	-	-	-	Generally high but consistent with concentrations expected in a system receiving sewage effluent. Gradual decrease from upper to lower reaches of lagoon
Total alkalinity "	36	38	95	50-82.5	-	-	-	-	-	-	-	-	-	No comment
Total hardness "	35	51	48	-	-	-	-	-	-	-	-	-	-	
Calcium "	4.5	6.9	8.9	-	-	-	-	-	-	-	-	-	-	
Magnesium "	5.9	8.3	6.4	-	-	-	-	-	-	-	-	-	-	
Sodium "	38.3	38.3	41.7	-	-	-	-	-	-	-	-	-	-	
Potassium "	1.9	2.6	7.9	-	-	-	-	-	-	-	-	-	-	
Sulphates "	11.4	15.6	12.9	-	-	-	-	-	-	-	-	-	-	
Chlorides "	47.3	54.1	64.5	-	-	(Station 6) 99.6	3 900	2 100	1 060	2 400	210	2 300	1 300	See notes on "salinity" in text
Silica "	18.5	17.4	13.0	-	-	-	-	-	-	-	-	-	-	No comment
Iron "	0.9	2.5	.5	-	-	-	-	-	-	-	-	-	-	
Fluorides "	1.8	.2	.8	-	-	-	-	-	-	-	-	-	-	
Free carbonic acid (as ppm carbon dioxide)	2.2	3.0	7.3	-	-	-	-	-	-	-	-	-	-	
Temperature °C	23	24.5	16	-	16.6-20	16.3	-	-	-	-	-	-	-	Bottom temperature slightly higher than surface (on some occasions by as much as 1.8°C). Minimum temperatures recorded in the lagoon are 13°C (river influence)
Turbidity (ppm silica scale)	108	53	30	-	-	16	-	-	-	-	-	-	-	Pre-1974 heavy discolouration generally evident
Colour (APHA units)	45	180	110	-	-	-	-	-	-	-	-	-	-	

* Stuart obtained information directly from B.N. Kirk Inc. Values underlined significant of disturbance

Table 45. Bacteriology of the lower Manzimtoti.

	Location	Date	Total Plate Count /ml x 10^3	*E. coli* I per 100 ml	*Salmonella* per 250 ml
			5 days @ 32°C	Confirmed	
in river	9 km above lagoon ([43])	21.1.64	120	1 800	
		14.5.64	**27 775**	**1 800 000**	
		15.6.64	**30 000**	**50 000**	
		16.11.64		200*	
		7.12.64		1 700*	+
in lagoon	At Station 8 (boat hire jetty) ([212]).	9.11.66	24,6	1 530	+
		21.11.66	113	3 350	+
		12.12.66	8,3	1 120	+
	Station A3 (national road bridge)**	10.3.75		2 500 to **16 000**	
		22.9.75		**35 000** to **160 000**	
	Station A4 (railway foot bridge)**	24.5.76		3 500 to **25 000**	

([43]) ([212]) — source of reference.
\+ and values in bold — significant of disturbance.
* membrane count
** Stuart (pers. comm.). who obtained values from B. N. Kirk Inc.

BIOTIC CHARACTERISTICS

Flora

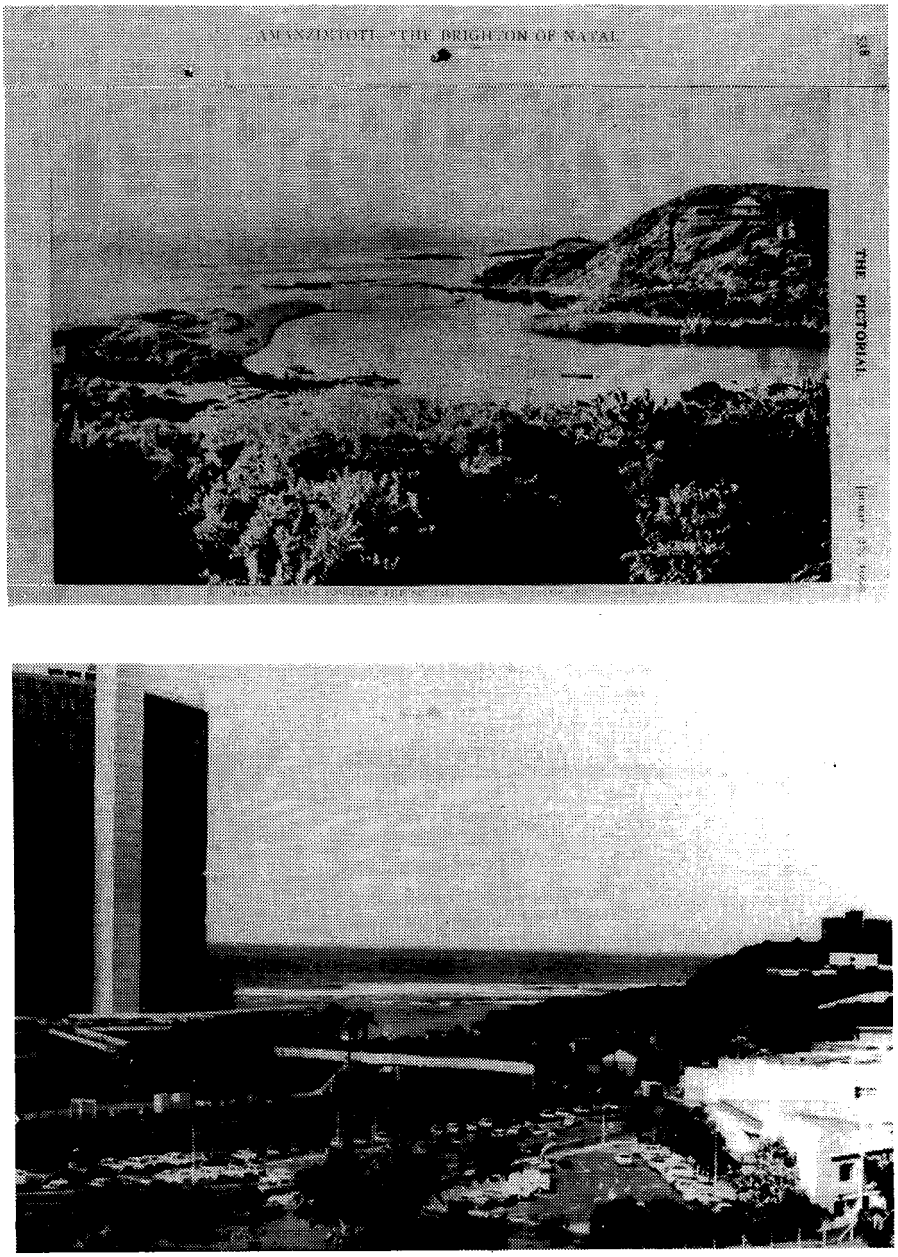
Due to urbanization, very little of the original vegetation surrounding the lagoon has remained undisturbed. Early photographs of the lagoon in 1909 are particularly interesting in this respect. Forest areas alongside the river and on some steep slopes above the head of the lagoon have remained partially intact.

The algology of the system has been thoroughly studied ([23]). During the survey period, (2 May 1972 to 16 August 1972) 14 species of diatoms (mainly *Nitzschia* and *Navicula*) three Cyanophyte species and nine species of Chlorophyta were identified as present. There was a marked increase in the algal density within the lagoon. In May 1972 this increase was 15 fold and attributed to nutrient availability below the sewage inflow. On this occasion, 90% of the community was made up by a bloom of *Phacus* (at densities of 5 750 per ml). The study concluded that the persistently high algal densities, the low species diversity and actual species composition, were all biological manifestations of a nutrient charged system ([23]).

Fauna

In 1946 Day ([108]) recorded the presence of two species of crabs, *Metapenaeus monoceros* (a swimming prawn), many *Musculus* (a bivalve) and *Thiara* (a gastropod) within the lagoon. Faunal surveys in 1966 ([304]) showed a poor variety of species in the lagoon, notably lacking in marine and estuarine forms of life (see Table **46**). On the sandbar, the more favourable oxygen exchange in the coarse sands, permits the development of an interstitial fauna. More recently (on 29 July 1971) Jackson (pers. comm.) found the molluscs *Melanoides* and *Trachycystis* in the lagoon. Surveys in the Manzimtoti river 9 km above the lagoon in 1964 (said to be done in

1963 in ([87])) revealed a community, (made up mainly of *Chironomidae*) which was indicative of moderate organic pollution ([43]). Similar surveys repeated in the river in 1974 ([87]) revealed that conditions had improved since 1964.



Seventy years of progress alongside the Manzimtoti lagoon, make rather an interesting comparative study.

Fish. van der Elst (pers. comm.) has tried netting in the lagoon on one occasion. The results were predictably disappointing. *Sarotherodon mossambicus* have been introduced by the Municipality to assist in mosquito control (Jackson, pers. comm.).

Birds. Although very few in number, 14 species of estuarine associated birds were found to be present in February 1972 by Sinclair (pers. comm.). However, above the lagoon, bird life alongside the river is reported to be varied.

Table 46. Aquatic fauna of the Manzimtoti lagoon (10 Nov. 1966) (after Turner *et al* [304]).

Biotope	Individuals/ sample	No. of species	Composition of major taxa %
*Marginal vegetation (near road bridge on south bank)	393	11	Copepods 45 *Melanoides* (Mollusca) 46
**Sediments at boathire jetty	653	7	Harpacticoid copepods 36 Tubificid (Oligochaete) 33 *Ceratonereis hircinicola (Polychaete)* 11
**Sediments on the sand bar	4822	14	*Harpacticoid copepods* 22 *Turbellaria* 66

* from a qualitative sweep over 3,0 m
** from cores covering 185 sq. cms.

SYNTHESIS

Our general state of knowledge of the Manzimtoti lagoon is good. This is because conditions within the lagoon deteriorated in the past to such an extent that it became imperative for attention to be given to the lagoon. With the knowledge that the Borough of Amanzimtoti maintain a "listening watch" upon quality in the system, additional investigations are not warranted.

The lagoon makes no ecological contribution to Natal's estuarine resources. It has fallen into its present degraded state as a result of urban encroachment, sewage pollution, and siltation. As an amenity to the Borough of Amanzimtoti however, the lagoon has considerable social value. Consequently it would seem sensible that steps be taken to ensure that the lagoon maintains this value in the future, in view of opinions expressed about it being unsafe for water contact.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry					Other									Flora			Fauna							Food Webs
MANZIMTOTI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids															★																		
Source of Information	Summary of available information																																
Day	1946	108		●																						●							
Harris	1953	145					●								●											●							
Brand *et al*	1964	43	●		●			●			○				○										○	○							
Turner *et al*	1966	304		●		●				●	●															●							
Livingstone *et al*	1966	212	●	●	●						●				●																		
Midgley & Pitman	1969	223			●																												
Fromme	1970 to 1975	132								●																							
Orme	1971	257	●		●			●		●																							
Jackson	1971 to 1976	pers. comm.				●									●											●	●						
Sinclair	1972	pers. comm.																										●					
Archibald	1972	23	●	●	●	●					●	●			●								●										
Coetzee *et al*	1974	87	◕	●							○														○	○	○						
Stuart	1974 to 1976	pers. comm.									●				●																		
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	233		●																				●									
1:25 000 Job No. 262	1976	500	●																														

2.1.9.3

LITTLE MANZIMTOTI

Synonyms

Little Amanzimtoti, sometimes abbreviated to Little 'Toti.

Zulu meaning

Presumably, a little stream which once carried pure and tasty "sweet water" ([87]).

Location.

30°05'S; 30°52'E.

Accessibility

The Little Manzimtoti lagoon lies 33 km south west of Durban. Most of it is easily accessible via various secondary roads along both banks.

Bridges

There are six bridges across the system, none of which have supports in the lagoon or in the river bed itself.

(a) a footbridge 475 m from the mouth
(b) a railway bridge 650 m from the mouth
(c) a disused railway bridge (presently used as a footbridge) 800 m from the mouth, and
(d) three major road bridges across the upper limits of the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 10 km^2 ([43]); 15 km^2

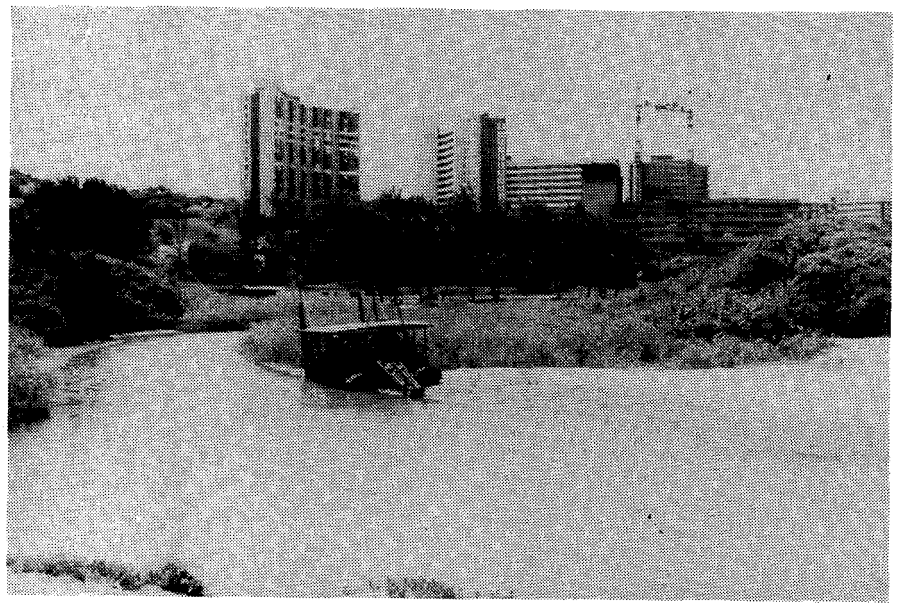
River length. 15 km ([43])

Mean annual run-off. No record.

Flow. The flows recorded ranged from 0,28 m^3/sec. to 1,14 m^3/sec. ([43]).

Flood history. No records are available. There is however, a flood protection berm around the sportsfield on the southern bank.

Dams. Existing or proposed — none.



A view of the lower reaches of the Little Manzimtoti lagoon, and of the dredger bought to restore its former depth. (4 February 1977)

Siltation. Freeway construction, realignment of the south coast national road (in the late 1960's) and, in the process, diversion of the Little Manzimtoti river, all led to severe siltation of the system (Maurice, pers. comm.). A special fund of R30 000 was eventually set aside to restore the lagoon to its former depth and condition. It was hoped that this could be accomplished by the purchase of a dredger (in 1972) by the Borough of Kingsburgh. However, no dredging ever took place because there was insufficient depth in the lagoon to float the machine. After a dragline operation (in 1975) in the upper reaches proved unsuccessful, the dredger was finally sold in 1977 by public auction (Maurice, pers. comm.).

Land ownership/use. 38,6% of the catchment is Bantu influenced, comprising the Umlazi location and the Amanzimtoti Mission reserve. Both these areas are destined to become incorporated into KwaZulu. Most of the remaining area is used for sugar-cane production.

The surrounds of the lagoon are completely urbanized. On the southern bank is Kingsburgh, comprising ±3 000 registered lots, a population of ±8 500 and a tourist influx of ±6 000 during the season. Holiday flats, a hotel, a sportsfield and a tea-room all occur in the immediate vicinity of the lagoon.

The beachfront holiday and residential flats of Doonside are in close proximity to the lagoon on the northern bank.

Local authority. Kingsburgh.

Estuary uses. In its present condition the lagoon is a liability rather than an asset. Aerial photos taken in 1948 confirm that boating was once a very popular pastime in the Little Manzimtoti lagoon.

Morphometry of the lagoon (see Fig. **60**)

Area. 1,5 ha.

Axial length. 800 m

Shoreline length. 1,7 km

Width.
Maximum: 45 m
Mouth: 2 m to 3 m during normal flow periods.
Floodplain: ±100 m.

Bathymetry. The lagoon is exceedingly shallow (i.e. less than 1 m).

Geomorphology

Geology. Granite and Dwyka tillite outcrop in the catchment ([43]), and bedrock at the national road bridge above the lagoon has been shown to comprise blue Dwyka shales at 11 m below mean sea level ([257]). Dolerite also outcrops in the near vicinity of the lagoon (du Preez, pers. comm.).

Nature of bottom materials. (see Fig. **61**). Orme ([257]) considers the bottom materials in the lagoon to comprise fine grey sand.

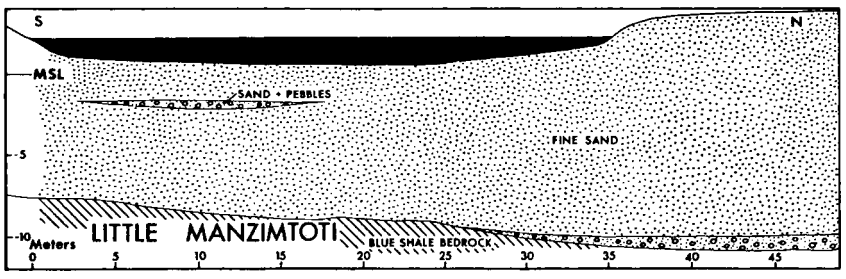


Fig. 61. Cross section through the Little Manzimtoti lagoon, after Orme ([257]).

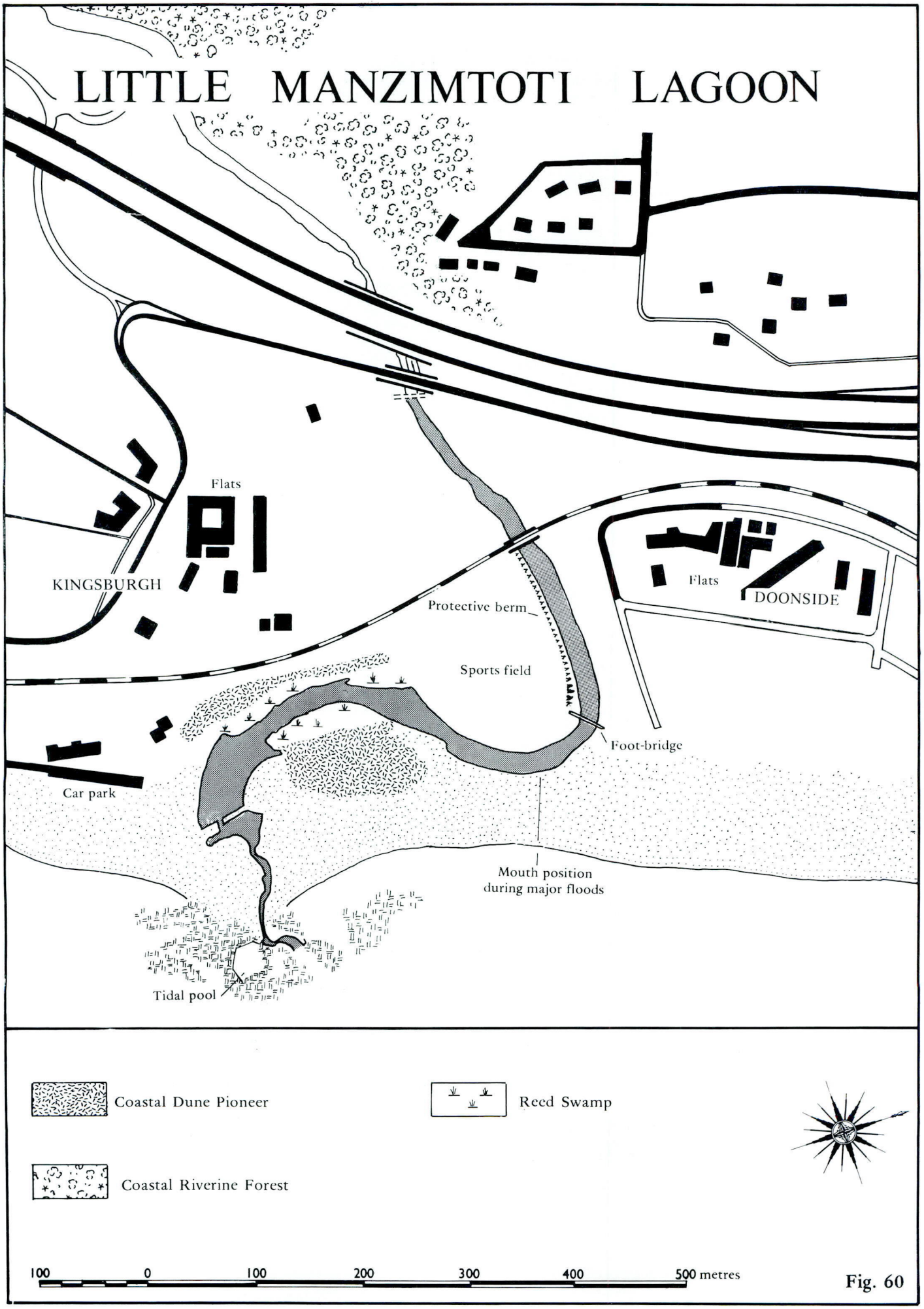

LITTLE MANZIMTOTI LAGOON
Flats
KINGSBURGH
Protective berm
Sports field
Flats
DOONSIDE
Foot-bridge
Car park
Mouth position
during major floods
Tidal pool
Coastal Dune Pioneer
Reed Swamp
Coastal Riverine Forest
100 0 100 200 300 400 500 metres

Fig. 60

Sandbar characteristics. The sandbar of the Little Manzimtoti is south extending. The mouth opens across an outcrop of Dwyka tillite, (du Preez, pers. comm.) which protrudes from the coast and has been used as a foundation for a tidal swimming pool. A distinct channel through these rocks has formed opposite the lagoon mouth. When in flood, the lagoon may open at a point where it deflects through 90° to the south. This is 250 m north of the existing mouth position. In the past the sandbar has been artificially raised so as to increase water levels in the lagoon (Maurice, pers. comm.).

Although breaching is unnecessary, because of a constant trickle of water to the sea, there is seldom any real tidal exchange. The perennial flow of the river is in all likelihood due to the discharge of effluent from the sewage works upstream.

Configuration of adjacent shore ([132])

Beach type — asymmetrical beach, sheltered from the south, and highly suitable for bathing.

Average beach slope — 5°
Average beach width — 130 m
Average sand grain size — 335 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents are reported to be absent in the near vicinity of the lagoon.

Physico-chemical characteristics

There is no data available from the lagoon itself. With a sewage works (installed in 1974) discharging a treated effluent into the river 1 km above the lagoon, the water is likely to be nutrient enriched.

In 1964 Brand *et al* ([43]) sampled the river 6 km above the lagoon (see Table **47**). They suggested that the higher than usual conductivity and proportion of chloride in the water may be due to the geology of the catchment.

Public health aspects

Bacteriology. The river water 6 km above the lagoon was regarded as verging on public nuisance levels (i.e. Class V) in 1964 ([43]) (see Table **48**). Conditions in the lagoon must be equally bad today because the sewage works effluent (although treated) adds to these background levels. A notice on the edge of the lagoon reads "The river may at times be polluted. People entering the water do so entirely at their own risk".

Table 48. Bacteriology of the Little Manzimtoti river (6 km above lagoon)

Date	Total Plate Count per ml x 10^3	*E. coli* I/100 ml
	5 days @ 32°C	Confirmed
21 January 1964	3,3	**> 1 800**
14 May 1964	**170**	700
15 June 1964	**270**	50
16 November 1964	—	**6 000***

* membrane count

Values in bold are significant of disturbance.

Table 47. Physico-chemical characteristics ([43]).

Locality: Little Manzimtoti R. Distance above lagoon : 6km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.7	7.8
Saturated pH value	8.8	8.5
Conductivity micromhos/cm	348	449
Total dissolved solids ppm (calcd.)	211	224
Dissolved oxygen mg/litre	8.1	10.4
% Saturation	93	102
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	0.9	1.7
Kjedahl nitrogen mg/litre	2.9	0.2
Ammonia mg/litre	0.1	0.2
Nitrites mg/litre	0.031	0.008
Nitrates "	0.40	0.38
Phosphates "	Trace	1.42
Total alkalinity "	59	80
Total hardness "	61	80
Calcium "	7.7	11.2
Magnesium "	10.2	12.7
Sodium "	49.7	53.4
Potassium "	2.1	2.2
Sulphates "	18.7	5.9
Chlorides "	60	72
Silica "	23	14
Iron "	1.1	0.3
Fluorides "	1.1	0.2
Free carbonic acid (as ppm carbon dioxide)	2.2	2.5
Temperature °C	22.0	14.5
Turbidity (ppm silica scale)	69	77
Colour (APHA units)	35	160
Appearance	Turbid & foamy	Turbid
Odour	-	-

Values underlined significant of disturbance.

Bilharzia. Both *Biomphalaria* in 1964 ([43]) and *Physopsis* (on 20 August 1973) Jackson (pers. comm.) have been found in the Little Manzimtoti river above the lagoon. The entry of a sewage effluent upstream probably makes conditions particularly favourable for these snails. Although an inspection (on 8 September 1976) in the lagoon proved negative, a strong possibility of bilharzia transmission nevertheless exists.

BIOTIC CHARACTERISTICS

Flora

Through urban encroachment around the lagoon, nothing of botanical value has remained. The reed *Phragmites*, is spreading in the lower reaches of the lagoon due to siltation, shallowing and the freshness brought about by artificially raising water levels. Aerial photos in 1948 show no reed encroachment at all.

Above the lagoon the river (west of the freeway) is well vegetated. Plans are underway to develop this area as a small nature reserve (Maurice, pers. comm.). Blooms of water hyacinth are problematic in the river above the lagoon (Abbott, pers. comm.).

Fauna

There is no information available on the fauna of the lagoon. In the opinion of Maurice (pers. comm.) it only contains mullet and a few *Callianassa* (sand prawn) near the mouth. Formerly the lagoon supported a rich population of *Upogebia* (the mud prawn) and fishing was good.

Bird life in the densely vegetated section of the river above the lagoon is reported to be prolific. Conditions certainly appeared favourable for aquatic life amongst marginal vegetation 6 km above the lagoon in 1964 ([43]).

SYNTHESIS

Our state of knowledge of the Little Manzimtoti lagoon is very poor, and based almost entirely upon hearsay. In its present severely degraded environmental condition, there is no reason to conduct investigations of the system other than bacteriological surveys, in the interest of public health.

However in terms of the "do's and don'ts" of lagoon management, the Little Manzimtoti serves to illustrate how modifications in the vicinity of the lagoon can rapidly create several problems. In this case road construction necessitated river diversion, and the two resulted in severe siltation. This in turn resulted in shallowing of the lagoon, and the expenses incurred in draglining and dredging. Shallowing also resulted in the need to raise the water levels artificially, and when combined, the two lead to reed encroachment. Furthermore, the lagoon is contaminated by sewage effluent, which increases the likelihood of bilharzia. Consequently it is nothing but an eyesore to the local authority, a danger to the public and definitely not an ecological asset.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other							Flora			Fauna								Food Webs
LITTLE MANZIMTOTI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids															★																			
Source of Information	Summary of available information																																	
Brand *et al*	1964	43	●		●			●			○					○										○								
Fromme	1970 to 1975	132								●																								
Orme	1971	257						●		●																								
Jackson	1973 to 1976	pers. comm.				●																				●	●							
Maurice	1977	pers. comm.					●			●											●			●			●	●	●					
du Preez	1977	pers. comm.						●																										
Aerial photos (Scogings)		No.																																
1:10 000 Job No. 261	1976	235		●						●														●										
1:25 000 Job No. 262	1976	499	●																															

2.1.9.4 **LOVU**

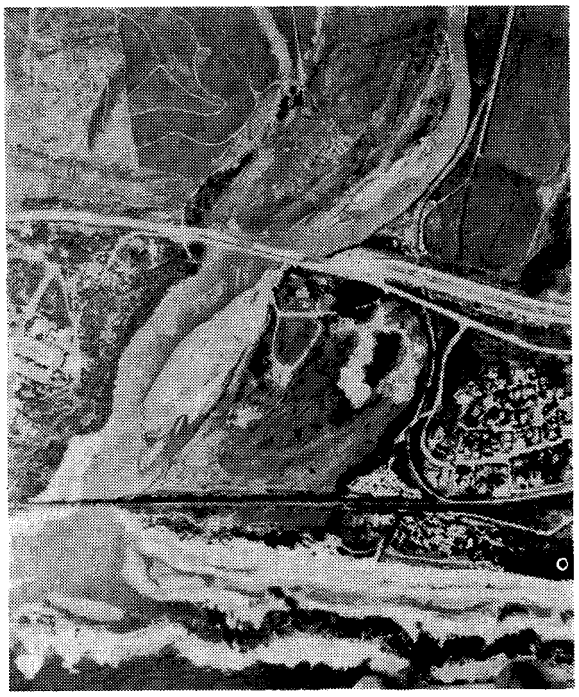
Synonyms
Illovo.

Zulu meaning
The name Lovu is said to have been derived either from the Mlovu trees (*Cordia caffra*) which grew on its banks in great profusion, or from the word which means "welcome" ([289]).

Location
30°07'S; 30°51'E.

Accessibility
By road, the Lovu estuary is 37,4 km south west of Durban. Various tracks on the floodplain render the northern bank of the estuary accessible to vehicles.

Bridges
(a) There is a railway bridge 100 m from the mouth, built upon an enormous 500 m long causeway across what was formerly wetland and water areas.

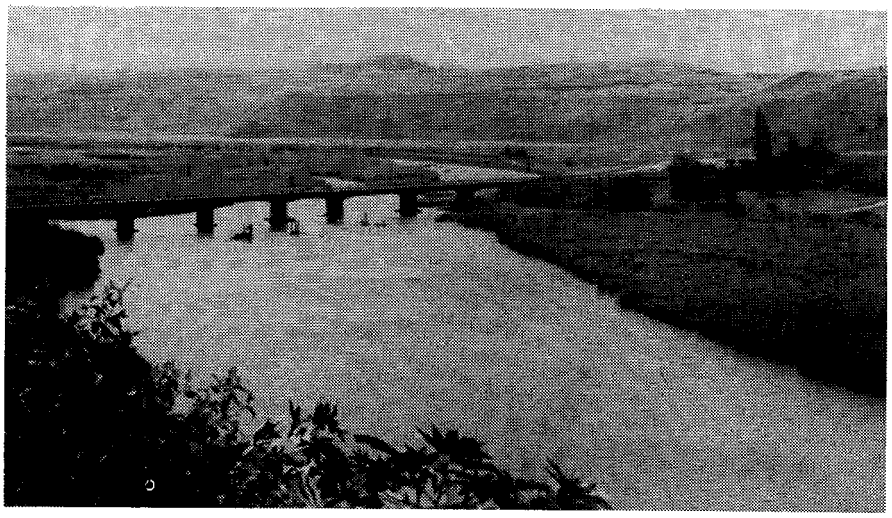


An aerial photograph of the Lovu estuary (taken by the Air Survey Co. of Africa in March 1976) shortly after the roadbridge had collapsed. Notice the embankment of the railway bridge.

(b) Some of the remains of the old railway bridge are still *in situ*. Useful photographs of this bridge appear in a Mercury Pictorial dated 7 May 1908.

(c) The main national road bridge crosses the estuary 800 m from the mouth. Part of this bridge collapsed after the floods of March 1976, resulting in the temporary construction of a low level causeway. The latter was removed in February 1977 (Sutton pers. comm.).

(d) The bridge of the south coast freeway is to cross the river immediatly upstream of the existing road bridge. Much difficulty has been encountered in designing this bridge because of the instability of the northern bank, (NRIO, pers. comm.). This is largely due to planting of sugar cane along the river bank, and its instability presently threatens the railway line which runs to the Illovo mill. A "training berm" has been built upstream to try and prevent the river from scouring and undercutting this bank.



A view of the national road bridge, and remains of the old railway bridge across the Lovu estuary. Also notice the encroachment of sugar cane onto the floodplain above the bridge.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 893 km^2 ([223]); 916 km^2 ([77]); 930 km^2 ([43, 257]); 945 km^2 ([220]); 1 036 km^2 ([213]).

River length. 135 km ([43]).

Mean annual run-off. 98 x 10^6 m^3 ([223]); 123 x 10^6 m^3 ([77, 257]); 125 x 10^6 m^3 ([213]).

Flow. Monthly means from flow data dating back to 1957 are available ([43]). The annual mean flow is 6,2 m^3/sec. There is surprisingly little variation in seasonal means, these being 5,5 m^3/sec. in winter and 7,0 m^3/sec. in summer. These figures relate to virtually the total flow from the river.

Flood history. The following information was provided by Bosch and Associates, from measurements made at the pump station of the Illovo mill. The bed level of the river at this point is 4,3 m above mean sea level.

Date	Height to which river rose above mean sea level
1935	8,22 m
1954	9,15 m
1956	8,57 m
*May 1959	9,99 m
1970	8,22 m
1971	7,81 m
**March 1976	10,37 m

*On this occasion, the road bridge and embankment of the railway bridge were washed away ([220, 257]). This flood was estimated to discharge from 1 266 m^2/sec. (van Niekerk, Kleyn & Edwards, pers. comm.) to 1 700 m^3/sec. ([220]).

**On this occasion, the existing road bridge collapsed, and the flood was estimated to discharge in excess of 2 000 m^3/sec. (Schmidt, pers. comm.). A Mr D. Watkins has a cine film

of the event. It has been suggested by Schmidt (pers. comm.) that floods are occurring with ever increasing frequency because the system no longer has the capacity to absorb such volumes of water. This situation has arisen from infilling as a result of high rates of siltation.

Dams.
Existing. None.
Proposed: Five potential sites have been located on the Lovu river ([77]) amongst which the lower Curraghmore dam is to be constructed first.

Siltation. Although no quantitative data is available, the bed level of the river and its estuary is reported to be rising because of excessive siltation (Bosch and Associates, pers. comm.).

Land ownership/use. Much of the upper catchment (near Richmond) is natural veld, bush and forest ([43]). 32% of the catchment is Bantu influenced (comprising the Umlazi location) and is destined to become incorporated into KwaZulu. On the coastal plain are the Illovo sugar estates. The Illovo mill is situated 3,5 km above the estuary and is the nucleus of a river-side village with a population of ±3 200 ([145]).

The estuary is surrounded by Winklespruit on the northern bank and Illovo on the southern bank. There is a large caravan park on the beach front immediately north of the estuary. The South African Railways Police rifle range and the Municipal rubbish dump have been located on the floodplain.

Future development includes proposals for a sportsfield, parade ground and buildings on the floodplain; a light industrial area immediately above the estuary and a sewage treatment plant on the southern bank (Maurice, pers. comm.). Part of the estuary is also to be set aside as a nature reserve, ([246]) (Maurice, pers. comm.).

Local Authority. Borough of Kingsburgh.

Estuary uses. Some power-boating and water-skiing takes place because the Lovu estuary is the closest fair sized expanse of water south of Durban. A limited amount of angling also occurs.

Much use is made of the river water above the estuary. A tributary of the Lovu (the Nungwana) is the source of supply for the Amanzimtoti Regional Water Supply Corporation; and ±,07 x 10^6 m^3 are abstracted each day by the Illovo estates for irrigation, milling and domestic purposes. ([43])

Morphometry of estuary (see Fig. **62**).

Area. 10,5 ha.

Axial length. 1,1 km

Shoreline length. 3,8 km, a figure increased considerably by two side channels on the southern bank of the estuary.

Width.
Maximum: 230 m
Mouth: 6 m wide during normal flow periods but during times of flood can exceed 75 m.
Floodplain: 800 m above the road bridge ([257]).

Shape. The estuary has lost much of its former area (see Fig. **63**) as a result of railway construction. This is particularly clear from photographs of the estuary in a Mercury Pictorial dated 5 December 1908.

Bathymetry. The maximum depth recorded (on 7 June 1977) was 2 m (pers. obs.). Elsewhere the estuary was 1 m to 1,6 m deep. The system becomes particularly shallow (0,4 m) upstream of the existing road bridge.

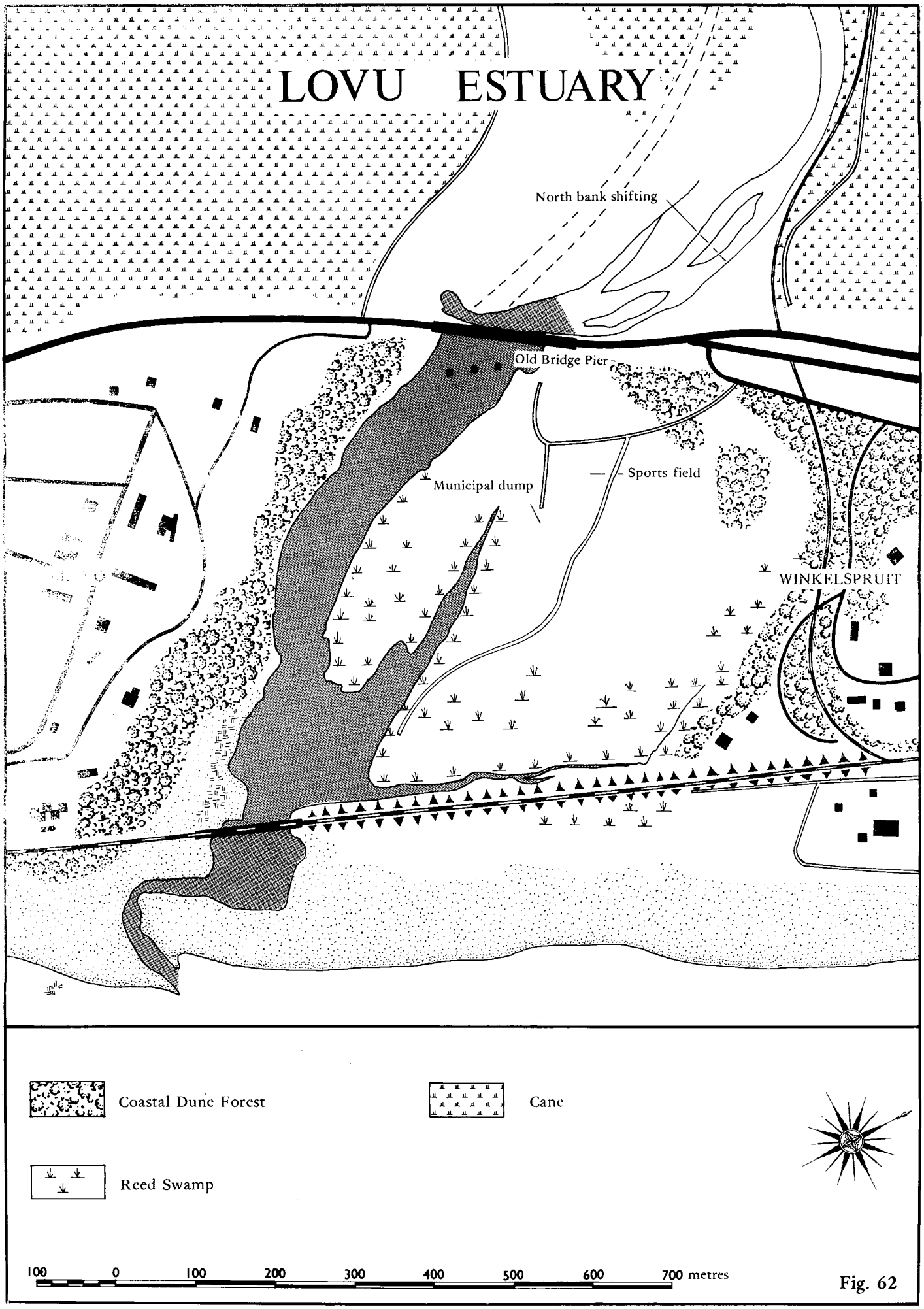

LOVU ESTUARY
North bank shifting
Old Bridge Pier
Municipal dump
Sports field
WINKELSPRUIT
Coastal Dune Forest
Cane
Reed Swamp
100 0 100 200 300 400 500 600 700 metres

Fig. 62

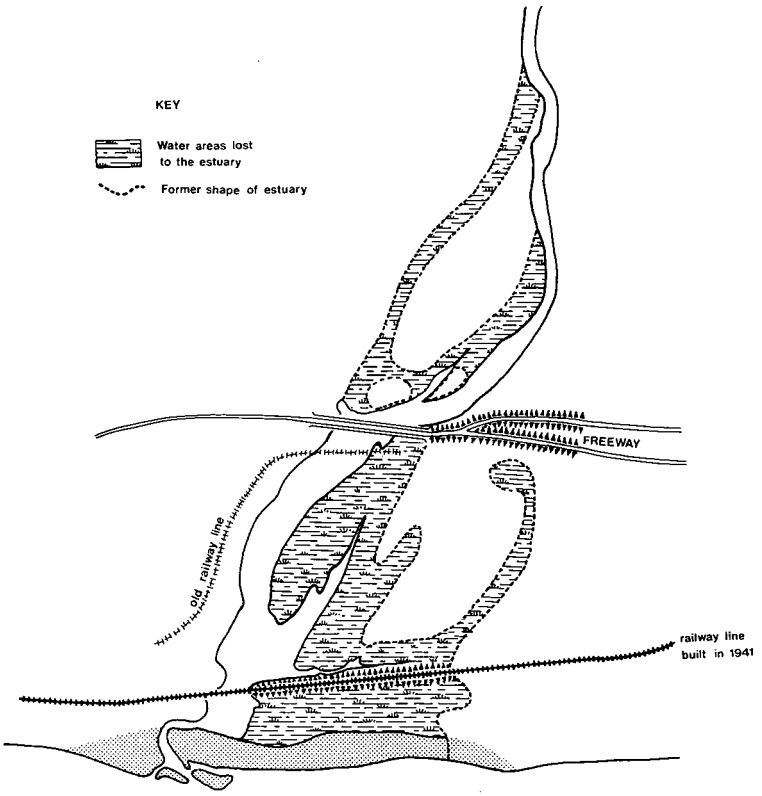
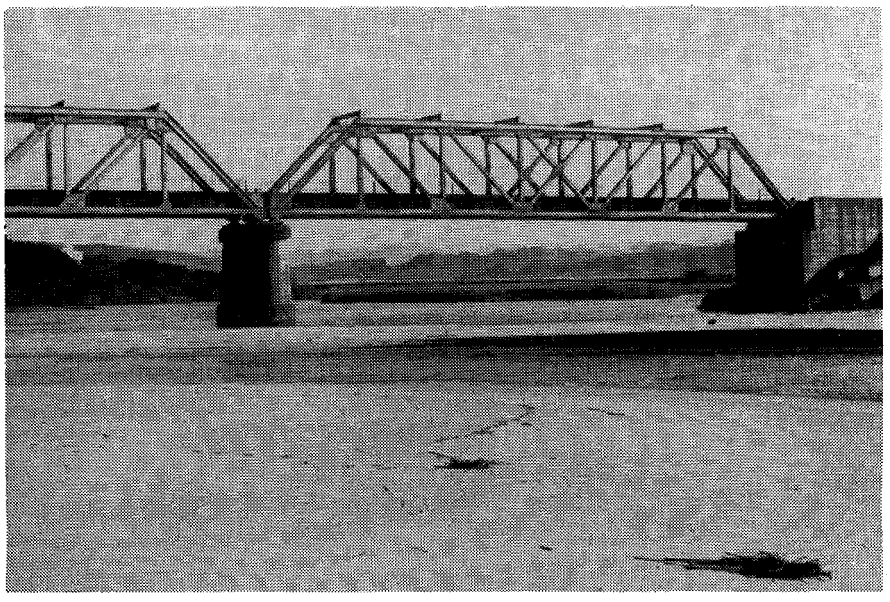


Fig. 63. Changes in the extent of the Lovu estuary arising from the construction of the bridges.

Geomorphology

Geology. The Lovu river traverses rocks of the Beaufort, Ecca and Dwyka series, as well as Table Mountain Sandstone and Granite, in its catchment. Near the coast, it passes over Dwyka tillite and Ecca shale ([43]). Above the 75 m contour, coastal red sands are present, at the base of which is a thick boulder bed ([77]). Alluvium in the Lovu valley can be 30 m deep. The Karroo sediments are down faulted and tilted seawards ([77]).

Nature of bottom materials. No record.



The mouth of the Lovu estuary — 7 June 1977.

Sandbar characteristics. Despite the fact that there is no prominent rock protection south of the Lovu estuary mouth ([132]) the bar is 250 m long and south extending. The mouth is very seldom closed because of the flow characteristics of the river, consequently, breaching of the bar is unnecessary. The mouth position is unstable. It may change from a broad "blown out" condition after floods (c.f. aerial photos 31 March 1976) to a central or more southerly position when they subside (c.f. Scogings series dated 12 June 1976).

Configuration of adjacent shore ([132]).
Beach type — open beach, suitable for bathing.

Average beach slope — 2°
Average beach width — 157 m
Average sand grain size — 284 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents are reported as present in the near vicinity of the lagoon.

Physico-chemical characteristics.

The ground water of the coastal area in the vicinity of the Lovu is reported to be highly mineralised ([77]), containing much chloride and sulphate. It has a permanent hardness which is in excess of 21% calcium carbonate. These characteristics do not appear to be reflected by the river water ([43]).

Brand *et al* ([43]) reported the evidence of heavy organic pollution below the Illovo sugar mill, which is situated on the northern bank of the river 3,5 km above the estuary. Thick mats of algae (*Oscillatoria tenuis*) provided confirmation of enriched conditions below the mill in June 1977 (pers. obs.). The fact that river temperatures were in excess of 35°C in both summer and winter (see Table **49**) suggest thermal pollution occurs as well. By way of contrast, water quality in the rest of the Lovu river was reported to be excellent ([43]).

Thus it is not surprising to find that contamination of the Lovu estuary is a regular event. In 1953 pollution from "cooling water and boiler blow down" was suspected ([145]). On 29 June 1977 an ash dam "accidentally" burst at 9.00 p.m. at the mill causing massive pollution of the estuary (Maurice and Beesley (pers. comm.)). It so happened that the estuary was well scoured and cleansed by spring tides within a few days.

Salinity. Jackson (pers. comm.) reported salinities ranging from 4‰ to 17,5‰ in the estuary on 8 August 1976. On 7 June 1977 surface salinities at low tide were zero until within the narrow channel which led to the sea (pers. obs.).

Table 50. Bacteriology of the Lovu river (3,5 km above the estuary).

Date	Total Plate Count per ml x 10^3	*E. coli* I/100 ml
	5 days @ 32°C	Confirmed
7 April 1964	37,5	4 600
14 May 1964	175	800
18 August 1964	**2 000**	490
26 August 1964	**5 000**	**69 000**
16 November 1964	—	**120 000***

*membrane count

Values in bold are significant of disturbance.

Public health aspects

Bacteriology. The only results available which give some indication as to the likely bacteriological condition of the estuary, are those of Brand *et al* ([43]). These were representative of conditions 3,5 km above the estuary, just below the Illovo mill (see Table **50**). At this

Table 49. Physico-chemical characteristics ([43]).

Locality: Lovu river Distance above estuary: ± 3.5km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.1	6.6
Saturated pH value	8.8	8.6
Conductivity micromhos/cm	168	188
Total dissolved solids ppm (calcd.)	96	120
Dissolved oxygen mg/litre	3.7	3.1
% Saturation	53	44
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	> 4	38
Kjedahl nitrogen mg/litre	Trace	1.6
Ammonia mg/litre	Trace	0.2
Nitrites mg/litre	Nil	Nil
Nitrates "	.10	Nil
Phosphates "	.15	.31
Total alkalinity "	48	55
Total hardness "	25	50
Calcium "	8.2	10.2
Magnesium "	1.1	6.1
Sodium "	13.0	23.6
Potassium "	.9	2.7
Sulphates "	Nil	1.9
Chlorides "	25.6	30.4
Silica "	17.7	9.1
Iron "	-	2.6
Fluorides "	-	0.1
Free carbonic acid (as ppm carbon dioxide)	7.5	26.9
Temperature °C	35.9	35.0
Turbidity (ppm silica scale)	30	28
Colour (APHA units)	-	90
Appearance	Poor	Foul
Odour	-	-

Values underlined significant of disturbance.

point the water was considered to be verging on public nuisance levels (i.e. Class V). In the dry season severe organic enrichment was evident, but faecal pollution was detectable throughout both wet and dry seasons. The mill community living alongside the river were suspected as being responsible.

Bilharzia. To date there is no evidence available to suggest that there are bilharzia snails in either the river or the estuary. Jackson's survey (pers. comm.) on 12 August 1976 proved negative.

BIOTIC CHARACTERISTICS

Flora

Due to the encroachment of sugar cane and the general reclamation of wetland areas adjacent to the estuary, there is not much of real botanical importance which remains.

On the steep southern bank, a strip of coastal dune forest has remained undisturbed, although the old railway line formerly ran through this area. On the northern bank of the estuary, reed swamp (*Phragmites communis*) dominates the area growing along the edges and former side channels of the estuary.

Small communities of black and white mangroves also occur alongside these channels. The transplantation of mangrove seedlings from other sources is being attempted. ([246])



An impression of the Phragmites reed swamps surrounding the lower reaches of the Lovu estuary. In the background is the railway line embankment which has brought about considerable change since its construction.

Fauna

There is very little information available on the fauna of the Lovu estuary.

Benthos. The estuary is considered to be poorly endowed in bottom dwelling animals, by Maurice (pers. comm.) although the collection of sand prawns (*Callianassa*) for bait occurs. Crabs (*Varuna* sp. and *Sesarma* sp.) are plentiful ([246]).

3,5 km above the estuary, heavy organic pollution was confirmed by the very poor species diversity amongst the bottom fauna and 82% dominance by the bristle-worm, *Dero* ([43]).

Fish. There are plenty of mullet (Mugilidae) in the Lovu estuary. During the winter months, catches of small perch, (*Acanthopagrus*) grunter (*Pomadasys*) and springer (*Elops*) are made (Maurice, pers. comm.). Once the flood waters arrive, angling is totally unrewarding. In the 1950's, garrick (*Lichia*) used to be caught at the road bridge and in 1974 a 27 kg kob (*Argyrosomus*) was "man-handled" out of the river by workers busy painting the bridge. (Maurice pers. comm.).

Birds. On 23 January 1977, Nicholls (pers. comm.) recorded 16 species of estuarine associated birds as present in the estuary. These were primarily various types of waders. However, of the 48 species listed by Cooper ([246]) 24 are estuary associated.

SYNTHESIS

Our general state of knowledge of the Lovu estuary is poor. This situation should be rectified because of the Borough of Kingsburgh's intention to set aside part of the estuary as a nature reserve. Apart from this, there is also the need for a hydrological model study because of the intended use to which the floodplain is to be subjected in the near future.

Of the various problems which reveal themselves in the Lovu estuary, siltation and pollution are the most serious. Various forms of floodplain encroachment (in the form of causeways, sugar cane and amenities) are also evident. The net result is that the estuary has become degraded to the extent that it is of little resource value to the province.

Development surrounding the Lovu estuary demonstrates one of the primary planning conflicts which have, over the past few decades, come to bear considerable pressure upon the estuarine environment of Natal. This is the practice of wetland reclamation and the development of floodplains. Apart from the ecological implications (see Section 3.1) such practices are particularly unwise where the flood characteristics of the country are known to be violent.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC											
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora			Fauna								Food Webs
LOVU ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids					★													★							←	★	→					
Source of Information	Summary of available information																																
Harris	1953	145			●						●				●																	
Meinecke	1959	220	●		●																												
Brand *et al*	1964	43	●		●			●			○				○										○	○							
Chew & Bowen	1965	77	●		●			●			○																						
Midgley & Pitman	1969	223	●		●																												
Fromme	1970 to 1975	132								●																							
Orme	1971	257	●		●					●																							
Loxton, Hunting & Assoc.	1971	213	●		●																												
NRIO	1975	pers. comm.	●	●	●		●	●		●								●															
Jackson	1976	pers. comm.				●																				●							
van Niekerk, Kleyn & Edwards	1977	pers. comm.	●		●																												
Bosch & Associates	1977	pers. comm.			●					●																							
Maurice	1977	pers. comm.																		●							●						
Nicholls	1977	pers. comm.																										●					
Norris Rogers	1978	246		●												●			●	●		●		●				●					
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	240		●						●														●									
1:25 000 Job No. 262	1976	497	●	●																													

2.1.9.5 **MSIMBAZI**

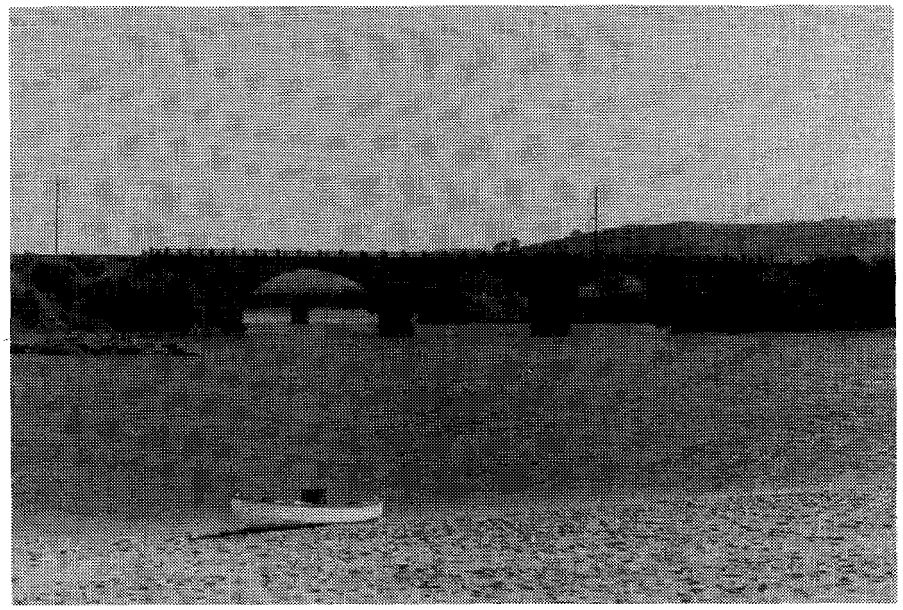
Synonyms
uMzimbasi; Umzimbẹzi

Zulu meaning
No record.

Location
30°08'S; 30°50'30"E

Accessibility
The Msimbazi lagoon lies 40 km south west of Durban. Both the lower and upper reaches of the lagoon are accessible via tracks on the northern bank, along which a major secondary road (route MR491) runs westwards to Umbumbulu.

Bridges
(a) A railway bridge (built in the 1940's) is situated 170 m from the mouth.
(b) The main national road bridge is situated 250 m from the mouth and is built upon a massive causeway which extends three-quarters of the way across the lagoon. The surprisingly minimal impact of this structure is apparent from the original morphometry of the lagoon shown by Harris ([145]).
(c) The remains of the old railway bridge protrude as causeways from both banks of the lagoon, 550 m from the mouth.
(d) The south coast freeway is destined to partially eliminate the upper reaches of the lagoon (see Fig **64**). This, plus a future interchange on the floodplain and the need (prior to representation by the Oceanographic Research Institute) to re-route the Umbumbulu road, involves river diversions, and the infilling of existing water areas.



Bridge relationships at the mouth of the Msimbazi lagoon. Orme ([257]) mentions that the circulation within the lagoon "is confused by the numerous bridge piers . . ."

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 33,7 km^2 ([73]); 34,2 km^2 (van Niekerk, Kleyn & Edwards, pers. comm.); 41,4 km^2 ([43]).

River length. 14,5 km ([73]) to 18 km ([43]).

Mean annual run-off. No record.

Flow. The river flows recorded range from ,08 m^3/sec. to ,85 m^3/sec ([43]).

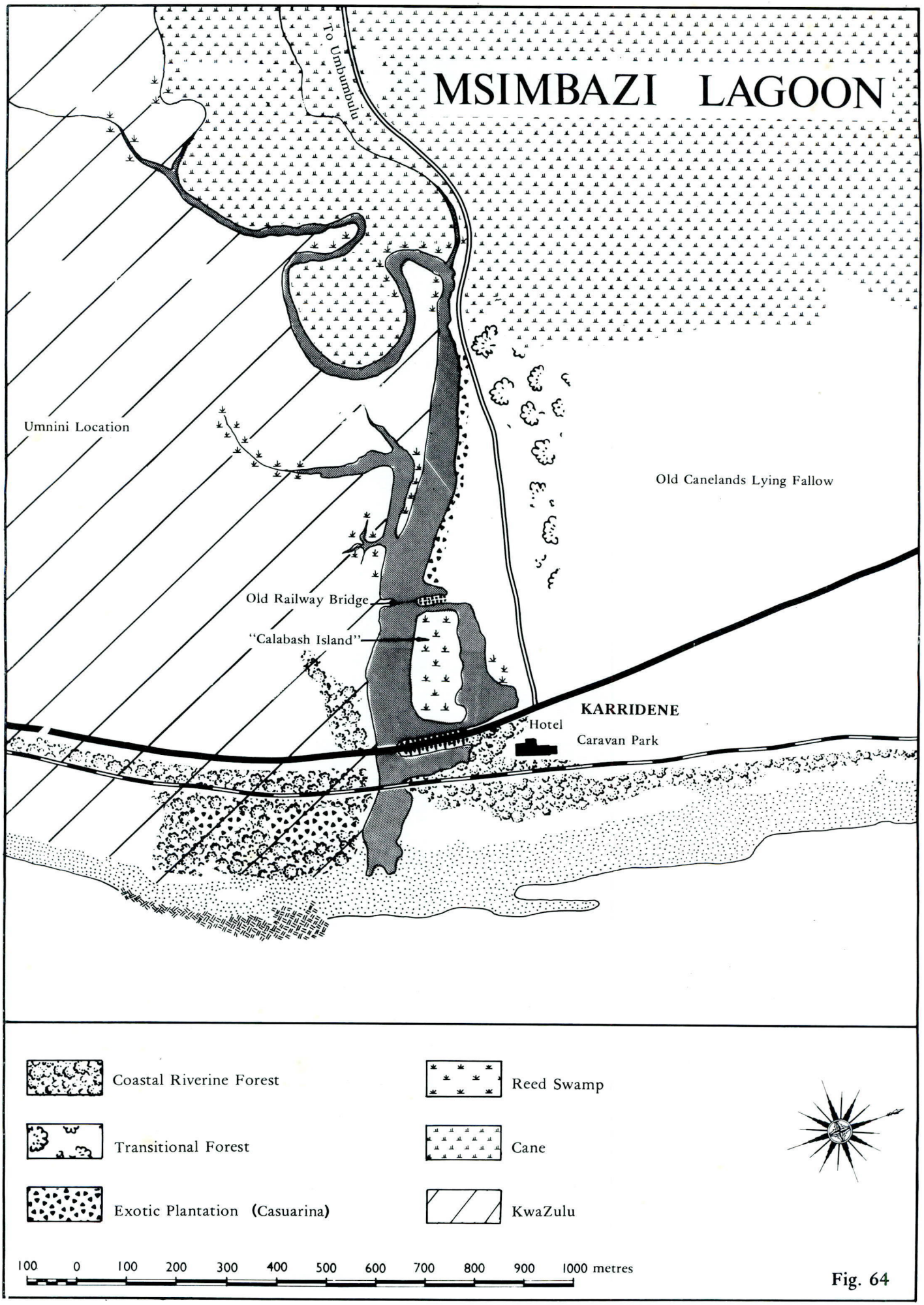
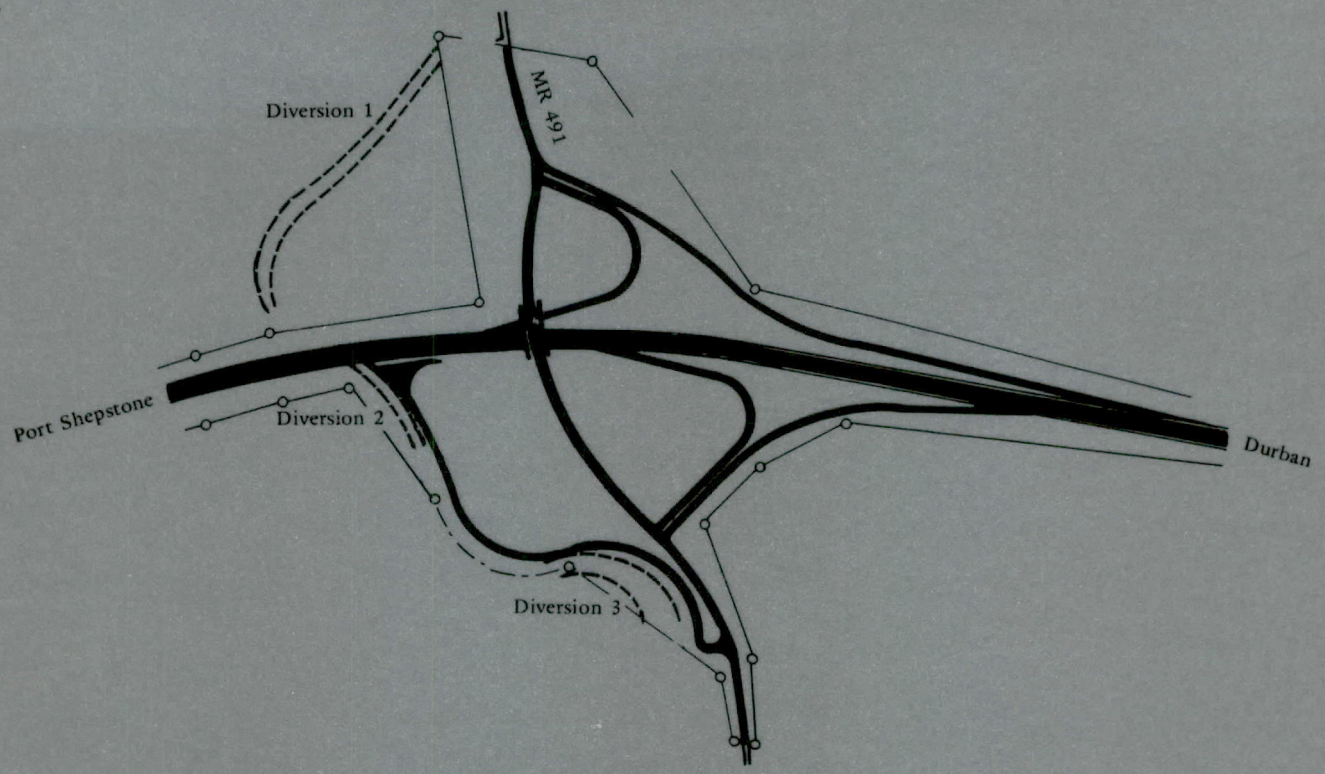

MSIMBAZI LAGOON
To Umbumbulu
Umnini Location
Old Canelands Lying Fallow
Old Railway Bridge
"Calabash Island"
KARRIDENE
Hotel
Caravan Park
Coastal Riverine Forest
Transitional Forest
Exotic Plantation (Casuarina)
Reed Swamp
Cane
KwaZulu
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 64


Diversion 1
MR 491
Port Shepstone
Diversion 2
Durban
Diversion 3

Flood history. During the May 1959 floods, Calabash Island was reported to be 1 m under water ([73]). Much damage was done to route MR491, although these levels were only sustained for a few hours. The peak discharge of a 1:100 year flood has been estimated at 157 m^3/sec. (van Niekerk, Kleyn & Edwards, pers. comm.). The various causeways across the system must aggravate backflooding at such times. Scour depths 5 m below the normal lagoon floor level are reported ([257]).

Dams. Existing or proposed — none.

Siltation. No record.

Land ownership/use. Although described as being "wholly native reserve" ([145]), 81% of the catchment is Bantu influenced comprising parts of the Umlazi location, the Mfume Mission reserve and the Umnini location. These areas are all destined to become incorporated into KwaZulu.

Immediately north of the lagoon, near the mouth, is the settlement of Karridene (comprising a hotel, flats and a caravan park), whilst higher up, the Illovo sugar estates (now owned by C. G. Smith Sugar Ltd) are encountered. The development of a township on the sugar cane covered hills overlooking the lagoon, is anticipated. On the northern bank "Space Properties" intend developing holiday houses, a caravan park, duplex flats, a commercial centre and a lagoon-side restaurant (Cameron, pers. comm.).

Situated on the southern bank is the Umnini location and on the coast 1,25 km south of the lagoon, a Bantu holiday resort makes use of the old buildings of Umgababa Minerals (Pty) Ltd.

Local Authority. Kingsburgh.

Estuary uses.

(a) Water skiing and boating.
(b) Angling (especially amongst the local Indian community).
(c) Ski-boats are launched in the lagoon when the mouth is open (Cameron pers. comm.).
(d) Day ([114]) reported the presence of a golf course in 1950 alongside the northern bank of the lagoon.
(e) On several occasions marina proposals have been proposed ([73]).

Morphometry of lagoon (see Fig **64**)

Area. Although Orme ([257]) talks of the Msimbazi as an "unusually large estuary . . ." its actual extent (excluding Calabash Island) is 13,2 ha. It is estimated to be 20 ha. in extent by Campbell, Bernstein & Irving ([73]).

Axial length. 2,8 km

Shoreline length. 8,4 km — a feature greatly increased by various side channels on the southern bank, and the perimeter of Calabash Island.

Width.
Maximum: — 110 m
Mouth: — No record, possibly 50 m during floods.
Floodplain: — In places 500—600 m wide.

Shape. The upper reaches of the lagoon comprise a series of oxbow-loops. Otherwise the main axis of the system is straight, and lies at right angles to the coast.

Bathymetry. Depths vary between 1,5 m to 2,5 m (pers. obs.)

Geomorphology

Geology. Dwyka and Ecca rocks outcrop in the catchment area ([43]). In the vicinity of the lagoon, Berea red sand and sandstones surround the system. Archaean granite (at 20 m below mean sea level) is reported as bedrock ([257]) and an outcrop of rocks near the mouth, which protrude into the lagoon from the southern bank, are made up of shale (du Preez, pers. comm.).

Nature of bottom materials. In 1950 Day ([114]) described the bank on the northern shore to comprise "soft glutinous mud . . ."; and the bottom of the river channel and of the lagoon near the

mouth to comprise sand. Orme ([257]) described the bottom materials (see Fig. **65**) as "lagoonal deposits of silty sands, fine to medium sands, silts and muds". The sandy deposits were rich in organic debris, and near the mouth, wash over marine sands become deposited in the lagoon. The firm sandy bottom in the upper reaches of the lagoon, is a noteworthy feature (pers. obs.).

Sandbar characteristics. The Msimbazi sandbar is 60 m long and 40 m wide and is atypical in that it does not become deflected either northwards or southwards at the coast. The crest level of the bar is generally very high and, if permitted to do so, the lagoon would normally impound an area of water considerably larger than that already described.

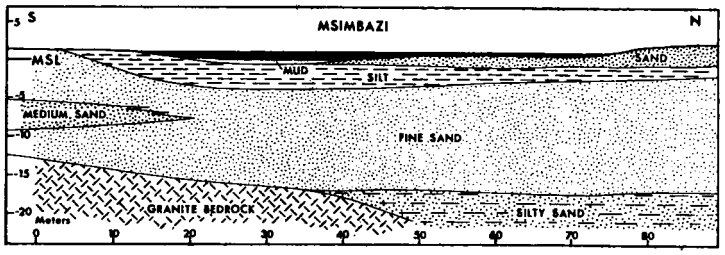


Fig. 65. Cross section through the Msimbazi lagoon after Orme ([257]).

Breaching. At the request of the Illovo sugar estates, bar breaching was (until July 1977), undertaken regularly by the Kingsburgh Municipality. This was considered necessary because flooding of sugar cane alongside the upper reaches of the lagoon was occurring. In May 1977 after representations by the Oceanographic Research Institute, the practice was abandoned after the Kingsburgh Council had agreed that it was inadvisable on ecological grounds ([18]).

Configuration of the adjacent shore. ([132])

Beach type — open beach, suitable for recreation.

Average beach slope — 3°	indicative of
Average beach slope (m) — 140	moderate surf
Average sand grain size (μ) — 330	zone conditions

Surf zone currents. Rip currents are reported to be absent in the near vicinity of the lagoon.

Physico-chemical characteristics

No information specific to the lagoon is available. However, some indication as to the likely physico-chemical conditions can be obtained from the results of Brand *et al* taken 2 km above the lagoon in 1964 (see Table **51**) ([43]). Several signs significant of disturbance were apparent, probably relating to run off from sugar cane fields.

Surface salinities were found to grade from 10‰ near the mouth to 4‰ at the head of the lagoon on 7 June 1977 (pers. obs). The clarity of the water was exceptionally good (Secchi ±200 cms).

Public health aspects

Bacteriology. Only the results obtained by Brand *et al* ([43]) from a point 2 km above the lagoon in 1964, are available. These provide some indication as to the likely conditions in the lagoon. There was some evidence of organic enrichment in the summer, and faecal pollution in winter (see Table **52**). The quality of the water (assigned to Class V) was considered to be verging on public nuisance levels. 'No Swimming' signs have been erected on the edges of the lagoon.

Bilharzia. A survey in September 1976 by Jackson (pers. comm.) failed to show the presence of bilharzia snails in either the lagoon or the river. In 1964 however, *Biomphalaria* were found on both the marginal vegetation and bottom of the river, 2 km above the lagoon ([43]). In addition *Bulinus (Physopsis) africana* was reported as abundant in a side stream of the system, by Day in 1950 ([114]).

Thus with a Bantu reserve on the southern bank, and the known presence of the vector snails in the river, the likelihood of bilharzia in the lagoon, exists.

Table 51. Physico-chemical characteristics ([43]).

Locality: MSIMBAZI Distance above lagoon : 2km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.5	7.3
Saturated pH value	8.6	8.5
Conductivity micromhos/cm	421	449
Total dissolved solids ppm (calcd.)	255	218
Dissolved oxygen mg/litre	5.8	5.7
% Saturation	69	56
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	0.6	5.8
Kjedahl nitrogen mg/litre	2.0	0.1
Ammonia mg/litre	0.1	nil
Nitrites mg/litre	.015	.004
Nitrates "	.28	.03
Phosphates "	Trace	1.46
Total alkalinity "	77.6	86.0
Total hardness "	70.2	77.6
Calcium "	8.6	10.4
Magnesium "	11.8	12.5
Sodium "	64	50
Potassium "	1.3	1.4
Sulphates "	17.3	1.9
Chlorides "	76	74
Silica "	24	12
Iron "	1.4	0.8
Fluorides "	1.4	0.3
Free carbonic acid (as ppm carbon dioxide)	5.6	8.4
Temperature °C	25.0	15.5
Turbidity (ppm silica scale)	48	30
Colour (APHA units)	15	70
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

Table 52. Bacteriology of the Msimbazi river ([43]) 2 km above the lagoon.

Date	Total Plate Count per ml x 10^3	*E. coli* I per 100 ml	Sewage fungus
	5 days @ 32°C	Confirmed	
21 January 1964	1,1	1 600	
14 May 1964	**100**	200	+
15 June 1964	**100**	**9 000**	+
16 November 1964		**50 000***	

+ and values in bold are significant of disturbance.
* membrane count.

BIOTIC CHARACTERISTICS

Flora

Most of the vegetation on lowland surrounding the system has been destroyed either by cultivation in the Bantu reserve south of the lagoon, or by the planting of sugar cane north of the lagoon ([18]). Where a golf course once occurred along the northern bank of the lagoon ([114]), a fringe of *Casuarina* grows today. Route MR491 also traverses what was a former wetland area of the Msimbazi lagoon, and effectively prevents it from making any detritus contribution to the lagoon.

Near the mouth, the coastal dunes on both banks remain reasonably well vegetated. On the northern bank trampling of the pioneer vegetation is evident, due to uncontrolled access to the beach. Around the caravan park, the area has been deliberately left well covered in trees. On the southern bank, the milkwood (*Mimusops caffra*) grows alongside the water's edge, in an almost mangrove-like situation. Several wetland communities occur. The most important of these is the low lying Calabash Island — a 2 ha expanse of sedges in the centre of the Msimbazi lagoon.



"Calabash Island" — a low lying expanse of sedges in the Msimbazi lagoon.

On the southern bank, inlets and backwaters spread amongst the halophilous communities (such as *Juncus, Paspalum* and *Sporobolus*) and *Phragmites* reeds fringe the upper reaches of the lagoon.

In 1950 Day ([114]) reported the presence of *Salicornia* and a species of "saw edged grass", but otherwise described the vegetation in much the same manner as above. He commented on the absence of mangroves.

Table 53. Aquatic fauna of the Msimbazi lagoon (after Day ([114]) in 1950).

Phylum	Number of Species		Remarks
	River	Lagoon	
Polychaeta	-	6	*Mercierella* - abundant
Mollusca	4	7	*Bulinus africanus* - abundant in river *Solen corneus* } common in *Musculus* sp. } lagoon
Crustacea	2	31	*Callianassa* - abundant in lagoon *Sesarma* - common in lagoon Various Amphipoda and Isopoda } common in lagoon *Penaeus indicus* - common
Insecta -	15	1	Principally *Pseudagrion* in river.
Amphibia	2	-	
Fish	2	20	*Mugil* spp. - abundant *Terapon jarbua* *Rhabdosargus holubi* *Ambassis safgha* *Gilchristella aestuarius* } common

Table 54. Aquatic fauna of Msimbazi river (after Brand *et al* ([43])) from a point 2 km above the lagoon in 1964.

Biotope	Individuals per sample	Number of species	Composition of major taxa	%
Marginal vegetation	1 480	23	Nematoda Chaetognatha Ostracoda	34.5 28.1 10.8
Sediments	1 487	16	*Chaetogaster* sp. *Pristina synclites* Nematoda Ostracoda	35.9 17.8 12.4

Fauna

The only information on the fauna of the Msimbazi lagoon is that provided by Day ([114]), after a survey in 1950 (see Table **53**).

Lower trophic levels. 45 species of animals (principally crustacea) were shown to be present in the lagoon, as well as 23 species in the river or from side streams alongside the lagoon. In 1964, the surveys of Brand *et al* ([43]) showed a similar diversity of organisms, from a point in the river 2 km above the lagoon (see Table **54**). The crab *Varuna litterata* was very much in evidence on 7 June 1977 (pers. obs.), and the upper reaches of the lagoon are thickly populated by the sand prawn *Callianassa* (Maurice, pers. comm.). Some fine swimming

prawns (*Penaeus indicus* and P. *monodon*) have been taken from the lagoon by Connell (pers. comm.) in recent years.

Higher trophic levels.

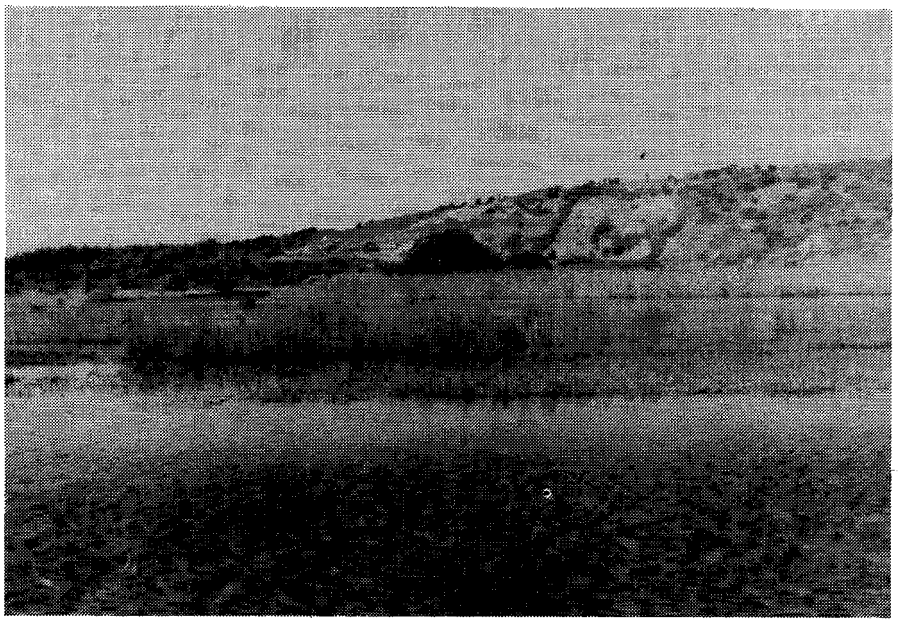
Fish: Day ([114]) showed 20 species of fish to be present in the lagoon in 1950, and two species in the river. Various species of mullet (*Mugilidae*) were plentiful and thornfish (*Terapon*), stumpnose (*Rhabdosargus*), glassies (*Ambassis*) and estuarine round herrings (*Gilchristella*) were common.

Birds: Estuarine associated birdlife seems to be concentrated around wetland communities in the middle reaches of the lagoon. On 7 June 1977 seven species were present (pers. obs.).

SYNTHESIS

Our present state of knowledge of the Msimbazi lagoon is fair, but regrettably outdated. In view of this, further biological investigations are definitely warranted. Such surveys will almost certainly show that the Msimbazi lagoon supports a viable population of estuarine animals, and that its contribution in this respect, is an important one when compared to other lagoons on the south coast.

The lagoon appears to have distinct conservation potential, thus the policy to cease lowering the level of the lagoon, has been adopted by the local authority ([18]). The lagoon is threatened by the likelihood of increased utilization for the purposes of speedboating, and should the "Space Properties" proposal be adopted, it is possible there could be deterioration in water quality. However, it is the impact that is likely to result from construction of the south coast freeway (see Fig. **64**) which is the principal threat to the system.



One of the oxbow loops of the Msimbazi lagoon which was destined to be infilled in order to re-route the Umbumbulu road.

The re-routing of route MR 491 across the floodplain, presented serious impications until discussions between the Oceanographic Research Institute, the Natal Roads Department and their Consulting Engineers, were held. The decision taken to modify the plan (van Niekerk, Kleyn & Edwards pers. comm.) is encouraging, although the fact that certain sections of the lagoon are to be infilled and the rivers diverted, represents a loss of water area, shoreline length and wetland communities. Such actions will also accelerate siltation and change flow relationships. This situation serves as a typical example to show how and why Natal's estuaries are becoming steadily more degraded.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora			Fauna							Food Webs
MSIMBAZI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids											★													←	★	→					
Source of Information	Summary of available information																																
Day	1950	114		●		●				●												●		●		●	●					
Harris	1953	145	●	●																												
Campbell, Bernstein & Irving	1964	73	●	●	●															●												
Brand *et al*	1964	43	●					●			○				○										○	○						
Fromme	1970 to 1975	132								●																						
Orme	1971	257			●		●	●		●																						
Cameron	1977	pers. comm.																		●												
du Preez	1977	pers. comm.						●																								
van Niekerk, Kleyn & Edwards	1977	pers. comm.	●		●																											
Anon	1977	18					●									●			●													
Maurice and Connell	1977	pers. comm.																								●						
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	243		●																			●									
1:25 000 Job No. 262	1976	496	●																													

2.1.9.6 **uMGABABA**

Synonyms
Mgababa ([257]).

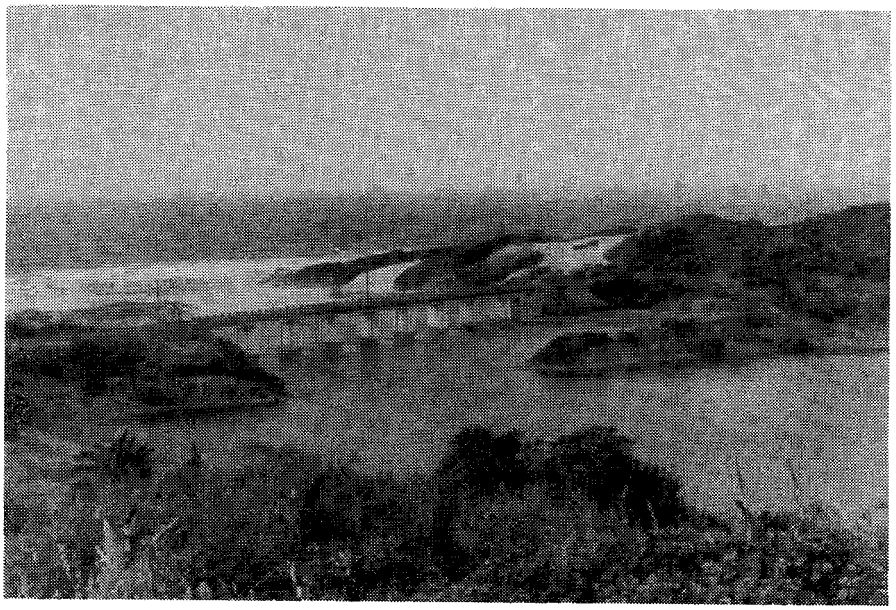
Zulu meaning ([289])
(i) "The river of jealousy" as a result of envy because of the fertility of the area, occupied by the Luthuli tribe.
(ii) "a river whose floodwaters spread over a very wide area".

Location
30°09'S; 30°50'E.

Accessibility
By road, the uMgababa lagoon lies 44 kms south west of Durban. On the northern bank, a track provides vehicular access almost to the mouth, and a secondary road runs along the edge of the floodplain just south of the upper reaches of the lagoon.

Bridges
Several bridges cross the uMgababa lagoon, most of which have adverse effects. There is:—

(a) a railway bridge 140 m from the mouth,
(b) the causeways of the old railway bridge which protrude 230 m from the mouth, and restrict flow within the lagoon,
(c) the main national road bridge 1,25 km from the mouth, and
(d) the bridge of the south coast freeway which is due to be built ±200 m above the existing road bridge. Construction will involve the diversion and semi-canalization of the upper reaches of the lagoon (van Niekerk, Kleyn & Edwards, pers. comm.) (see Fig. **66**).



The old and the new railway bridge at the mouth of the uMgababa lagoon (12 July 1977). The causeways of the former, adversely affect the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. Other than an estimate by Midgley and Pitman ([223]) of 88 km², there is general agreement that the catchment of the uMgababa is between 35 km² and 39 km² in size (van Niekerk, Kleyn & Edwards (pers. comm.) ([43], [252]).

River length. 13 km ([252]) to 16 km ([43]).

Mean annual run-off. $13{,}5 \times 10^6 m^3$ ([223]).

Flow. Flows of 0,08 m^3/sec. have been observed in summer ([43]). There is no flow during the dry season.

Flood history. 1:100 year floods have been estimated to discharge 152 m^3/sec (van Niekerk, Kleyn & Edwards, pers. comm.). The downstream consequences of flooding must, however, have been considerably reduced by the presence of the Umnini dam.

Dams.
Existing: The Umnini dam is 1,8 km above the head of the lagoon. It was built in the late 1950's or early 1960's ([252]) to supply water to uMgababa Minerals (Pty) Ltd. This Company (now inoperative) was intent upon extracting titanium from the coastal dunes in the near vicinity of the lagoon ([145]).

Proposed: None.

Siltation. Quantitative records are unavailable. However, the Umnini dam must have acted as a sediment trap since its construction above the lagoon.

Land ownership/use. The entire catchment comprising the Umlazi location and the Mfume Mission reserve is Bantu influenced, and destined to become incorporated into KwaZulu.
The lagoon itself is surrounded by the Umnini location.

Local authority. At present the Department of Bantu Administration, but in the process of being handed over to KwaZulu.

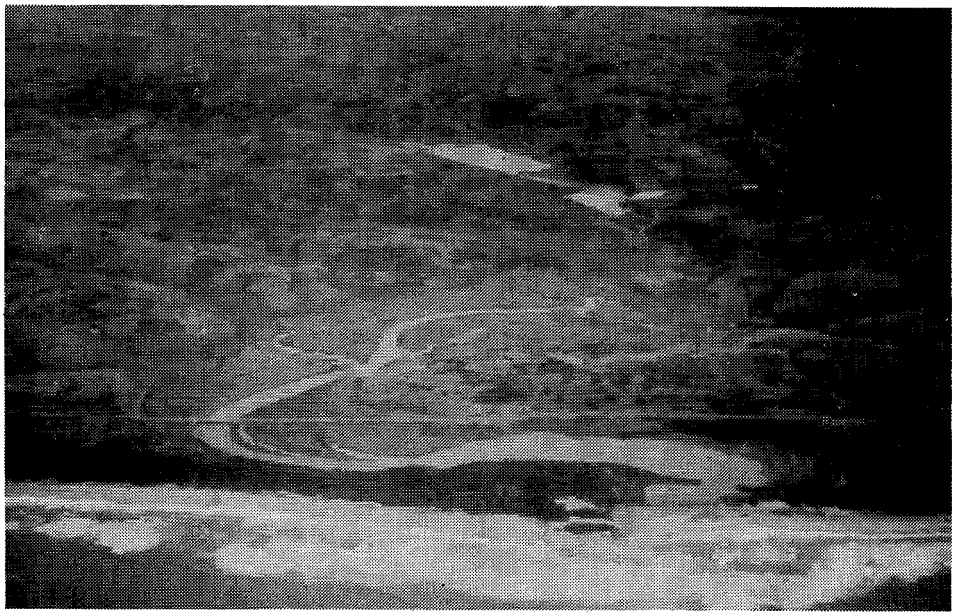
Estuary uses. The lagoon is a popular spot for fishing and the collecting of bait, especially by Indians. Angling is reported as good only when the mouth is open (Maurice, pers. comm.). Boating is limited to the odd canoeist. African cattle graze along the edges of the lagoon.

Morphometry of the lagoon (see Fig. **66**).
Area. 17,6 ha.

Axial length. 2,4 kms

Shoreline length. 8,2 km

Width.
Maximum: 160 m, although Orme ([257]) suggests the lagoon is 400 m wide.



An aerial photograph of the uMgababa lagoon taken in August 1970 by E. Moll. Notice the relationship of the Umnini dam in the lagoon.

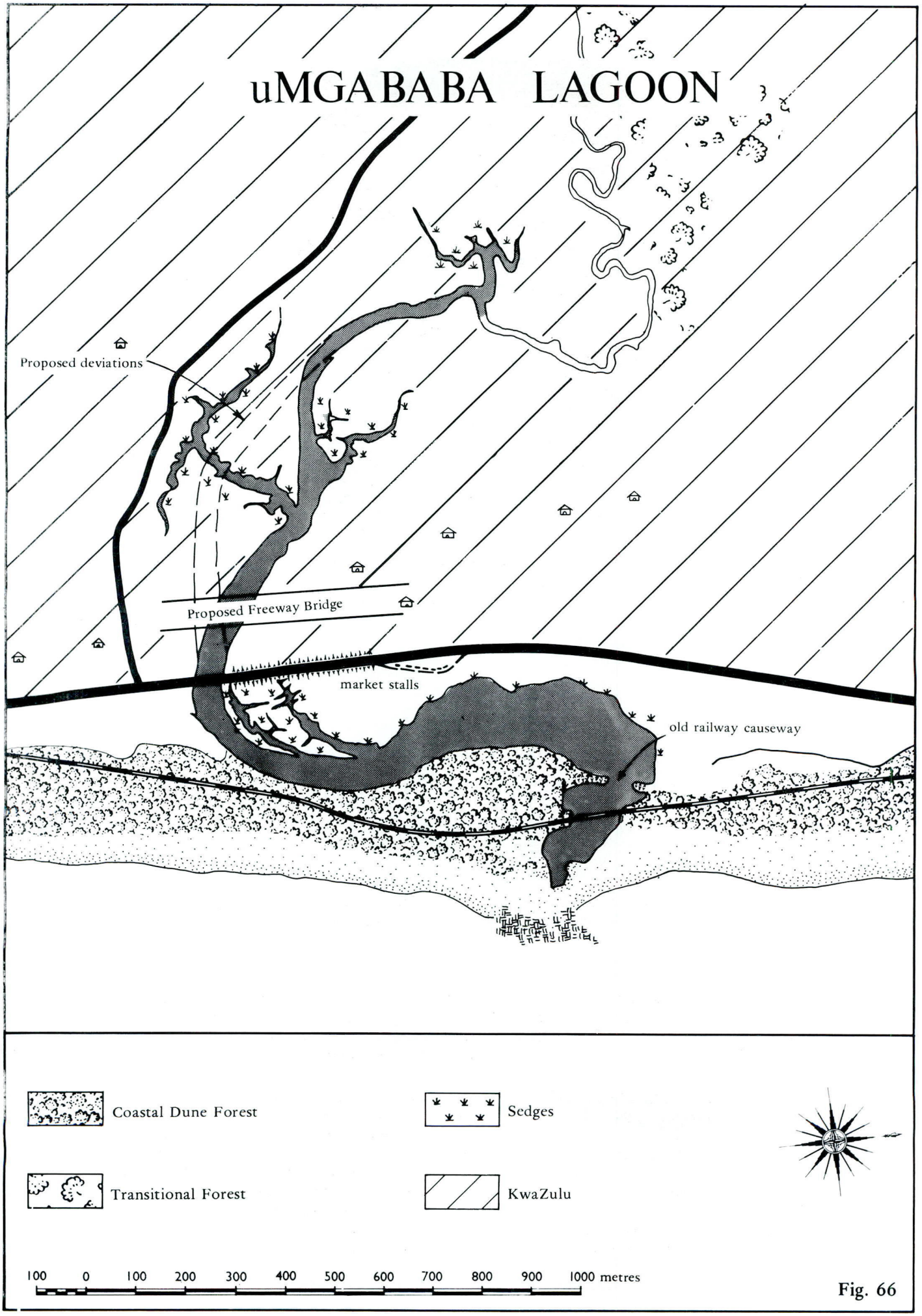
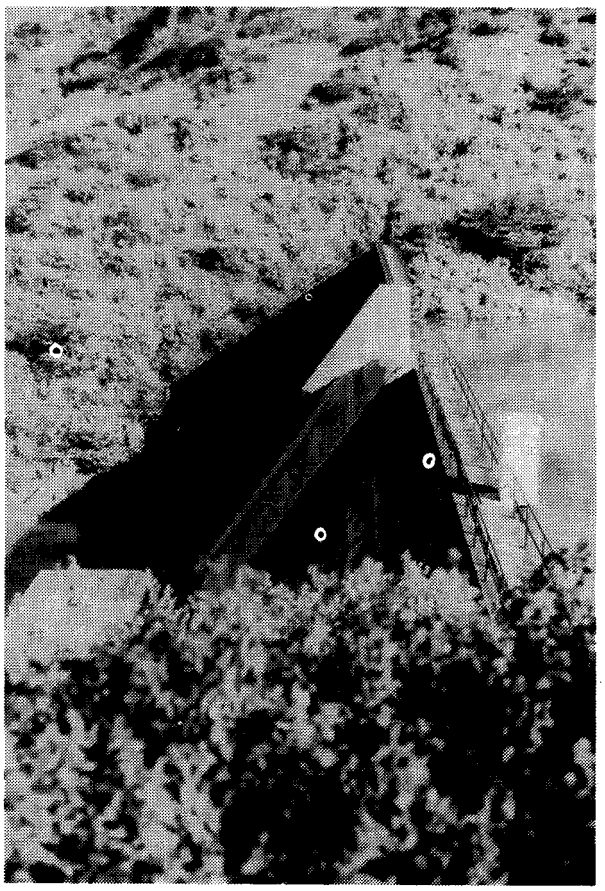

uMGABABA LAGOON
Proposed deviations
Proposed Freeway Bridge
market stalls
old railway causeway
Coastal Dune Forest
Transitional Forest
Sedges
KwaZulu
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 66



The Umnini dam is located 1,8 km above the head of the uMgababa lagoon (3 June 1978).

Mouth: Aerial photography suggests that if the mouth is open, it may vary in width from 10 m at low flow periods to 70 m during floods.
Floodplain: 350 m wide above existing road bridge.

Shape. The lagoon is S shaped, but contains numerous side channels and inlets. In comparing the uMgababa to other lagoon systems in Natal, these are unusual features. Inlets of this nature effectively increase the shoreline length which enables far better utilization of the lagoon by estuarine forms of life.

Bathymetry. Day ([111]) refers to a deep hole between the old and new railway bridges. This situation is confirmed by Maurice and Menné (pers. comm.). The maximum depth recorded was 2,6 m in this vicinity on 17 June 1976, and 1,2 m to 1,5 m elsewhere ([252]). Considerable changes in depth occur when the mouth opens.

Geomorphology

Geology. The catchment area is made up principally of Dwyka tillite, whilst Ecca shale occurs around the lagoon ([43]). This situation is confirmed by du Preez (pers. comm.) and by Orme ([257]). The latter shows that bedrock below the lagoon, lies at 15 m below mean sea level. Maud ([219]) provides information on river terraces on the uMgababa.

Nature of bottom materials. In 1950 Day ([111]) commented that "the bottom of the estuary was surprisingly sandy, though there was soft mud in the backwaters". Orme ([257]) considers the first 5 m of the bottom sediments to comprise fine sand and lagoonal black clay; as well as coarse, fluvial sand of recent flood origin in the scour channel (see Fig. **67**). Chemical analyses of the uMgababa sediments ([252]) have revealed the bottom materials to be rich in nitrogenous matter (especially in winter when the system is stable) and anoxic where high concentrations of easily oxidisable organic matter was present. The results of trace metal analysis (see Table **55**) show that considerable variation occurred throughout the lagoon in the dry season. Nevertheless, when compared to other estuaries in Natal, the level of heavy metals

revealed was relatively low. Most of them were reasonably well associated with the sediment iron content, with the exception of mercury (in the wet season). Apart from this, there was little evidence of artificial enrichment. Higher than desirable results for lead and zinc at one station were attributed by Turner to the proximity of the main road bridge and the influence of traffic. ([252])

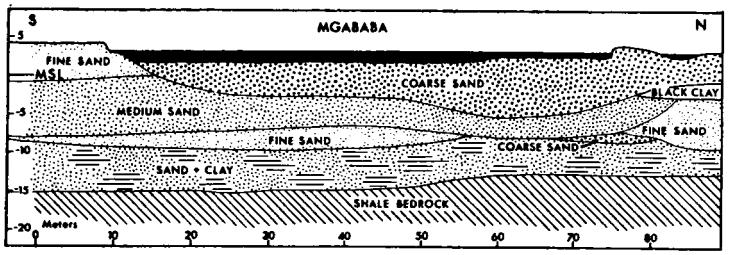


Fig. 67. Cross section through the uMgababa lagoon after Orme ([257]).

Table 55. Average trace metal concentrations in sediments of the uMgababa lagoon (after Oliff *et al* ([252])).

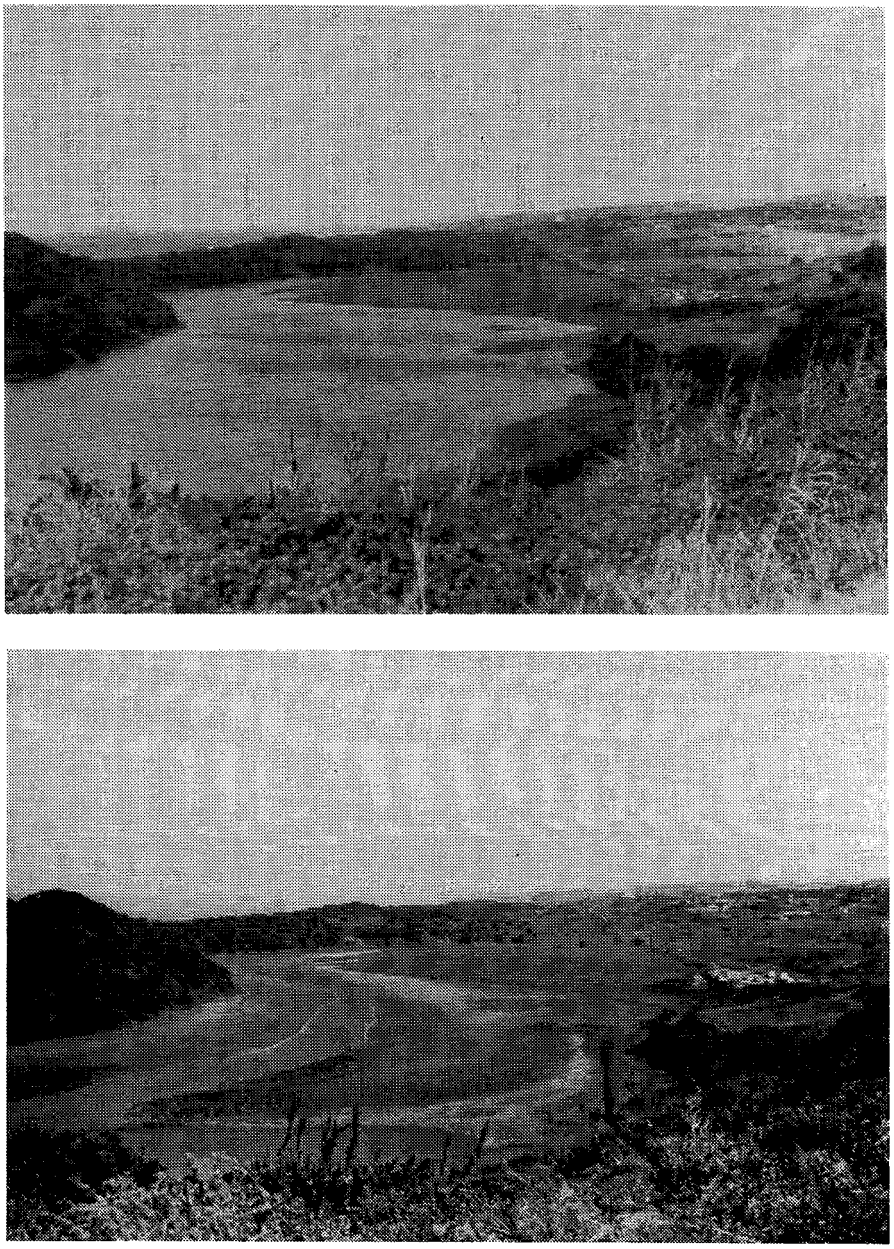
	17 June 1976		1 February 1977	
		Iron/element ratio		Iron/element ratio
Mercury	0,014	496 288	0,095	58 779
Copper	3,7	3 022	1,4	3 073
Cadmium	0,28	28 782	0,35	12 518
Lead	4,6	1 653	4,3	1 098
Zinc	7,8	1 875	4,9	1 153
Iron	7 016	—	4 302	—
Chromium	15,0	467	7,0	642
Nickel	—	—	5,01	—
Cobalt	6,0	—	—	—

All values expressed in micrograms/gram dry weight.

Sandbar characteristics. Oliff *et al* ([252]) refer to the lagoon as being "blind", and attribute this to its small catchment area. It is more likely to be due to the Umnini dam. Orme ([257]) stresses that the uMgababa lagoon is a north deflected system on a coast where most systems are deflected south. This is because the lagoon sweeps northwards for almost 900 m behind an ancient barrier dune which is now densely vegetated. It does however deflect southwards, before opening to the sea behind a rocky promontory. Scouring and wave diffraction behind the latter, seals the lagoon behind a 50 m long **south** extending sandbar.

The protrusion of the old railway causeway from both the northern and southern bank of the lagoon, must create an obstruction to flow, scour and tidal exchange patterns. These structures therefore play a part in determining how long the lagoon remains in contact with the sea, when it is open.

The bar is not breached artificially and opens naturally after periods of heavy rain ([252]). Maurice (pers. comm.) claims that the lagoon opens regularly 8 to 10 times per year, whilst Menné (pers. comm.) says that it opens very rarely.



Considerable changes in depth occur when the mouth of the uMgababa lagoon opens. Above is the lagoon at a high level (on 12 July 1977) and below at a low level (on 25 March 1977).

Configuration of adjacent shore ([132]).
Beach type — sheltered, asymmetrical beach suitable for bathing.

Average beach slope — 5°
Average beach width — 75 m
Average sand grain size — 608 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are apparently absent in the near vicinity of the lagoon.

Physico-chemical characteristics (see Table **56**).

Thermal properties. In June 1976, temperatures ranged from 17°C to 18,4°C at the surface and from 18,5°C to 21,4°C at the bottom ([252]). Surface temperatures in the lagoon

Table 56. Average physico-chemical characteristics from 5 stations.

Locality: uMgababa Lagoon	(252)				(90)	
	17 June 1976		1 February 1977		22 June 1977	
	Surface	Bottom	Surface	Bottom	Surface	Bottom
Salinity °/oo	8.5	15.5	8.2	13.9	32.3	33.3
Temperature °C	17.7	19.5	27.8	27.5	19.4	18.7
Dissolved oxygen mg/litre			7.6	4.8	7.7	6.8
Oxygen absorbed mg/litre			3.36		<u>6.5</u>	<u>12.1</u>
Silica mg/litre					1.0	.97
Kjedahl nitrogen mg/litre			.79		.51	1.3
Ammonia mg/litre					.018	.062
Nitrates mg/litre					.021	.030
Phosphorus µg/litre					2.4	0.6
<u>Heavy metals</u>:						
Mercury µg/litre			<u>0.822</u>			
Copper µg/litre			1.811			
Cadmium µg/litre			0.073			
Lead µg/litre			<u>2.515</u>			
Zinc µg/litre			1.981			
Iron µg/litre			186.07			
Cobalt µg/litre			<u>9.64</u>			

Values <u>underlined</u> significant of disturbance.

ranged from 27,2°C to 29,4°C in February 1977. In the deepest section of the lagoon, bottom temperatures dropped to 25,2°C ([252]).

In June 1976 (with the lagoon closed) reversed temperature stratification was evident. However this was not the case in June 1977 ([90]).

Transparency. Day recorded Secchi values of 60 cm in the lagoon in 1950 ([111]).

Salinity. In winter (17 June 1976) marked salinity stratification occurred only near the mouth (i.e. 11,4‰ at the surface and 31,6‰ at the bottom) and at the head of the lagoon (i.e. 1,8‰ at surface and 12,6‰ at bottom) ([252]). Throughout the rest of the lagoon, salinities were virtually uniform at 10,5‰, probably due to mixing by wind action. The following year (June 1977), the situation was totally different ([90]) as salinities were uniform and very high (31‰) at the **head** of the lagoon.

In summer (1 February 1977) salinities remained above 15‰ in the lower reaches of the lagoon, and stratified in its deeper sections. Towards the head of the lagoon, salinities dropped to below 10‰, and graded to 0,8‰ near the river ([252]).

Nutrients. The relatively high Kjedahl nitrogen levels (i.e. an average of 791 micrograms/litre) in February 1977, was considered to be attributable to the high levels found in the Umnini dam above the lagoon (i.e. 800 micrograms/litre to 1 200 micrograms/litre) ([252]). Satisfactory levels of oxygen occurred throughout the lagoon.

Heavy metals. In general, heavy metal contamination was shown to be low in February 1977. However, in common with the sediments, mercury was the exception ([252]) (see Table **56**).

In the water, mercury levels were 2,7 times higher than the normal maximum figure (averaging 0,82 micrograms/litre). From the muscle of *Acanthopagrus berda* (perch) mercury levels averaged 1,14 micrograms/gram dry weight. From *Panulirus homarus* (crayfish) opposite the mouth, mercury levels averaged 0,48 micrograms/gram dry weight.

Of the other heavy metals analysed, cobalt levels in the water were higher than those generally encountered in Natal, and lead was high near the road bridge. The latter was attributed by Turner (pers. comm.) to be the influence of traffic.

In animal tissues, lead and cobalt were found to be high in *Upogebia* (mud prawn) and zinc high in *Crassostrea* (oyster).

River water. Table **57** expresses the results of Brand *et al* ([43]) from samples taken in 1964, 1,75 km above the lagoon. Emphasis in this survey was given to mineralization of the water, and its relationship to the geology of the catchment. Thus the results relate to a spectrum of chemical characteristics very different to those already discussed.

Public health aspects

Bacteriology. No data specifically from the lagoon is available. Therefore only the 1964 results of Brand *et al*([43]) can be used to assess the likely conditions in the lagoon (see Table **58**). These show that faecal pollution and organic enrichment were detected during the dry season, 1,75 km above the lagoon. These characteristics were attributed to use of the river by Bantu for bathing, washing clothes and watering animals.

Table 58. Bacteriology of the uMgababa river ([43]) (1,75 km above the lagoon).

Date	Total Plate Count per ml x 10^3	*E. coli* I/100 ml	*Salmonella* per 250 ml
	5 days @ 32°C	Confirmed	
21 January 1964	1,15	94	
14 May 1964	7,5	33	
15 June 1964	**600**	**> 1 800**	
16 November 1964	—	1 200	+

+ and values in bold are significant of disturbance.

Table 57. Physico-chemical characteristics.

Locality: uMgababa river Distance above lagoon 1,75km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.5	7.4
Saturated pH value	9.6	8.4
Conductivity micromhos/cm	258	423
Total dissolved solids ppm (calcd.)	165	215
Dissolved oxygen mg/litre	7.9	8.3
% Saturation	97	84
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	0.9	0.5
Kjedahl nitrogen mg/litre	2.8	0.5
Ammonia mg/litre	0.2	0.5
Nitrites mg/litre	<u>0.023</u>	0.005
Nitrates "	0.56	0.08
Phosphates "	Trace	<u>1.57</u>
Total alkalinity "	39.9	77.3
Total hardness "	47.4	80.4
Calcium "	6.0	14.1
Magnesium "	7.9	11.0
Sodium "	36.4	44.5
Potassium "	2.0	2.3
Sulphates "	15.8	10.2
Chlorides "	52.4	69.8
Silica "	16.4	13.1
Iron "	<u>0.9</u>	<u>0.8</u>
Fluorides "	0.9	0.2
Free carbonic acid (as ppm carbon dioxide)	2.3	<u>6.0</u>
Temperature °C	26.5	16.5
Turbidity (ppm silica scale)	54	24
Colour (APHA units)	15	70
Appearance	-	-
Odour	-	-

Values <u>underlined</u> significant of disturbance.

Bilharzia. To date, there is no evidence to suggest that bilharzia snails occur either in or above the lagoon. Their occurrence in the Umnini dam is, however, very likely.

BIOTIC CHARACTERISTICS

Flora

Beds of *Zostera* were reported as present in 1950 ([111]). Day also reported the northern banks to be swampy, with isolated reedbeds, *Juncus* and *Salicornia* being present. A few mangroves are struggling for survival near the road bridge ([231]). The banks in the upper reaches of the lagoon are flat and grass covered. Near the water's edge, sedges occur such as *Juncus*.

The thickly forested dunes lying between the sea and the lagoon, are a particularly valuable asset to the area as a whole.

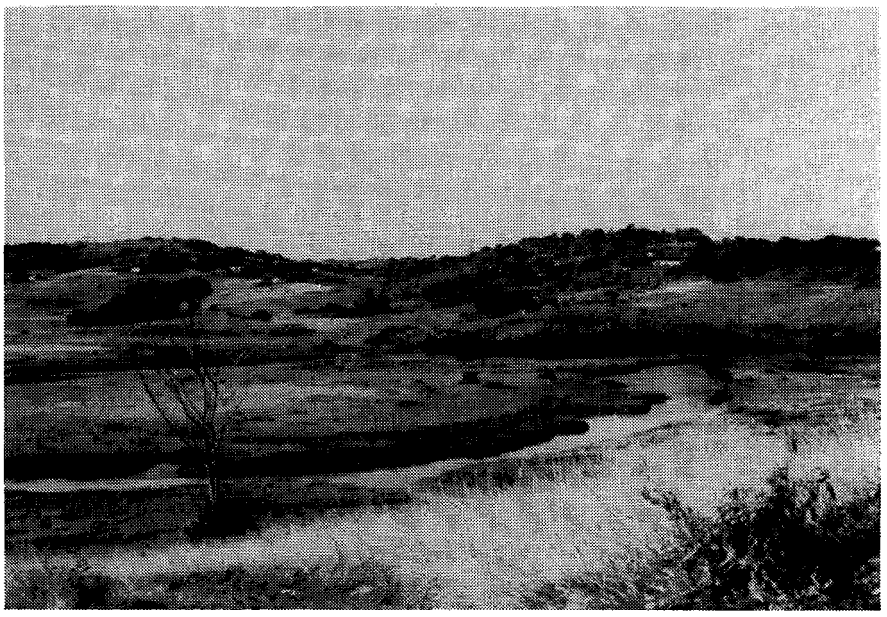
Fauna.

Lower trophic levels.

Zooplankton: Day described copepoda (probably *Acartia*) as abundant in 1950 ([111]), and Grindley (pers. comm.) has samples from the lagoon (taken in 1968) that have not yet been examined. In February 1977 however, the lagoon was shown to be completely dominated by the calanoid copepod *Acartia natalensis* ([252]). Excluding fish larvae, 33 taxa were found, and the best hauls contained up to 38 700 zooplankters per 50 m haul of a sled net. Settled volumes amounted to 6 ml. A follow up survey in June 1977 ([90]) showed a 3 to 4 fold increase in numbers (i.e. 137 952 zooplankters per 50 m haul with settled volumes of up to 20 ml). These results indicate how favourably the system responds during winter, when the mouth is closed, and there is no flooding or strong river flow.

Benthos: 35 benthic organisms were found to be present in 1950 by Day ([111]). Those listed as abundant were *Callianassa* (a prawn), *Apseudes* (a tanaid), *Paramunna* (an isopod), *Assiminea* (a gastropod) and *Balanus* (a cirripede). In June 1976, a similarly diverse and abundant fauna of 23 taxa were present ([252]) with maximum numbers of 2 769 organisms/4 litres of sediment.

The composition of the fauna was however quite different. For instance 7 species of polychaetes (with *Ceratonereis* as dominant) and one amphipod were present in 1976, as compared with 3 species of polychaetes and 7 species of amphipods in 1950. Furthermore the shrimps, prawns and crabs described as present in 1950 by Day ([111]) were absent in 1976. Although sampling techniques differ, such differences may also be attributable to changes in substrate since 1950 and the disappearance of *Zostera* beds. *Upogebia* are presently common in the system, and influxs of swimming prawns do occur occasionally (Menné, Maurice, pers. comm.). The latter appears to favour the side channels and backwaters of the system.



Backwaters in the upper reaches of the uMgababa lagoon were destined to be infilled when construction of the freeway begins (see Synthesis).

Sampling 1,75 km above the lagoon was undertaken in 1964 by Brand *et al* ([43]). These results revealed that the bulk of the animal numbers above the lagoon were made up of the polychaete *Nais*. The diversity of organisms was not particularly striking and was in general indicative of disturbed conditions.

Benthic meiofauna: The results obtained during surveys in February and June of 1977 ([90]) showed the meiofauna to be a numerically significant component of the Umgababa fauna. The mean population density was found to be in the region of 0,5 million organisms per square metre. The June survey yielded considerably higher numbers than the February survey, especially in the upper reaches of the lagoon. This was because of more stable winter conditions in the lagoon.

Higher trophic levels.

Fish: The juveniles of only 3 of the main species of estuarine fish were recorded as present by Wallace in 1975 ([329]) whereas 14 species of fish were recorded as present by Day in 1950 ([111]). Those listed as abundant were *Gilchristella aestuarius* (estuarine round-herring) and *Sarotherodon mossambicus* (bream). In June 1976, *Mugil cephalus* (broadhead mullet), *Acanthopagrus berda* (perch) and the larvae of gobiidae, *Syngnathus* (pipefish) and *Hippocampus* (sea-horse) were present ([252]). The latter does not feature in Wallace's checklist of the fishes occurring in Natal's estuaries ([328]).

SYNTHESIS

Our state of knowledge of the uMgababa lagoon is good, and much of it has been obtained recently. Bacteriological data is lacking. A concerted effort should be made to establish the source of the relatively high levels of mercury which are evident in the system (water, sediment and animal tissues). Mercury tracing in the river above the Umnini dam could be rewarding. The effect of traffic on concentrations of lead and zinc in estuaries (Turner, pers. comm.) is an intriguing aspect which requires further study. This is because of the large numbers of estuaries in Natal which are traversed by bridges. If traffic is influential in this regard, then a comparison of lead and zinc levels in a series of bridged estuaries and unbridged estuaries would be revealing.

In its present environmental condition the uMgababa lagoon is one of the most important on the Natal south coast, and has considerable conservation potential. Having a dam above it (as a silt trap) and being surrounded by an undeveloped Bantu reserve, the lagoon is likely to retain its present environmental character. The amount of estuarine life which the lagoon supports is impressive, and the dune forest east of the system is a valuable natural asset.

It is unfortunate that some of the more serious of the lagoon's problems are not likely to be solved easily. These are mercury contamination, and the imminent impact of the south coast freeway. However, consultation between the Oceanographic Research Institute, van Niekerk, Kleyn & Edwards and the Roads Department has gone a long way towards minimizing the impact. It was agreed to leave all existing water areas as backwaters (rather than infilling them with spoil), to inter-connect such areas by pipes under the approaches of the road, and to shelve and revegetate the banks of the lagoon diversion. Decisions of this sort are encouraging, and hopefully there will be increased liaison at such levels in the future.

The "throttling effect" of the old railway causeway at the mouth of the lagoon, is the only other problem from which the uMgababa suffers. If feasible, these structures should be removed, because they interfere with several basic hydrological relationships within the system (see section 3.1).

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																							BIOTIC									
			Physiography		Physics				Geomorphology			Chemistry					Bacteriology	Other								Flora			Fauna							Food Webs
uMGABABA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles				
Data Voids													★											←	★	→								
Source of Information	Summary of available information																																		
Day	1950	111		●	●					●												●		●	●		●	●						
Harris	1953	145																		○															
Brand *et al*	1964	43	●		●			●			○				○										○	○									
Maud	1968	219									●	●																							
Midgley and Pitman	1969	223	●		●																														
Fromme	1970 to 1975	132								●																									
Moll *et al*	1971	231																				●													
Orme	1971	257		●	●			●		●																									
Wallace	1975	329																									●								
Oliff *et al*	1977	252	●	●		●	●	●		●		●	●												●		●	●							
Connell *et al*	1977	90		●							●														●		●								
van Niekerk, Kleyn & Edwards	1977	pers. comm.	●		●																														
Maurice	1977	pers. comm.		●			●																			●									
Aerial photos (Scogings)		No.																																	
1:10 000 Job No. 261	1976	247		●																			●												
1:25 000 Job No. 262	1976	494	●																																

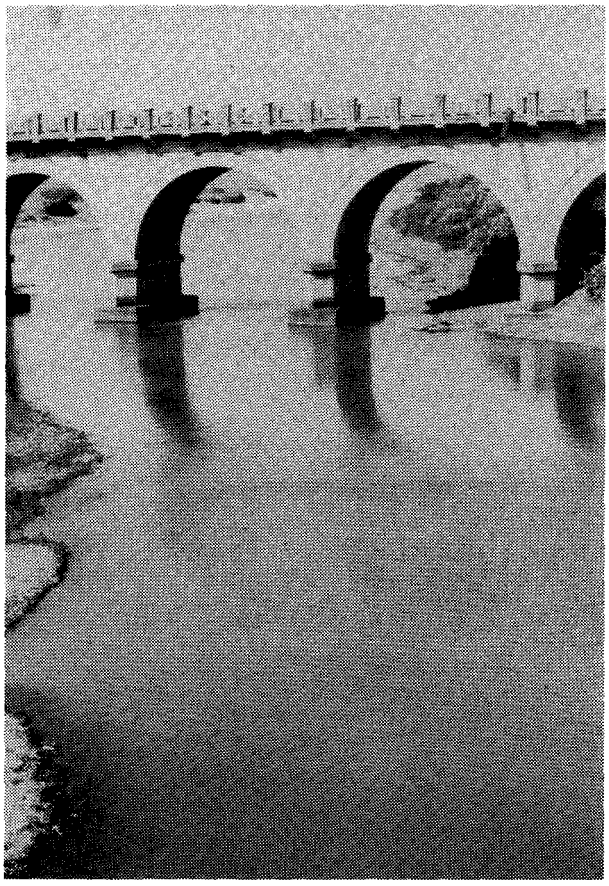
2.1.9.7 **NGANE**

Synonyms
iNgane.

Zulu meaning
"a child, or a small one" ([289]) . . . in probable reference to the size of the system.

Location
30°10'30"S; 30°49'30"E.

Accessibility
The Ngane lagoon is 46 km south west of Durban, and is easily accessible. Roads run alongside both banks.



The Ngane lagoon — looking downstream from the national road.

Bridges
(a) The railway bridge crosses the lagoon 150 m from the mouth.
(b) The national road bridge is 270 m from the mouth.
(c) The south coast freeway is to cross the Ngane river immediately above the head of the lagoon. Three large culverts will be provided for river flow (van Niekerk, Kleyn & Edwards, pers. comm.).

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 12,2 km^2 (van Niekerk, Kleyn & Edwards, pers. comm.); 20,7 km^2 ([43]).

River length. 8 km ([43])

Mean annual run-off. No record.

Flow. From the limited data available, low flows are characteristic ([43]).

Flood history. 1:100 year floods are estimated to discharge 84 m^3/sec. (van Niekerk, Kleyn & Edwards, pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. No record.

Land ownership/use. 91% of the catchment (comprising the Umlazi location and the Umnini location) is Bantu influenced and destined to become incorporated into KwaZulu.
There are Bantu holiday chalets and cottages on both banks of the lagoon.

Local authority. Bantu Administration.

Estuary uses. Bait collection, paddling and swimming by Bantu.

Morphometry of lagoon (se Fig. **68**)

Area. 1,36 ha.

Axial length. 340 m

Shoreline length. 750 m

Width.
Maximum: 60 m
Mouth: No record.
Floodplain: 250 m wide above the head of the lagoon.

Bathymetry. No record.

Geomorphology
Geology. The catchment is made up principally of Ecca shales ([43]), whilst near the lagoon, dolerite overlain by Berea red sands occurs (du Preez, pers. comm.).

Nature of bottom materials. No record.

Sandbar characteristics. The sandbar is 70 m long and south extending. The lagoon mouth opens across a dolerite sill at the southern end of the bar.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics
No data from the lagoon itself is available. In 1964, the stream 5 km above the lagoon, showed heavy organic enrichment and mineralization (see Table **59**) especially in the dry season, when the proportions of sodium and chloride were unusually high ([43]). Several signs significant of disturbance were apparent, and the water quality was classified as verging on public nuisance levels.

Public health aspects
Bacteriology. No information from the lagoon is available. With the close proximity of Bantu holiday cottages, conditions are liable to be poor. In 1964, faecal pollution was detected in summer 5 km above the lagoon ([43]). Constant organic enrichment was evident (see Table **60**).

Bilharzia. Both *Biomphalaria* and *Physopsis* were found in the Ngane river in 1964 ([43]). Consequently there is a very strong likelihood of bilharzia in the lagoon.

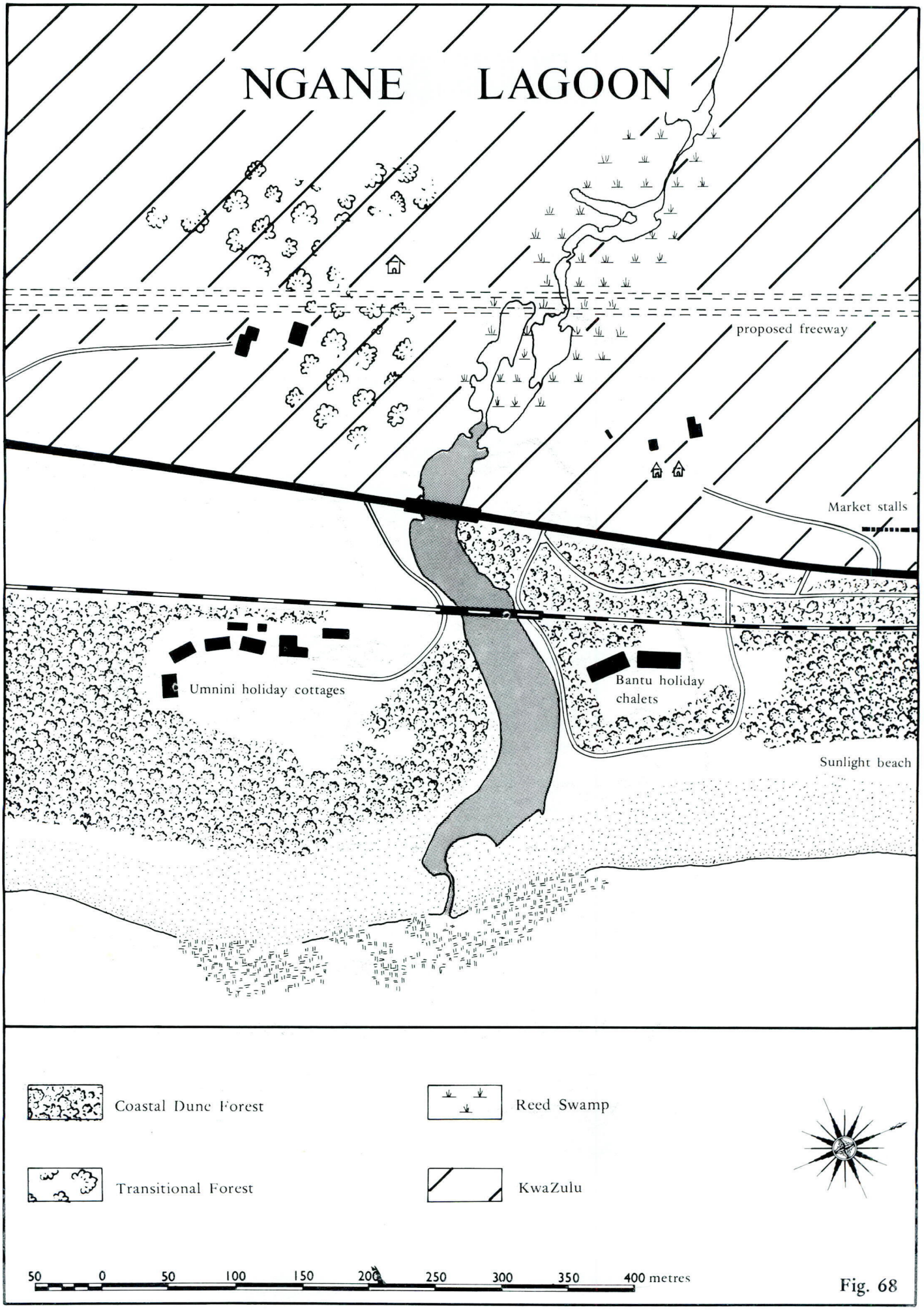

NGANE LAGOON
proposed freeway
Market stalls
Umnini holiday cottages
Bantu holiday chalets
Sunlight beach
Coastal Dune Forest
Reed Swamp
Transitional Forest
KwaZulu
50 0 50 100 150 200 250 300 350 400 metres

Fig. 68

Table 59. Physico-chemical characteristics ([43]).

Locality: Ngane river Distance above lagoon : 5.5km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.8	7.4
Saturated pH value	8.3	7.5
Conductivity micromhos/cm	571	2 268
Total dissolved solids ppm (calcd.)	358	1 180
Dissolved oxygen mg/litre	7.4	2.2
% Saturation	88	21
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	0.9	28.5
Kjedahl nitrogen mg/litre	4.6	2.3
Ammonia mg/litre	0.2	nil
Nitrites mg/litre	0.025	0.005
Nitrates "	0.91	0.10
Phosphates "	Trace	1.13
Total alkalinity "	99	242
Total hardness "	110	362
Calcium "	13.1	44.2
Magnesium "	18.9	61.1
Sodium "	83.5	279
Potassium "	1.5	4.8
Sulphates "	21.7	12.9
Chlorides "	130	550
Silica "	23.7	8.0
Iron "	0.7	0.9
Fluorides "	0.7	0.5
Free carbonic acid (as ppm carbon dioxide)	3.2	18.6
Temperature °C	24.0	12.5
Turbidity (ppm silica scale)	87	67
Colour (APHA units)	25	50
Appearance	Turbid	Dirty
Odour	-	-

Values underlined significant of disturbance.

Table 60. Bacteriology of the Ngane river

Date	Total Plate Count per ml x 10^3	*E. coli* I/100 ml
	5 days @ 32°C	Confirmed
21 January 1964	35	**> 1 800**
14 May 1964	**180**	500
15 June 1964	**380**	50
16 November 1964	—	**4 000***

* membrane count
Values in bold are significant of disturbance.

BIOTIC CHARACTERISTICS

Flora

Mangroves are reported to be present ([231]). Although patches of coastal dune forest on either side of the lagoon have been cleared around holiday chalets, a fringe of forest has been left intact alongside the lagoon itself.

An extensive wetland area above the lagoon probably serves as the major nutrient supply of the system, and drainage therefrom is likely to be considerably altered by the construction of the new freeway.

Fauna

There is no information available on the fauna of the Ngane lagoon. Maurice (pers. comm.) reports that it maintains an exceedingly rich supply of "cracker shrimp" (*Callianassa kraussi*). Ease of access has lead to heavy exploitation of these organisms by Indians.

The aquatic life found 5 km above the lagoon, was reasonably diverse and typical for a stream of this nature ([43]).

SYNTHESIS

Our state of knowledge of the Ngane lagoon is poor. However, by virtue of its small size, its present environmental condition, and its prospective fate when the new freeway is built — it has very little resource value as a lagoon system. As a recreational amenity for Bantu, concern should be expressed about the water quality of the Ngane from the point of view of human contact, because from what can be deduced, the lagoon is likely to be faecally contaminated and bilharzia infested. Any investigations to confirm this with a view to eliminating such problems, should be encouraged.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other						Flora			Fauna						Food Webs
NGANE ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids															★																
Source of Information	Summary of available information																														
Brand *et al*	1964	43	●		●			●			○				○							●			○	○					
Moll *et al*	1971	231																				●									
NTRPC	1974	236						●																							
du Preez	1977	pers. comm.						●																							
van Niekerk, Kleyn & Edwards	1977	pers. comm.	●		●																										
Maurice	1977	pers. comm.																								●					
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 261	1976	250		●																			●								
1:25 000 Job No. 262	1976	493	●																												

Synonyms

Umkomaas; Mkomanzi (1:250 000 sheet No. 3030).

Zulu meaning

Derived from the word uMkhamazi, the name relates to the sighting of a whale in the estuary at some time in the past. Stayt ([289]) gives the meaning of the word to be either "the river of the cow whales" or "the great whale river". Robertson ([271]) suggests that the estuary was so named because it was here that "the Bantu saw whale cows suckling their young". If this is true, such sightings are indicative of the sort of condition the estuary must once have been in.

Location

30°12'S; 30°49'E.

Accessibility

By road, the Mkomazi estuary is 49 km south west of Durban. Provision for vehicular access to the mouth has been made on the southern bank, but elsewhere (except at one spot on the northern bank) the estuary is relatively inaccessible, except by boat. A railway line runs along the southern bank to the South African Industrial Cellulose Corporation (SAICCOR) factory.

Bridges

Both the national road bridge, and the railway bridge cross the estuary together at the mouth of the system. The bridge pillars are said to have a stabilizing effect on the movement of the sandbar ([316]).

The traffic volume across the road bridge in 1971 was in excess of 5 000 vehicles/day ([236]). The bridge of the south coast freeway is destined to cross the estuary ±1 km from the mouth. This bridge would be almost in the position of the old railway bridge as indicated in ([112, 145]). Its position is still uncertain due to difficulties being experienced in reaching bedrock on which to establish foundations (van Niekerk, Kleyn & Edwards, pers. comm.) A seismic investigation (by detonation) was undertaken in July 1977.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. Most estimates of the catchment area of the Mkomazi are in the vicinity of 4 300 km^2 (i.e. 4 222 km^2 ([245]); 4 273 km^2 ([220]); 4 300 km^2 ([257]); 4 350 km^2 ([204]); 4 359 km^2 ([213]); 4 389 km^2 (van Niekerk, Kleyn & Edwards, pers. comm.).

The estimate of Midgley and Pitman ([223]) (which is some 2 000 km^2 less) could be a miscalculation.

River length. 298 km ([220, 245, 257])

Mean annual run-off. 1 072 x 10^6 m^3 ([213])

Flow. Information on flows for the Mkomazi river can be obtained from several sources ([145, 204, 236, 257, 316, 345, 346]).

Over the period 1965 to 1967 the mean annual discharge was estimated to be in the vicinity of 30 m^3/sec. Seasonal flows range from an average of 42 m^3/sec. ([236]) to 48 m^3/sec. ([257]) in summer, and from 10 m^3/sec. ([257]) to 12,5 m^3/sec. ([236]) in winter.

Flood history. Catastrophic floods from the Mkomazi occurred in May 1959, washing away the combined road/railway bridge ([220]). 5 km upstream water levels were 11 m higher than normal ([316]), and the flood discharge was estimated at 6 226 m^3/sec. ([220]). Normal flood discharges (e.g. February 1974) are estimated at 845 m^3/sec. ([316]). In March 1976 water levels rose 9 m higher than normal winter river levels when discharges increased to 2 740 m^3/sec. (van Niekerk, Kleyn & Edwards, pers. comm.). The latter were considered to be 15 to 20 year floods. Prior to these, severe floods were experienced in 1917 and 1924 when the floodwaters reached the parapet of the old national road bridge (Young, pers. comm.).

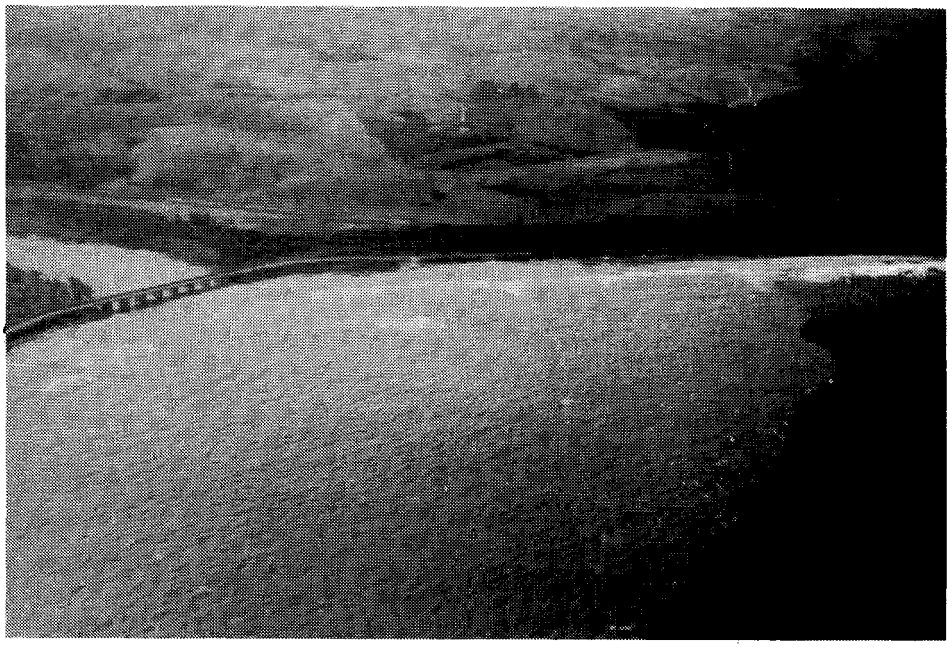
Level fluctuations: In the 1920's a tidal regime was evident 5 km from the mouth. Since then, such influences have become limited by siltation and changes in bed level to within ±2 km of the mouth (Young, pers. comm.).

Dams.

Existing. There is an intake weir upstream of the estuary which deflects water into SAICCOR's water treatment plant. 36,4 x 10^6 m^3 of water are abstracted per annum ([213]).

Proposed: The Josephine dam has been proposed 180 km upstream ([245, 271]), with a total capacity of 1 018 x 10^6 m^3 ([236]). Being rated as foremost in terms of economic viability, it is almost certain that it will be built.

Siltation. The mean annual silt load over the period 1965 to 1967 was estimated to be 900 000 tons/year ([250, 257]). Other quantitative assessments ([236]) are a total sediment load of 752 000 tons in summer and 15 000 tons in winter. The resident time of sediment is 15 to 20 years ([316]) before scouring by floods. Vast silt plumes develop out to sea opposite the estuary mouth.



Silt plumes opposite the mouth of the Mkomazi estuary. (Photo by E. Moll, December 1971).

It should be noted that high rainfall in the catchment does not necessarily coincide with the highest monthly suspended sediment loads ([346]). For example in February 1967, 160 mm of rain in the catchment was estimated to generate a total sediment load of 608 000 tons, whilst on another occasion 190 mm of rain in the catchment produced 494 000 tons of silt.

Land ownership/use. 26% of the catchment area is Bantu influenced, comprising the districts of Polela, Ixopo and Mpendle. All of these are destined to become incorporated into KwaZulu. The Mkomazi also drains the district of Richmond.

On the northern bank of the estuary are old cane farms which are destined to become a future coloured township (Maurice, pers. comm.).

On the southern bank of the estuary is the town of Umkomaas, formerly called Port Scott in honour of the Governor in 1856 ([289]). Near the head of the estuary is the SAICCOR factory which manufactures cellulose for the production of rayon.

Local authority. Umkomaas Town Board and SAICCOR Health Committee.

Estuary uses. The Mkomazi estuary is used as a skiboat base, one of the major attributes being the fact that the mouth of the estuary is seldom closed. The estuary is also used for fishing, canoeing and occasional water-skiing. Many people also come to the estuary to relax or walk along its banks.

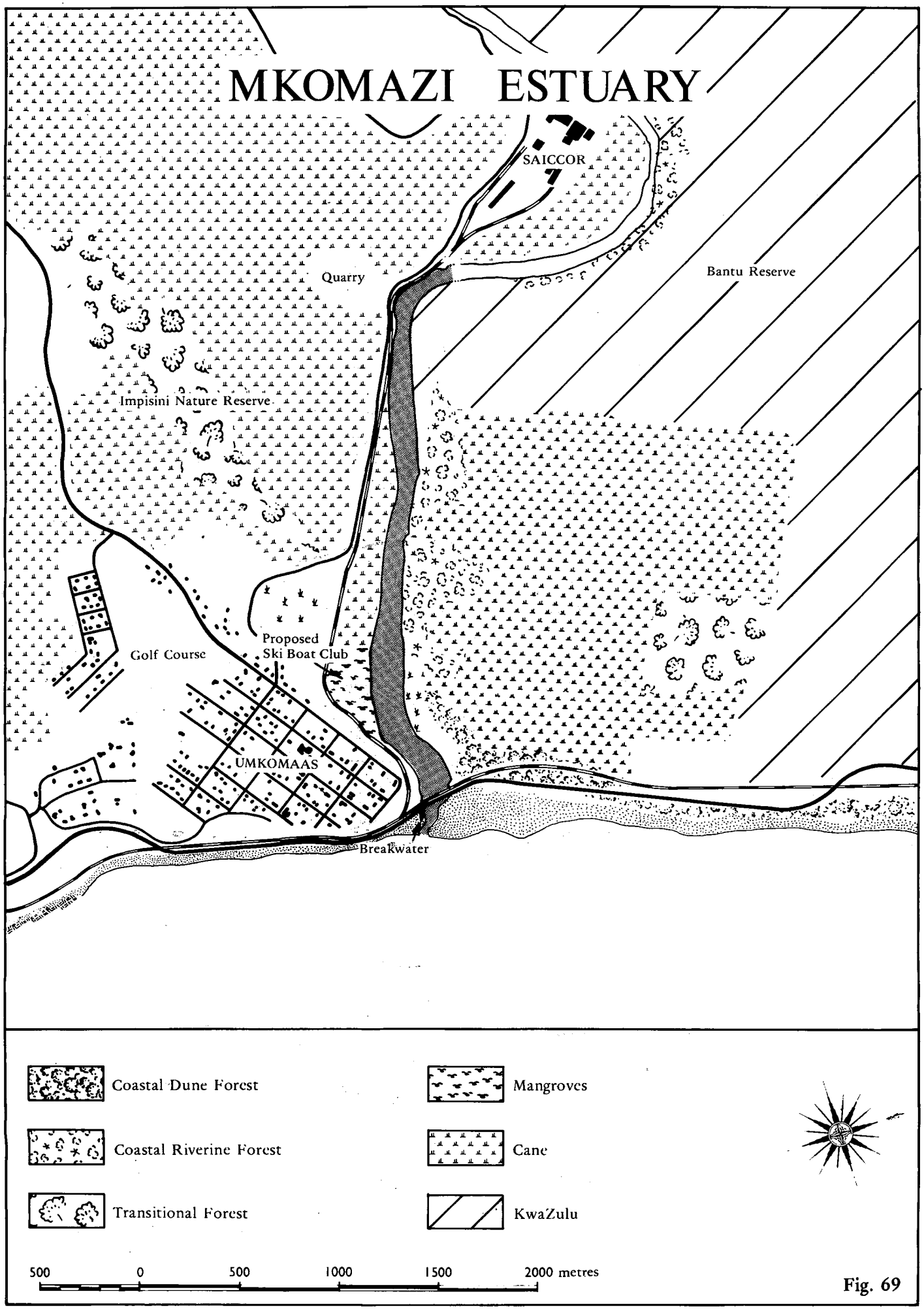

MKOMAZI ESTUARY
SAICCOR
Quarry
Bantu Reserve
Impisini Nature Reserve
Golf Course
Proposed
Ski Boat Club
UMKOMAAS
Breakwater
Coastal Dune Forest
Coastal Riverine Forest
Transitional Forest
Mangroves
Cane
KwaZulu
500 0 500 1000 1500 2000 metres

Fig. 69

Morphometry of estuary (see Fig. **69**)

Area. 37,8 ha.

Axial length. ±3 km

Shoreline length. 6,2 km

Shape. Just over 1 km inland, the estuary takes a 90° bend towards the north. It is interesting to note that in 1914 this was known as 'Alligator Point' (Mercury Pictorial 29 May 1914) because of the number of crocodiles shot at this location.

Width.
Maximum: 200 m
Mouth: 45 m (at normal flow periods)
Floodplain: 300 m to 500 m ([257]).

Bathymetry. In 1920 the estuary was reported to be not less than 6 m deep at any point (Young, pers. comm.). At this stage a launch (with 32 passengers) used to operate on the estuary taking people up to the old Drift Hotel. Coasters, such as the S.S. Somtseu (Mercury Pictorial 17 July 1914) could also enter the estuary, and tie up alongside a wharf at the old sugar mill ([289]). Although periodic scouring takes place during floods ([316]), the estuary is at present an average of 1,5 m deep at low tide, with only one or two spots 3 m to 4 m deep (Maurice, pers. comm.).

Geomorphology

Geology. The river traverses a whole succession of geological formations in its catchment ranging from old granites to Stormberg series ([245]). From recent investigations at the site of the new bridge, boring has revealed that in excess of 80 m of sediments overlie bedrock in certain places (van Niekerk, Kleyn & Edwards, pers. comm.). This situation is very different to that described by Orme ([257]), who described Karroo dolerite as bedrock 18 m below mean sea level on the northern bank of the estuary. Dolerite also outcrops at the coast, on the southern side of the estuary mouth, according to du Preez (pers. comm.). It appears to form a sill (or resistant ledge) across the estuary, which retards down-cutting.

Nature of bottom materials. (see Fig. **70**). The estuary has been described as a "sand choked" system ([204]). Black silt is found 7 m to 15 m below such deposits ([257]). Day ([112]) mentions "thigh deep" mud banks on the southern bank of the estuary in the 1950's. Near the mouth, the overlying deposits are medium to coarse grained "washover" marine sands. They were found to be coarser if deposited on a flood tide than if deposited on an ebb tide ([316]). An aerial photograph (dated 15 May 1971) clearly shows that a centrally positioned island, called Chocolate Island periodically appears ±1 km from the mouth. This developes as a result of deposition during years which are not associated with flooding (Thomas, pers. comm.). Severe floods (such as in 1959 or 1976) wash the island away during the course of channel migrations.

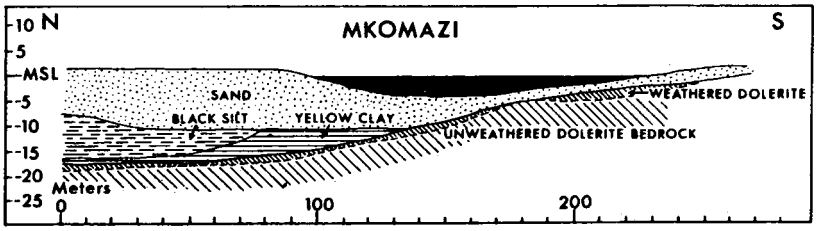


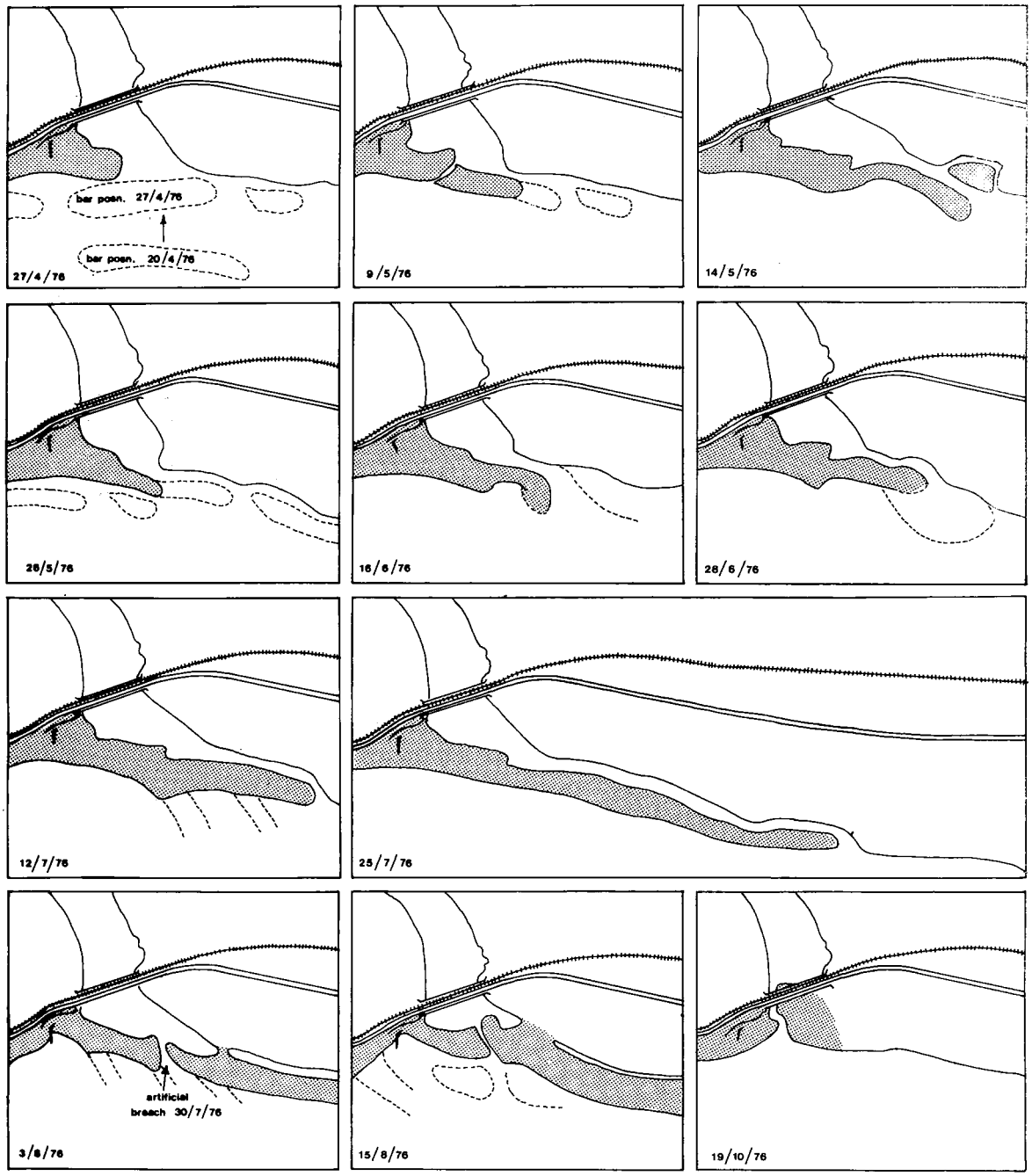
Fig. 70. Cross section through the Mkomazi estuary after Orme ([257]).

Sandbar characteristics. The Mkomazi sandbar is normally a massive, south directed feature. However, the mouth position can migrate from its normal southerly position to a northerly position during or after floods (see Fig. **71**). It may close completely in the dry season ([257]) but this is a rare occurrence. Van Heerden found the mean size of the spit material (as an indication of maturity) to decrease northwards ([316]). He suggests spit growth (or progradation) in a southerly direction was by overwash and beach drift. On the other hand, spit growth in a northerly direction occurred

under the influence of the longshore current and southerly swells, when flood materials forming an offshore bar were available.

Breaching is normally not necessary, although ski-boat owners, have been known to encourage the mouth position to switch from a northerly position (such as that on 25 July 1976) to a more southerly position by breaching (see Fig. **71**). They do this in order to create a more convenient point of exit for their boats. Details of this process are given by van Heerden ([318]).

Fig. 71. Movement of the sandspits and bars at the mouth of the Mkomazi estuary between April and August 1976 (after van Heerden, 1976).



Configuration of adjacent shore ([132]).
Beach type — asymmetrical sheltered beach, suitable for recreation.

Average beach slope — 5°
Average beach width — 104 m
Average sand grain size — 629 microns
} indicative of rough surf zone conditions

Surf zone currents. Several rip currents can develop in the vicinity of the estuary mouth under certain circumstances, according to van Heerden ([316]), whilst Fromme ([132]) regards them as absent. The nearshore current direction is set towards the north ([261, 316, 320]).

Physico-chemical characteristics

Despite the presence of the SAICCOR factory just above the estuary, the chemistry of the Mkomazi estuary has never been thoroughly studied. During the period 1955—1957 severe pollution of the estuary was caused by the disposal of SAICCOR's effluent onto a beach just south of the Mkomazi (Maurice & Thomas, pers. comm.) ([320]). The factory effluent has since been conducted by pipeline from a point north of the estuary mouth, onto the sea-bed 2,5 km offshore ([5, 64]). Pollution of the estuary occurred because the effluent (a black liquor called calcium lignosulphate) was less dense than sea water, and was being brought into the estuary from the beach outfall position, on the tides. Here it would create a high oxygen demand which resulted in the death of fish in the estuary.

Quantitative assessments of the effects of the effluent upon the littoral fauna were made by Burton before ([63]) and three years after ([68]) the commencement of effluent flow from the factory. No changes exclusively due to the effluent were detectable. Fishing is reported to be excellent next to the effluent position offshore (Smale, pers. comm.). Effluent is still brought inshore by the south-east winds, where, in conjunction with the wave action, results in the production of a white foam that covers the shore. This foam is broken up with the aid of dispersants. The ecological effects of the dispersant are unknown, but are generally considered to be minimal.

Today pollution of the Mkomazi estuary is still probable for several reasons:

(1) The original beach outfall position remains in use during emergencies (in event of pump or power failure).
(2) Effluent brought inshore by the south-east winds can still enter the estuary at high tide.
(3) The sludge of alum and silt emerging from SAICCOR's water treatment plant may be having some effect in the estuary and,
(4) there is a drainage canal below the factory on the southern bank, from which a warm iridescent effluent often runs (Maurice, pers. comm.).

Table 62. Bacteriology of the Mkomazi river (2 km above the estuary).

Date	Total Plate Count per ml x 10^3		*E. coli* 1/100 ml	Total Coliforms /100 ml	*Salmonella* /250 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient	Confirmed		
March 1971			602	13 500	+
July 1971			88	1 084	+
3 Feb 1972	336	240			
21 Feb 1972	650	420	100		
5 July 1972	**7 200**	61	275		
31 July 1972	**2 000**	210			
16 Aug 1972	120	**6 000**			
15 Jan 1973	70	**1 600**			

+ and values in bold are significant of disturbance.

Table. 61. Physico-chemical characteristics ([204]).

Locality: Mkomazi river Distance above estuary: 2km	SUMMER 1964	WINTER 1964
Hydrogen ion concentration (pH)	7.8	8.2
Saturated pH value	9.6	8.5
Conductivity micromhos/cm	60	230
Total dissolved solids ppm (calcd.)	63	142
Dissolved oxygen mg/litre	8.2	8.3
% Saturation	99	95
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	2.8	2.9
Kjedahl nitrogen mg/litre	0.2	0.2
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	.26	.03
Phosphates "	.61	.08
Total alkalinity "	21.8	60.3
Total hardness "	42.4	60.8
Calcium "	6.8	13.8
Magnesium "	6.2	6.4
Sodium "	5.7	24.8
Potassium "	0.7	1.0
Sulphates "	nil	14.4
Chlorides "	5.9	29.1
Silica "	-	-
Iron "	-	-
Fluorides "	0.7	0.2
Free carbonic acid (as ppm carbon dioxide)	0.7	0.8
Temperature °C	25.0	23.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

Data from a survey of the Mkomazi river in 1970 is available ([204]). Table **61** shows the results obtained from a station 2 km above the estuary.

Public health aspects

Bacteriology. Data from the estuary itself is either non-existent or undisclosed. In the 1950's Harris ([145]) suspected that the effluent from septic tanks was reaching the estuary. Based upon the limited data from a station 2 km above the estuary and above SAICCOR, mild organic enrichment was evident in 1972 ([204]) (see Table **62**). The presence of *Salmonella* in 1971, was indicative of a source of faecal pollution above the estuary. Loxton, Hunting & Associates ([213]) concluded that the Mkomazi "appears to be slightly, and possibly only locally polluted . . .", although the river is also said "to contain water of poorer than acceptable quality . . ." ([236]).

Bilharzia. The vector snail *Biomphalaria pfeifferi* has been found in the Mkomazi catchment ([204]), but the chances of bilharzia occurring in the estuary are remote.

BIOTIC CHARACTERISTICS

Flora

It is interesting to note that in the 1950's Day ([112]) commented on the presence of a mangrove/reed swamp community only on the northern bank of the estuary. The area where these occurred appears to have become lost to the estuary since the new bridge was built at the mouth. He also made mention of large reed swamps on the southern bank, and a *Hibiscus tiliaceus* fringe on steep banks below the town. Urban encroachment (on the southern bank) and sugar cane, has replaced most of the vegetation around the estuary. Mention is made of refuse being used to reclaim swamp land in the past ([145]). A few forested slopes remain on the northern bank, where the terrain is too steep for cultivation.

The only botanical communities of any value remaining around the estuary are both on the southern side. These are:

(1) A mangrove community ([231]) amongst which a new skiboat base has been proposed (Thomas, pers. comm.). The cutting of mangroves (for hut construction) and the ring barking of mangroves (for medicinal reasons) by Bantu is one threat to which these trees are presently subjected (Thomas, pers. comm.). Drainage channels leading from the swamp have also become blocked, with the result that fresh water is becoming impounded and killing certain parts of the swamp.
(2) The forested valley of the Impisini Nature Reserve which is ±40 ha in size.

Fauna

Lower trophic levels.

Zooplankton: Zooplankton samples have been taken from the estuary (in ±1968) by Grindley (pers. comm.) the examination of which has not yet been undertaken.

Benthos: Day ([112]) considered the bottom fauna of the Mkomazi estuary to be poor after his survey in 1950 and attributed this to "muddiness". 18 species of benthic animals were found amongst which *Upogebia, Macrobrachium* spp. and various crabs (*Sesarma, Uca*) and the gastropod (*Cerithidia decollata*) were common in the mangrove community. *Apseudes* (a tanaid) was also common in the estuary, but no penaeid prawns were present. According to Brown ([54]) the gastropod *Neritina gagates* was collected from the Mkomazi in 1939.

Burton also commented on the sparseness of the benthic fauna in the estuary in 1955 ([63]). Only three species were present in the sand. The isopod (*Pontogeloides latipes*) was found in numbers of up to 200/m^2 near the mouth. This is suggestive of marked deterioration within 5 years.

Upogebia and a species of swimming prawn are still present (Maurice, pers. comm.), the latter amongst marginal vegetation. *Caridina nilotica* (a shrimp) have been taken from this niche 2 km above the estuary in 1972 ([204]).

Higher trophic levels.

Fish: Records of catches made in the Mkomazi estuary in 1914 are available from various Mercury Pictorials amongst which are descriptions of catching "20 baskets of shad", colossal rock cod (weighing 180—270 kg) and kingfish (weighing 100 kg). Sharks were also very common in the estuary (see Mercury Pictorial dated 26th June 1914). Day's survey in 1950, revealed 9 species of fish to be present, the most common being mullet ([112]). Angling is generally poor (Maurice, pers. comm.) and confined to small grunter (*Pomadasys*) or perch (*Acanthopagrus*), although occasionally a fair catch of salmon (*Argyrosomus*) can be made. Angling fleetingly improved during April to

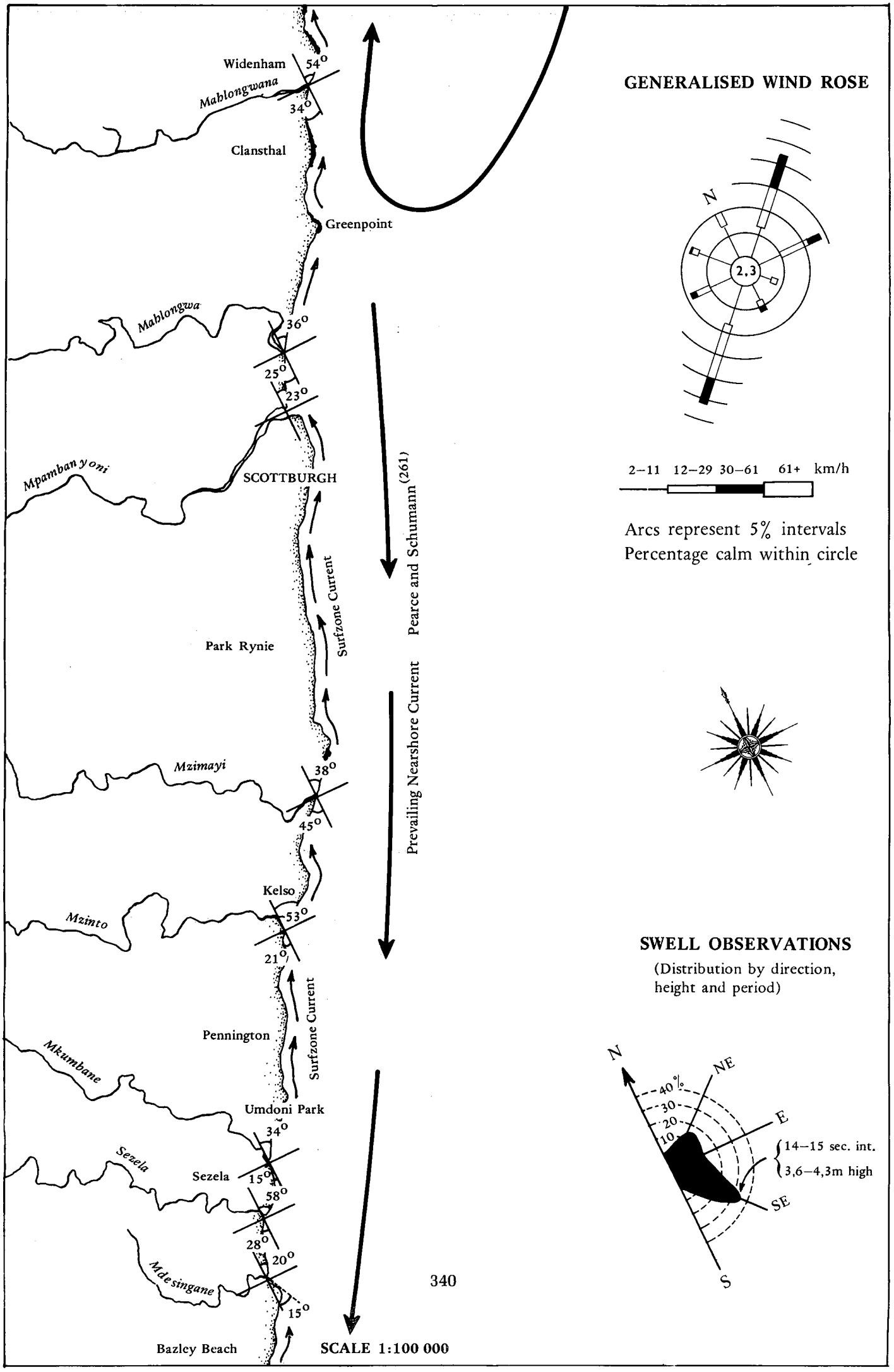
May 1977. At the time the water of the estuary had become noticeably clearer (Maurice, pers. comm.). Species present included razor bellies (*Hilsa*), slimies (*Leiognathus*), mullet (*Mugilidae*) juvenile shad (*Pomatomus*), yellow tailed kingfish (*Caranx*), pompano (*Trachinotus*) and garrick (*Lichia*). Eels (*Anguilla*) also make extensive use of the estuary (Beesley pers. comm.) and Mkomazi river system ([204]). Construction of the Josephine dam will no doubt restrict the movements of this fish in the future. However as eels are particularly sensitive to pollution (Jubb, pers. comm.) their occurrence therefore suggests that the system is not polluted.

Birds. On the cliffs opposite the SAICCOR factory a Grey heron colony (of ± 30 nests) is well established (Thomas, pers. comm.). The presence of waders was mentioned by Day in 1950 ([112]). Of the six estuarine associated species sighted by Nicholls in January 1977 (pers. comm.) various terns were the most conspicuous birds utilizing the mouth of the estuary.

SYNTHESIS

With the Mkomazi being the estuary of one of the largest rivers in Natal, our knowledge of the system (in particular our biological understanding) is poor. Although the estuary has been considered worthy of conserving by Hopwood ([189]), outwardly it is in a severely degraded state. One of the principal reasons why the estuary is in this condition is because of the severe rate of siltation. Furthermore it appears likely that the estuary is still polluted by wastes from the SAICCOR factory. A series of surveys to establish whether this is the case should be undertaken. Simultaneous ecological surveys are also warranted, to establish how much use is made of the estuary by estuarine organisms. Until such times that both of these surveys have been undertaken, it is not really possible to assess the present resource value of the Mkomazi estuary.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																								BIOTIC													
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other												Flora			Fauna										Food Webs
MKOMAZI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles								
Data Voids											★															◄	★	►										
Source of Information	Summary of available information																																						
Brown	1939	54																									●												
Day	1950	112								●													●				●	●	●										
Harris	1953	145			●										●																								
Burton	1955	63																									●												
Burton *et al*	1958	64																									●												
Meinecke	1959	220	●		●																																		
Wylie	1966 to 1967	345, 346			●					●																													
Midgley & Pitman	1969	223	●		●																																		
Oliff *et al*	1969	250								●																													
Kemp *et al*	1970 to 1973	204	●		●					●	○				○											○	○												
Fromme	1970 to 1975	132								●																													
Moll *et al*	1971	231																				●																	
Ninham, Shand & Partners	1971	245	●					●																															
Loxton, Hunting & Associates	1971	213	●		●						○																												
Orme	1971	257	●	●	●			●		●																													
NTRPC	1974	236			●			●			○																												
van Heerden	1976	316			●					●																													
Young and Maurice	1977	pers. comm.		●	●		●				●									●							●		●										
Thomas	1977	pers. comm.					●				●								●			●							●										
van Niekerk, Kleyn & Edwards	1977	pers. comm.	●		●			●		●																													
Hopwood	1978	189						●											●			●																
Aerial photos (Scogings)		No.																																				
1:10 000 Job No. 261	1976	254		●						●												●		●															
1:25 000 Job No. 262	1976	492	●	●																				●															


Widenham
54°
Mahlongwana
34°
Clansthal
Greenpoint
Mahlongwa
36°
25°
23°
Mpambanyoni
SCOTTBURGH
Surfzone Current
Park Rynie
Mzimayi
38°
45°
Kelso
53°
21°
Mzinto
Pennington
Surfzone Current
Mkumbane
Umdoni Park
34°
Sezela
Sezela
15°
58°
28°
20°
Mdesingane
15°
Bazley Beach
Prevailing Nearshore Current
Pearce and Schumann (261)
SCALE 1:100 000
GENERALISED WIND ROSE
N
2,3
2–11 12–29 30–61 61+ km/h
Arcs represent 5% intervals
Percentage calm within circle
SWELL OBSERVATIONS
(Distribution by direction, height and period)
N
NE
E
SE
S
40%
30
20
10
14–15 sec. int.
3,6–4,3m high

2.1.10.1

MAHLONGWANA

Synonyms
Amahlongwana ([257]).

Zulu meaning
No record.

Location
30°14'S; 30°48'E.

Accessibility
By road the Mahlongwana lagoon is 53km south west of Durban. Although crossed by the national road, vehicular access to the water's edge is lacking. However, the upper reaches of the lagoon can be reached via a sugar cane track on the southern bank. This leads to a small bridge at the head of the lagoon.

Bridges
The railway line and the national road cross the lagoon 50m and 300m from its mouth respectively. The bridge site of the south coast freeway is approximately 500m above the headwaters of the lagoon (van Niekerk, Kleyn & Edwards, pers. comm.).

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 17 km^2

River length. 6 km.

Mean annual run-off. No record.

Flow. Ward (pers. comm.) maintains flow is perennial.

Flood history. 1:100 year floods have been estimated to discharge only 40 m^3/sec. (van Niekerk, Kleyn & Edwards, pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. No record. The Mahlongwana lagoon does not appear to be badly silted, probably because of the small catchment area and low run-off.

Land ownership/use. Most of the catchment area is under sugar cane and presumably owned by the Crookes Bros.
On the northern bank of the lagoon is the township of Widenham. The southern bank is undeveloped, except for the sugar cane fields west of the national road.

Local authority. Widenham.

Estuary uses. No record.

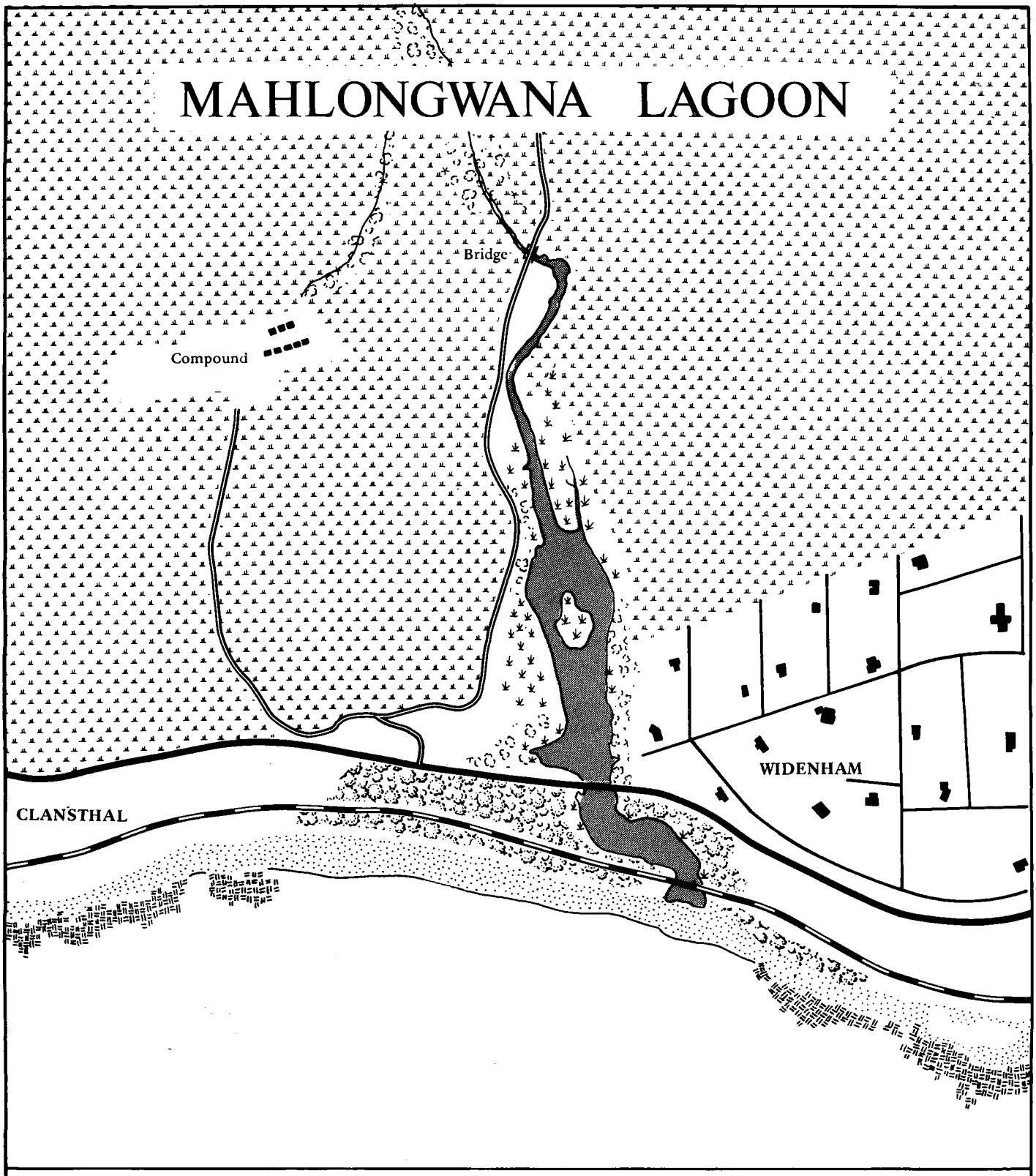
Morphometry of lagoon (see Fig. **72**).

Area. 6,84 ha

Axial length. 1,3 km

Shoreline length. 3,1 km, including the periphery of a 0,5 ha island in the centre of the lagoon.

Width.
Maximum: 150 m
Mouth: no record
Floodplain: 200 m



Coastal Dune Forest

Reed Swamp

Coastal Riverine Forest

Cane

100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 72

Bathymetry. No record.

Geomorphology

Geology. The catchment area is made up of Dwyka tillite ([236]). At the road bridge Dwyka tillite occurs as bedrock 15 m below mean sea level ([257]). According to the Department of Geological Survey dolerite outcrops along both sides of the lagoon and on the coast at Widenham (du Preez, pers. comm.).

Nature of bottom materials. No record

Sandbar characteristics. Without rock protection south of the lagoon, the sandbar (now stabilized by the railway line and vegetation) is north extending. Although Orme has described the mouth of the lagoon as being "frequently blocked by littoral drift..." ([257]), Ward (pers. comm.) is of the opinion that the porosity of the sandbar is such that it seldom opens despite perennial flow from the river. It has also been described by van Heerden as a semi-permanent bar which opens naturally once or twice after floods in summer (as on 16th March and 8 May 1976) ([316]). In the latter case, the bar had reformed through "overwash" by 27 May 1976, indicating a limited period of 19 days contact with the sea. With sugar cane alongside the lagoon, the bar is probably breached artificially.

Configuration of adjacent shore ([132]).
Beach type — bight, suitable (with reservations) for bathing.

Average beach slope — 8°	indicative of
Average beach width — 62 m	rough surf zone
Average sand grain size — 989 microns	conditions

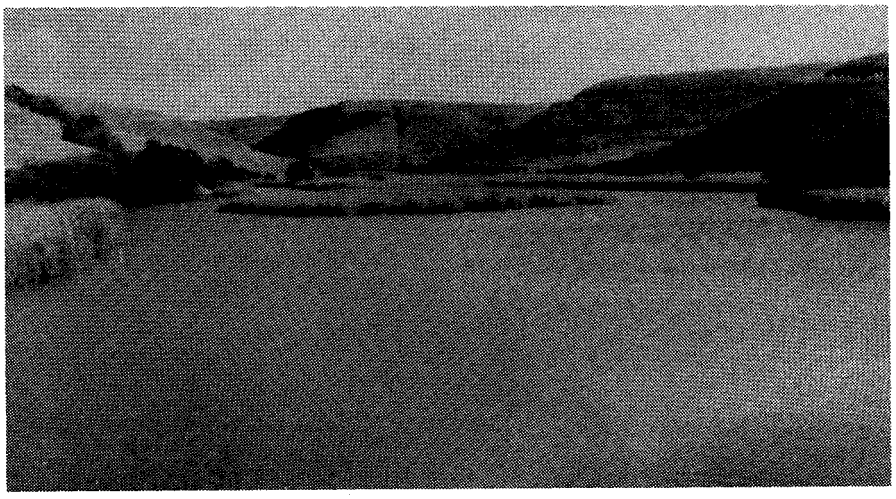
Surf zone currents. Rip currents are apparently absent in the near vicinity of the lagoon.
The Mahlongwana lies just north of Greenpoint, i.e. that point on the south coast at which two opposing nearshore currents diverge, according to Pearce and Schumann ([261]).

Physico-chemical characteristics. No record.

Public health aspects

Bacteriology. No record.

Bilharzia. No record.



A general impression of the Mahlongwana lagoon, showing the reed covered island in the centre.

BIOTIC CHARACTERISTICS

Flora

Near its mouth, both banks of the lagoon are well covered by coastal dune forest. Cane encroachment upon the middle and upper reaches of the lagoon has taken the normal toll of

original vegetation. *Phragmites* reed swamps occur on the edges and on an island in the centre of the lagoon. They are important components of the system to preserve as sources of organic detritus.

Fauna

No record. Angling and attempts to collect bait organisms from the Mahlongwana lagoon have apparently met with very little success (Maurice, pers. comm.).

SYNTHESIS

Our state of knowledge of the Mahlongwana lagoon is very poor. Consequently to make any sort of assessment regarding its resource potential or its present environmental condition is speculative. However, when compared to neighbouring systems the Mahlongwana lagoon appears to have sufficient potential to warrant further study, and to suggest that in the interim it be regarded worthy of protection. The only problem apparent is that of sugar cane encroachment.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text.	ABIOTIC																				BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other						Flora			Fauna						Food Webs
MAHLONGWANA			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																						←★→		←★→							
Source of Information	Summary of available information																														
Fromme	1970 to 1975	132								●																					
Orme	1971	257						●																							
NTRPC	1974	236						●																							
van Heerden	1976	316								●																					
van Niekerk, Kleyn & Edwards	1977	pers. comm.	●		●																										
du Preez	1978	pers. comm.						●																							
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 262	1976	257		●																			●								
1:25 000 Job No. 261	1976	491	●																												

2.1.10.2 **MAHLONGWA**

Synonyms
Amahlanga ([107]); Amahlongwa (Natal Roads Dept.) Black Rock Lagoon (1:50 000 sheet No. 3030 BC & BD).

Zulu meaning
No record — the word 'Mhlanga' generally means something to do with reeds.

Location
30°45'45"E; 30°16'15"S.

Accessibility
By road the Mahlongwa lagoon is 59 km south west of Durban. There is a track on the southern bank which leads down to the mouth of the lagoon.

Bridges
The railway bridge and the national road bridge cross the lagoon 100 m and 150 m from the mouth respectively. The bridge for the south coast freeway is to be located 250 m above the head of the lagoon (Zakrzewski Assoc. Inc., pers. comm.).

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 98 km^2 ([206]); 104 km^2 ([223]).

River length. 23 km ([206])

Mean annual run-off. 14,7 x 10^6 m^3 ([223])

Flow. Rough estimates of flow in 1970 were 0,2 m^3/sec. in the summer and 0,03 m^3/sec. in the winter ([206]).

Flood history. In 1976 flood levels were just below the deck of the road bridge, at which stage the entire floodplain was under water. 1:100 year floods are estimated to discharge 240 m^3/sec. (Zakrzewski Assoc. Inc., pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. No quantitative information is available. However, the Mahlongwa does not carry a great deal of silt according to Collocott (pers. comm.).

Land ownership/use. 67,5% of the catchment (essentially its upper reaches) is Bantu influenced, being made up of the Umahalangwa Mission reserve and Location No.1. Both these areas are destined to become part of KwaZulu in the near future. The lower reaches of the catchment comprise sugar cane farms belonging to the Crookes Bros., so that most of the lagoon lies within the estate.

Freeland Park, with a population of 400 to 500 (Collocott, pers. comm.) lies immediately south of the lagoon. A small portion of the southern bank in this vicinity is zoned as public open space. The Crookes Bros. have considered developing a holiday resort in the vicinity of the lagoon at some stage in the future (Collocott, pers. comm.).

Local authority. The Mahlongwa lagoon is controlled by the Crookes Bros.

Estuary uses. The owners have attempted to maintain the lagoon in an unspoilt condition by restricting access, in order to avoid the destruction and pollution which is generally associated with public places. Use of the lagoon is limited to a little boating and water-skiing.

Morphometry of lagoon (see Fig. **73**).
Area. 5,9 ha

Axial length. 1,4 km

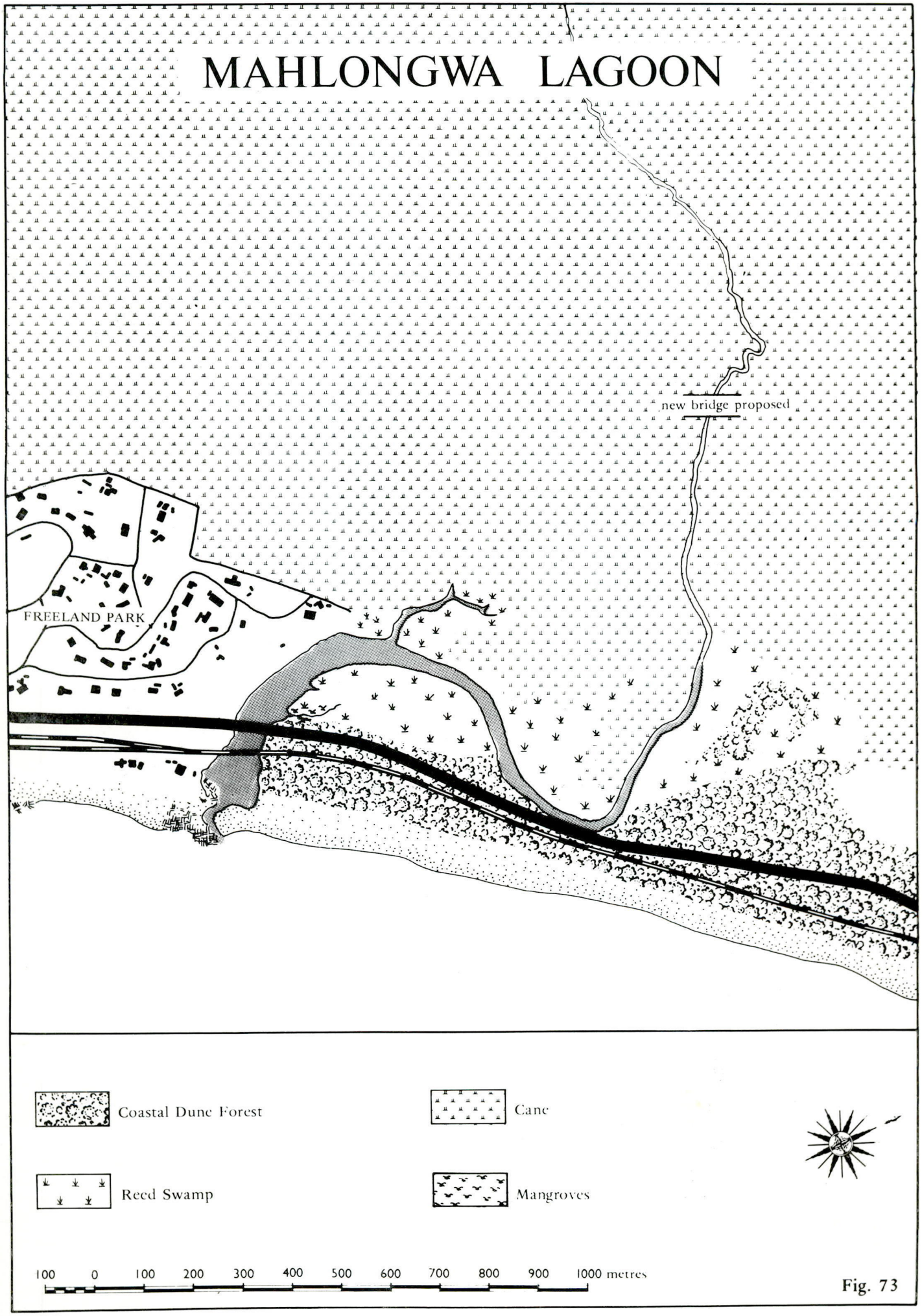
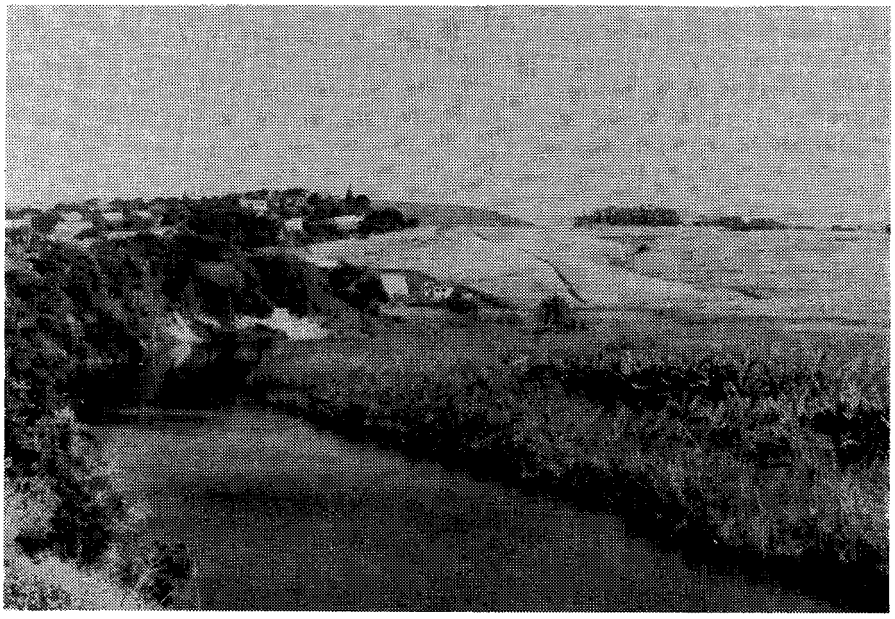

MAHLONGWA LAGOON
new bridge proposed
FREELAND PARK
Coastal Dune Forest
Cane
Reed Swamp
Mangroves
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 73

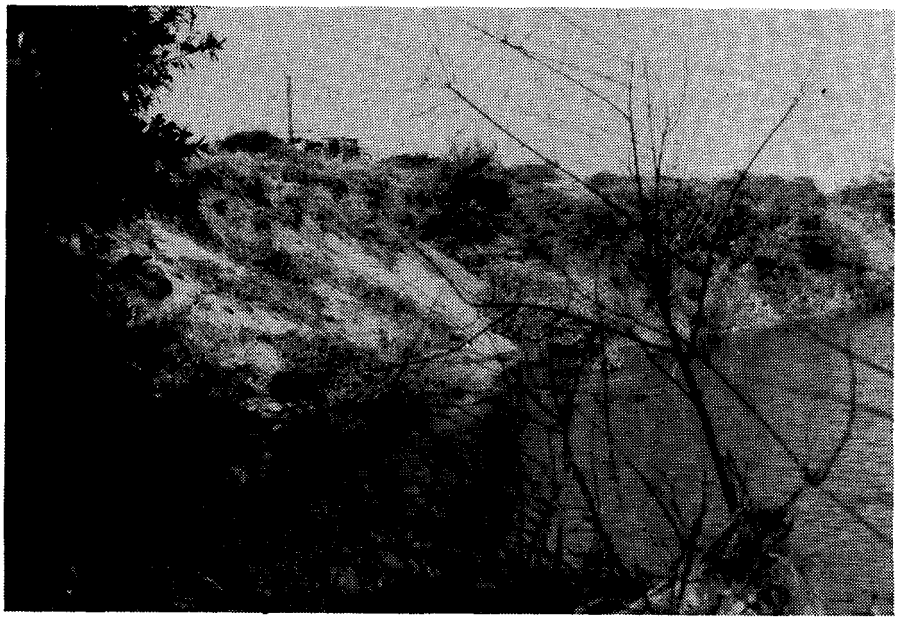
Shoreline length. 3,3 km

Width.
Maximum: 115 m
Mouth: ± 20 m at low flow periods
Floodplain: 300 m



The middle reaches of the Mahlongwa lagoon (12 July 1977) — showing the reed-swamps on the western bank.

Shape. Examination of aerial photographs and early maps ([145]) indicate that the lagoon was a very different shape in the past (see Fig. **74**). Reclamation of land adjacent to the lagoon for cane farming, and general infilling, have resulted in a loss of water and swamp areas. The lagoon is also shifting south in such a manner that it threatens to undercut the national road in the near future.



Undercutting of the national road by the Mahlongwa is likely to present problems in the near future (12 July 1977).

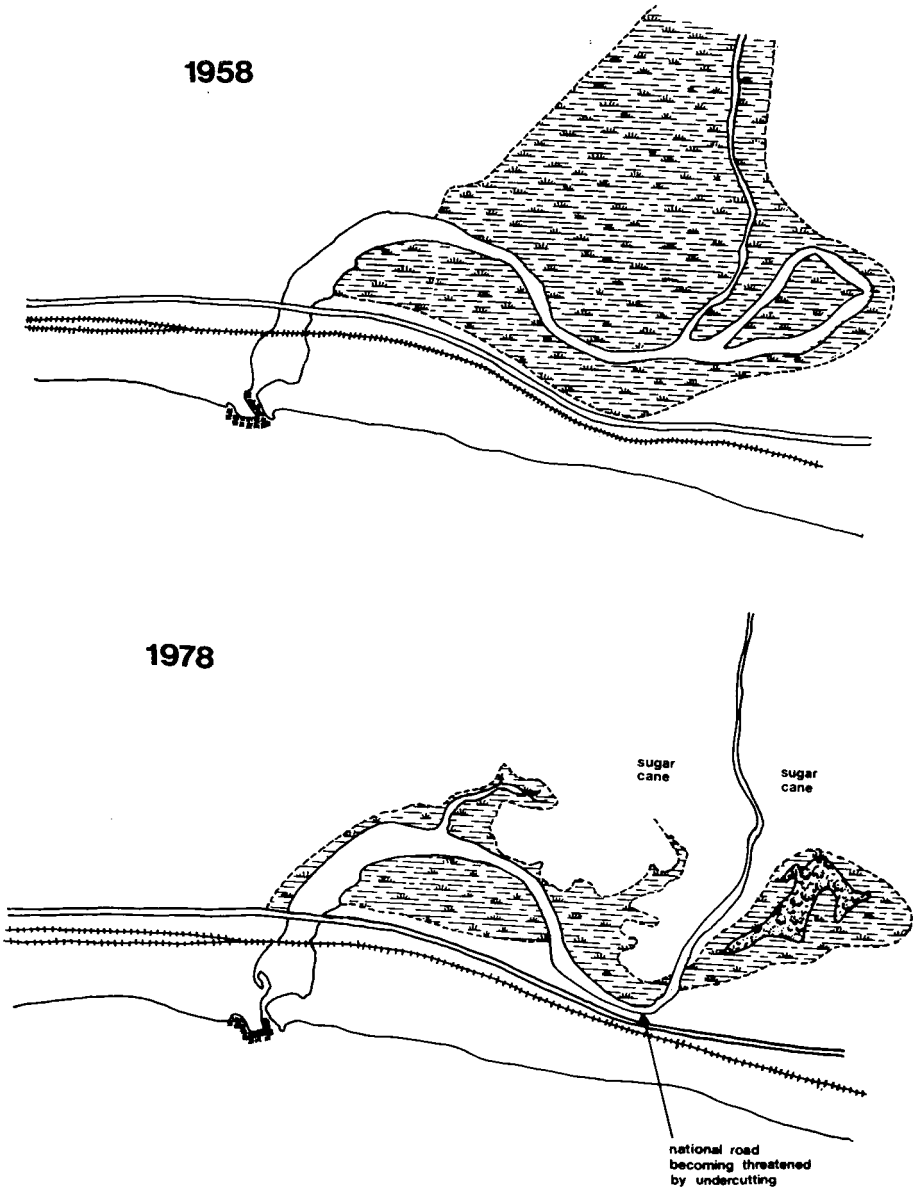


Fig. 74. Probable changes in the extent of the Mahlongwa lagoon over the last 20 years.

Bathymetry. The maximum depth of the lagoon (near the mouth) is 2,5 m (pers. obs.).

Geomorphology

Geology. Dwyka tillite outcrops in the catchment area ([236]) whilst near the lagoon Ecca shales appear, which are overlain by Berea red sands (du Preez, pers. comm.).

Nature of bottom materials. In 1947 Day ([109]) reported that in the middle reaches of the lagoon the bottom materials were composed of black mud. Below the bridge and near the mouth, clean sand overlay this mud.

Sandbar characteristics. The Mahlongwa sandbar is short (80 m) and south extending. The mouth opens across rocks and lies protected behind a rocky headland immediately south of the mouth.

The bar is occasionally opened manually (at the natural point of exit) by the Crookes Bros., to flush the lagoon when the water becomes smelly. This is suggestive of enrichment arising through the irrigation of canefields.

If closed, the bar is overtopped at high spring tides. However, there is generally water trickling out of the lagoon, which ensures that there is regular (albeit limited), contact with the sea (Levin, pers. comm.).

Configuration of adjacent shore ([132]).
Beach type — sheltered, asymetrical beach, suitable for bathing.

Average beach slope — 6°
Average beach width — 67 m
Average sand grain size — 659 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are reported as present in the near vicinity of the lagoon.

Physico-chemical characteristics.
In July 1947 Day ([109]) recorded temperatures of 31,5°C from the lagoon. This is surprisingly high for mid-winter. Secchi disc values ranged from 10 cm to 30 cm and salinities were very low.
Other than these records (now 30 years out of date) there is no information on the physico-chemical characteristics of the Mahlongwa lagoon. However, some idea as to expected conditions can be obtained from information on the chemistry of the river water in 1970, 6 km above the lagoon ([206]) (see Table **64**). The only sign significant of disturbance was the higher than normal phosphorus values during the rainy season.

Public health aspects
Bacteriology. The only data (now 5 years old) which may give some indication as to the bacteriological quality of the lagoon, is that which pertains to the river from samples taken 6 km above the lagoon in 1972 ([206]) (see Table **65**). Sporadic faecal pollution and organic enrichment was evident, the latter almost certainly due to the influence of sugar cane in the catchment.

Table 65. Bacteriology of the Mahlongwa river (6 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* I per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C @ 24 hrs @ ambient	Confirmed
March 1971			**7 400**
August 1971			214
5 Feb 1972	140	**384**	150
23 Feb 1972	320	**1 200**	1 700
5 July 1972	77	**5 900**	310
2 Aug 1972	160	75	2 160
16 Aug 1972	40	**830**	
15 Jan 1973	500	**920**	

Values in bold are significant of disturbance.

Bilharzia. No record.

BIOTIC CHARACTERISTICS
Flora
Day commented on the absence of aquatic plants in the lagoon in 1947 ([109]). The surrounds of the lagoon, have been encroached upon by sugar cane (see Fig. **73** and **74**), thus whatever buffer strips of *Phragmites* or wetland have remained, become all the more important to conserve. Black mangroves (*Bruguiera*) are present ([189, 231]) alongside a small backwater in the lower reaches of the lagoon. Despite this, a mangrove associated fauna appears to be lacking (pers. obs.)

Table 64. Physico-chemical characteristics ([206]).

Locality: Mahlongwa river Distance above lagoon: 6km	SUMMER Jan 1970	WINTER July 1970
Hydrogen ion concentration (pH)	7.8	8.1
Saturated pH value	8.4	8.1
Conductivity micromhos/cm	389	550
Total dissolved solids ppm (calcd.)	217	344
Dissolved oxygen mg/litre	8.6	<u>10.8</u>
% Saturation	104	<u>114</u>
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	4.9	4.3
Kjedahl nitrogen mg/litre	0.6	0.5
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.14	0.20
Phosphates "	<u>.46</u>	.08
Total alkalinity "	89	120
Total hardness "	84	110
Calcium "	11.2	16.2
Magnesium "	13.6	16.8
Sodium "	41.0	87.5
Potassium "	2.1	1.8
Sulphates "	11.9	21.1
Chlorides "	66	111
Silica "	-	-
Iron "	-	-
Fluorides "	0.4	0.4
Free carbonic acid (as ppm carbon dioxide)	2.8	1.8
Temperature °C	25	18
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values <u>underlined</u> significant of disturbance.

A noteworthy strip of coastal dune forest occurs between the eastern bank of the lagoon and the sea. Both the railway line and national road pass through this area.

Fauna

Only unpublished information based on collections by Day in July 1947 ([107, 109]) is available as an indication of what estuarine organisms live in the Mahlongwa lagoon. His results (see below) revealed an almost fresh water fauna to be present, which was restricted mainly to the marginal vegetation.

Lower trophic levels.

Amphipoda: three species (*Chiltonia capensis* — abundant)
Isopoda: one species
Crab: one species
Insecta: five species
Shrimp: one species (*Caridina nilotica* — common)
Gastropoda: two species (*Assiminea* — common)

Higher trophic levels.

Fish: four species (*Sarotherodon mossambicus* — common)

On the other hand, Maurice (pers. comm.) claims that the lagoon is full of *Callianassa* (white cracker shrimp) and that snapper (*Lutjanus*), perch (*Acanthopagrus*) and the odd tarpon (*Megalops*) can be caught when the mouth is open. After a survey in January 1977, Nicholls (pers. comm.) reported there to be little estuarine birdlife. Night herons and Pied kingfishers (breeding) have been observed.

Information on some of the riverine animal communities 6 km above the lagoon is available, from surveys made in June 1972 by Kemp *et al* ([206]). Indications were that conditions at the time were very favourable for aquatic life above the lagoon.

SYNTHESIS

Our general state of knowledge of the Mahlongwa lagoon is poor, and outdated. From the general appearance of the lagoon however, its resource potential should be evaluated because, when compared to other lagoons on the south coast, the Mahlongwa gives the distinct impression of being one of the better ones. Confirmation of its conservation potential also comes from opinions expressed by Cooper (pers. comm.) and Hopwood ([189]).

The only problems apparent in the lagoon are sugar cane associated, these being cane encroachment, wetland reclamation and organic pollution. These all threaten the productivity of the system in various ways (see Section 3.1).

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC								
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other								Flora			Fauna						Food Webs
MAHLONGWA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																						◄—★—►			◄—— ★ ——►						
Source of Information	Summary of available information																														
Day	1947	107, 109				●				●																●	●	●				
Harris	1953	145		●																											
Midgley & Pitman	1969	223	●		●																										
Kemp *et al*	1970 to 1972	206	●		●			●			○				○											○	○					
Fromme	1970 to 1975	132								●																					
Moll *et al*	1971	231																				●									
Zakrzewski Assoc. Inc.	1977	pers. comm.	●																												
Collocott	1977	pers. comm.																		●											
Maurice	1977	pers. comm.																								●	●				
Hopwood	1978	189																				●									
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 261	1976	264		●																				●							
1:25 000 Job No. 262	1976	488	●																												

2.1.10.3 **MPAMBANYONI**

Synonyms

Umpambinyoni ([220]); Umpambumyani (Natal Archives).

Zulu meaning

Stayt ([289]) presents two possible meanings for the word emphambanyoni —

(a) "the river that deceives the birds", because it criss-crosses so much or, alternatively
(b) the river which is "criss-crossed by the flight of birds" because of the flocks of swallows which fly backwards and forwards between cliffs in its upper reaches.

Location

30°16'45"S; 30°45'30"E.

Accessibility

By road the Mpambanyoni lagoon is 60 km south west of Durban. Vehicles can reach the southern bank and a car-park has been provided above the mouth of the lagoon.

Bridges

(a) The railway bridge (built in 1973/1974) is 120 m from the mouth, and built on an open span because of flooding.
(b) The national road bridge is 370 m from the mouth, and protected by concrete sheet piling to prevent damage by floods.
(c) Between the two bridges, the foundations of the old railway line occur in the bed of the lagoon. The embankment of the latter (now removed) caused rapid siltation in certain parts of the lagoon because of severe soil erosion in the catchment (Levin, pers. comm.). This then led to reclamation and development of the silted up areas.
(d) A bridge for the south coast freeway is to be built ±1,2 km above the lagoon in the near future.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 517 km^2 ([213]); 544 km^2 ([220]); 564 km^2 ([223]); 567 km^2 ([206, 245, 257]).

River length. 100 km ([206, 245, 257]).

Mean annual run-off. 32,1 x 10^6 m^3 ([245]); 36 x 10^6 m^3 (Zakrzewski Assoc. Inc., pers. comm.); 52,4 x 10^6 m^3 ([223]).

Flow. A rough estimate of the average flow in 1970 was ,71 m^3/sec. ([206]).

Flood history. The Mpambanyoni is subject to violent flooding, a reminder of which is that in 1959 both the road and railway bridges were destroyed ([220, 257]). At peak flow in the 1959 floods, the river was estimated to be discharging 1 228 m^3/sec. ([220]). The floods of March 1976 (discharging over 1 000 m^3/sec.) caused a northerly shift of the river, which washed away the railway line leading to the Renishaw mill. The fact that this bank withstood the 1959 floods, is suggestive of this event being attributable to the encroachment of sugar cane since that time. An outcrop of granite on the southern bank of the river also has the effect of forcibly directing floodwaters against the northern bank (Zakrzewski Assoc. Inc., pers. comm.).

Much debris in the form of sugar cane and trees is brought down into the lagoon and sea each year by floods (Collocott, pers. comm.). Floods of this nature are generally symptomatic of land mismanagement.

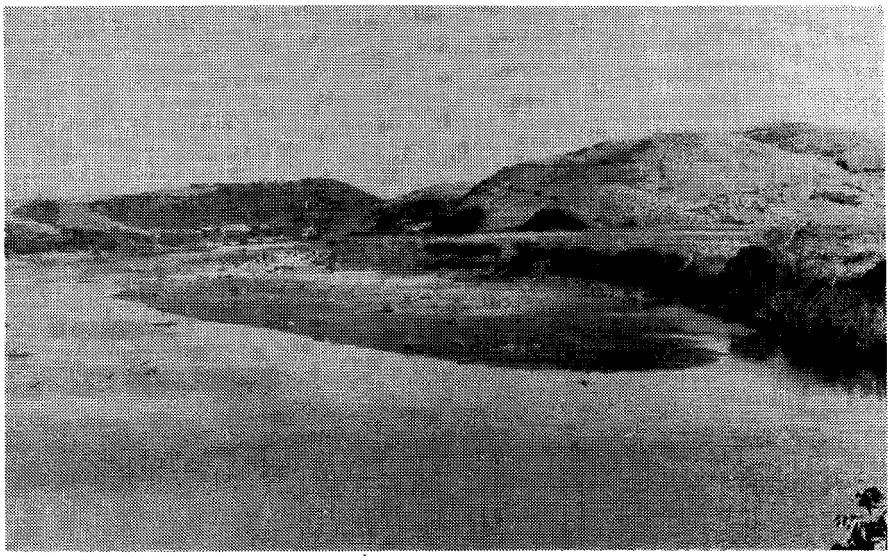
Dams.

Existing: None.

Proposed. The McAndrews dam site (with a potential capacity of 38,4 x 10^6 m^3 ([236])) has been located 38,6 km above the lagoon ([245]). Construction has been given low priority because of dubious economic viability ([236]).

Siltation. The Mpambanyoni lagoon has become completely ruined by silt emanating from its drainage basin. Virtually none of the original system remains because bed levels have been raised to the extent that the sea scarcely penetrates more than 200 m into the lagoon. Annual siltation at

the McAndrews dam site has been estimated at 0,28 x $10^6 m^3$ ([245]). It is thought that most of the silt comes from Location Nos. 1 and 2 in the St. Michaels's Mission reserve (Levin, pers. comm.), where amongst other things, maize grown right up to the edge of the river, results in severe bank erosion. Cane farming lower downstream has had the same effect. The reserve was once closed, in order to implement the soil conservation measures necessary for its recovery, but has since reverted to its former condition (Levin, pers. comm.).



A view of the upper reaches of the Mpambanyoni lagoon, showing the severe siltation. (24 February 1977).

Land ownership/use. 53% of the catchment comprising the St. Michael's Mission reserve is Bantu influenced, and destined to become incorporated into KwaZulu. Most of the remaining area is under sugar cane, the majority of which belongs to the Crookes Bros.

On the northern bank of the lagoon is a chip and putt course and waterways in which children go boating. Freeland Park extends northwards along the coast. The Renishaw sugar mill was in operation above the lagoon until closed down in 1975.

South of the lagoon is Scottburgh, with a resident population of ± 5 000 (Collocott, pers. comm.).

On either side of the river the land has been zoned as public open space. A light industrial area (cabinet making, brick making, welding, etc.) is to be developed above the lagoon on the northern bank (Quiggin, pers. comm.).

Local authority. Borough of Scottburgh.

Estuary uses. The Mpambanyoni lagoon has no recreational value and is not used for any purpose. It is regarded as more of a liability than an amenity by the Local Authority. Silt causes the sea at Scottburgh to become dirty, and uninviting to bathers. Bathing is prohibited at such times because of the likelihood of shark attack. The silt laden sea is thus said to detract from the tourist appeal of Scottburgh, and results in a loss of revenue and many complaints (Collocott, pers. comm.).

0,33 x 10^6 m^3 of water are abstracted annually from the river through well points just above the old mill site, to supply the Scottburgh township ([245]).

Morphometry of lagoon (see Fig. **75**)

Area. 2,32 ha

Axial length. 250 m

Shoreline length. 800 m

Width.
Maximum: 120 m
Mouth: 15 m during normal flow periods.
Floodplain: 350 m

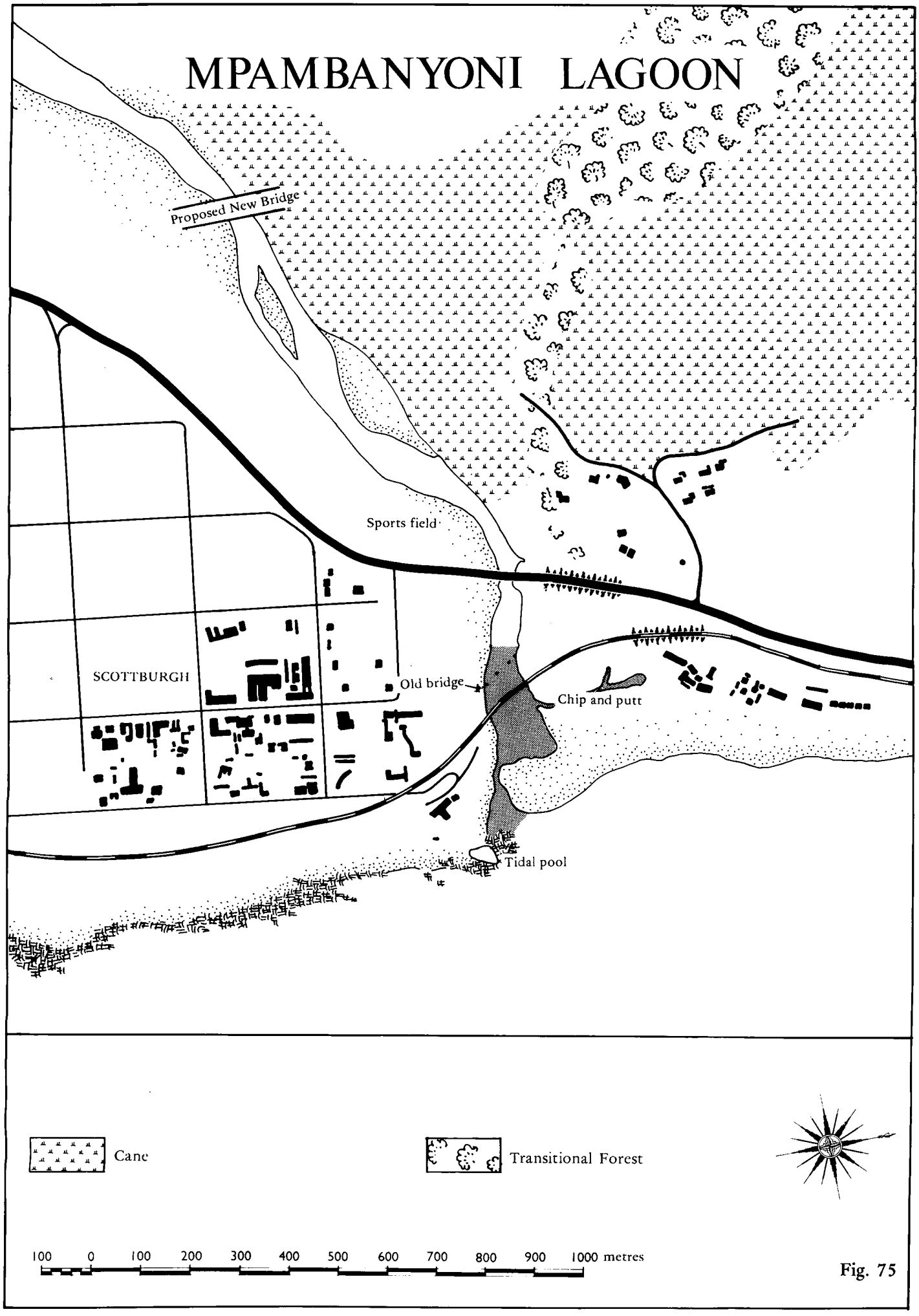

MPAMBANYONI LAGOON
Proposed New Bridge
Sports field
SCOTTBURGH
Old bridge
Chip and putt
Tidal pool
Cane
Transitional Forest
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 75

Bathymetry. In 1959 the estuary was 4,5 m deep at the road bridge (Levin, pers. comm.). Today it is nowhere deeper than 1 m. There were once hopes of establishing a harbour in the Mpambanyoni, in which case Scottburgh would have become known as Devonport [289] or Port Devon (Levin, pers. comm.). Eventually the whaling jetty at Park Rynie partially fulfilled this requirement [189].

Geomorphology

Geology. Within the catchment area, the river is said to traverse Ecca shales, Table Mountain Sandstone, Granite and Dwyka tillite [245]. Although the underlying rock around the lagoon has been shown as Ecca Shale [236], drilling by Zakrzewski Assoc. Inc. (pers. comm.) has shown granite below the southern bank, and dolerite shale below the northern bank. According to the Department of Geological Survey, Table Mountain Sandstone outcrops on the southern bank of the lagoon near its mouth (du Preez, pers. comm.).

Nature of bottom materials. The estuary is largely filled with coarse, fluvial sand [257]. Boreholes drilled 23,5 m deep into these sediments did not encounter bedrock at the site of the existing road bridge [257]. Zakrzewski Assoc. Inc. (pers. comm.) have shown bedrock to occur at 40 m on the southern bank and at 12 m on the northern bank at the site of the proposed bridge.

Sandbar characteristics. The Mpambanyoni sandbar is 160 m long, 40 m wide and south extending. Very occasionally the mouth position may switch to the north (Levin, pers. comm.).

Breaching is unnecessary because the channel is normally kept open by a low flow of water throughout the year. In the past it has been known to close occasionally in winter.

Configuration of adjacent shore [132].

Beach type — sheltered assymetrical beach, suitable for bathing.

Average beach slope — 5°
Average beach width — 60 m
Average sand grain size — 371 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents are apparently absent in the near vicinity of the lagoon.

Physico-chemical characteristics

Although no data from the lagoon is available, there is a little information on the chemistry of the river water from a point just downstream of the mill 2 km from the lagoon [206] (see Table **66**). Since the closure of the Renishaw sugar mill in 1975, pollution of the lagoon has been reduced. Nevertheless, judging from the smell of the water reported by Collocott and Levin, (pers. comm.), anaerobic conditions used to develop in the lagoon.

Today however, silt remains as the major pollutant. [245]

Public health aspects

Bacteriology. There is no information available on the bacteriology of the Mpambanyoni lagoon. However, a study of the river water [206] at a point just downstream of the mill only showed signs of sporadic organic enrichment (see Table **67**).

Harris [145] suggested that the mill compound was the source of faecal pollution evident in the lagoon in the 1950's. He reported that "high counts in the lagoon contrasted with lower values in the sea . . .". This compound no longer exists and the shacks have been demolished. In general, conditions must have improved since closure of the Renishaw mill. Sewage from the town is pumped from a treatment plant onto the golf course or out to sea (Collocott, pers. comm.).

Bilharzia. Although there is no evidence to show that bilharzia occurs in the Mpambanyoni river system, the chances of it being present are nevertheless good.

BIOTIC CHARACTERISTICS

Flora

As a result of cane-farming above the lagoon, and the development of recreational facilities on both banks, the original flora of the Mpambanyoni lagoon is virtually non-existent.

Fauna

There is no information on the fauna of the Mpambanyoni lagoon, although it too, is reported to be very poorly developed (Maurice, pers. comm.). This can be attributed to the inhospitable coarse nature of the bottom materials and violent scouring by floods.

Information on the riverine communities 2 km above the lagoon in June 1972 is available [206].

Table **66.** Physico-chemical characteristics. ([206])

Locality: Mpambanyoni river Distance above lagoon: 2km	SUMMER Feb 1970	WINTER July 1970
Hydrogen ion concentration (pH)	7.6	8.2
Saturated pH value	8.5	7.8
Conductivity micromhos/cm	291	890
Total dissolved solids ppm (calcd.)	167	524
Dissolved oxygen mg/litre	8.4	9.5
% Saturation	102	109
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	4.6	3.7
Kjedahl nitrogen mg/litre	0.8	0.7
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	.15	.52
Phosphates "	.36	.11
Total alkalinity "	66.3	147.5
Total hardness "	72.9	181.3
Calcium "	11.1	31.6
Magnesium "	11.0	24.8
Sodium "	26.3	124.7
Potassium "	2.2	4.4
Sulphates "	16.9	43.6
Chlorides "	42.3	188.1
Silica "	-	-
Iron "	-	-
Fluorides "	0.4	0.4
Free carbonic acid (as ppm carbon dioxide)	3.2	2.1
Temperature °C	25.0	22.0
Turbidity (ppm silica scale)	Turbid	Fair
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

The results showed positive signs of disturbance (i.e. low species diversity in the marginal vegetation, and of the 12 organisms in the sediment, 96,9% were one particular type of midge larvae (belonging to the Tanytarsini)).

Table 67. Bacteriology of the Mpambanyoni river (2 km above the lagoon) prior to closure of the Renishaw mill.

Date	Total Plate Count per ml x 10^3		*E. coli* 1/100 ml	
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed	Presumptive
March 1971	—	2 600	—	7 900*
July 1971	—	—	61	186*
10 Feb 1972	27	**720**	—	100
23 Feb 1972	380	263	1 333	2 000
5 July 1972	110	**3 900**	214	320
2 Aug 1972	200	110	—	120
16 Aug 1972	**1 850**	**2 200**	—	
15 Jan 1973	480	350	—	1 600

Values in bold are significant of disturbance.
* Total coliform counts/100 ml

Birds. 11 species of estuarine associated birds were recorded as present in January 1972 by Sinclair, but all were very few in number. In January 1977 only four species were present (Nicholls, pers. comm.).

SYNTHESIS

Other than a fair hydrological and geological understanding, our state of knowledge of the Mpambanyoni lagoon is poor. Furthermore it appears that there is no benefit to be gained from studying the system, because in its present environmental condition the Mpambanyoni is one of the poorest, and most degraded of Natal's estuaries. It has been rated as having absolutely no resource value. Its decline has been almost totally due to severe siltation from Bantu reserves in the catchment. Nearer the sea, sugar cane cultivation contributes to the problem. Prior to 1975, the lagoon was contaminated by wastes from the Renishaw sugar mill.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora			Fauna							Food Webs
MPAMBANYONI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																																
Source of Information	Summary of available information																															
Harris	1953	145			●										●																
Meinecke	1959	220	●		●																										
Midgley & Pitman	1969	223	●		●																										
Kemp *et al*	1970 to 1972	206	●		●						○				○										○	○					
Fromme	1970 to 1975	132								●																					
Ninham, Shand & Partners	1971	245	●		●			●		●																					
Orme	1971	257	●							●																					
Loxton, Hunting & Assoc.	1971	213	●																												
NTRPC	1974	236						●																							
Zakrzewski Assoc. Inc	1977	pers. comm.			●			●		●																					
Levin	1977	pers. comm.								●										●	●										
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 261	1976	266		●						●													●								
1:25 000 Job No. 262	1976	487	●																												

Synonyms

Umzimai (1:250 000 sheet No. 3030). There is liable to be confusion between this Mzimayi and another river with the same name 30 km south (see Section 2.1.11.7). Qualification, such as Mzimayi (north) (as used by Ninham Shand & Partners ([245])) or abandonment of the name Mzimayi for the more southerly of the two systems, is therefore recommended.

Zulu meaning

No record.

Location

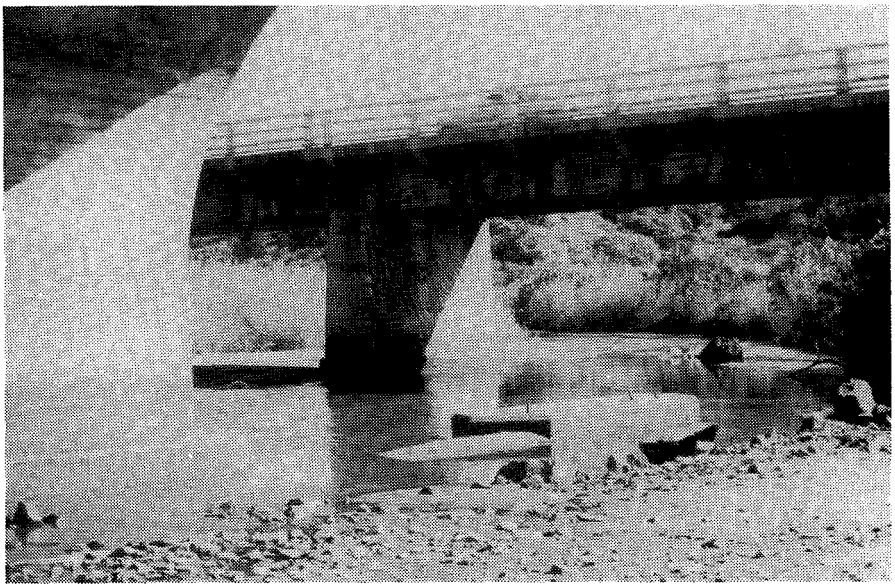
30°20'45"S; 30°43'45"E.

Accessibility

By road the Mzimayi lagoon is 70 km south west of Durban. A track leads down from the national road to the mouth of the lagoon on its northern bank.

Bridges

The lower reaches of the lagoon are adversely affected by the railway bridge (20 m from the mouth) the national road bridge (30 m from the mouth) and three large foundations of the old railway bridge between the two.



Bridge relationships at the mouth of the Mzimayi lagoon (3 June 1978)

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 31 km^2

River length. ± 20 km

Mean annual run-off. No record.

Flow. No record.

Flood history. Floodplain indicators above the lagoon suggest the Mzimayi river can be prone to quite violent floods.

Dams.

Existing: The E. J. Smith dam ([289]) acts as the water supply for Scottburgh and Park Rynie. It is controlled by the Umzinto Regional Water Supply Corporation ([145]).

Proposed: None.

Siltation. No record.

Land ownership/use. Virtually the entire catchment is used for the production of sugar cane.
Around the lagoon itself, the land is undeveloped, although the development of facilities for holiday-makers has been proposed (NTRPC, pers. comm.). 3,5 km north is Park Rynie and 750 m south is Adam's Spruit. The latter is a small independent stream with the Happy Wanderers caravan park and chalets on the southern bank.

Local authority. Ocean View.

Estuary uses. Sand for construction is extracted from the mouth of the lagoon. Otherwise the lagoon is not used for any purpose, except by the occasional picnicker.

Morphometry of lagoon (see Fig. **76**).
Area. 0,9 ha

Axial length. 250 m

Shoreline length. 570 m

Width.
Maximum: 30 m
Mouth: 4 m wide during normal flow periods.
Floodplain: 130 m wide above the head of the lagoon.

Bathymetry. No record.

Geomorphology
Geology. According to the Department of Geological Survey, both the surrounds of the lagoon and its catchment are made up of granite-gneiss of the Archaean complex (du Preez, pers. comm.). Granite outcrops at the mouth of the lagoon on its northern bank.

Nature of bottom materials. No record.

Sandbar characteristics. The Mzimayi lagoon is one of the few north deflected systems on the south coast of Natal. This appears to be due to the lack of rock protection, south of the lagoon. This exposes the system to the direct impact of the prevailing swell.
The mouth of the lagoon opens across rocks at the end of a 130 m long north extending sandbar. No information about how long the lagoon remains closed, or whether it is breached artificially could be found. It is probably closed for most of the year and permitted to open naturally.

Configuration of adjacent shore ([132]).
Beach type — asymmetrical, sheltered beach, unsuitable for bathing.

Average beach slope — 7°
Average beach width — 80 m
Average sand grain size — 877 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are reported as present in the near vicinity of the lagoon.

Physico-chemical characteristics. No record.

Public health aspects.
Bacteriology. No record. With a sugar cane influenced catchment and compounds adjacent to the river upstream, both organic and faecal pollution are likely.

Bilharzia. No record.

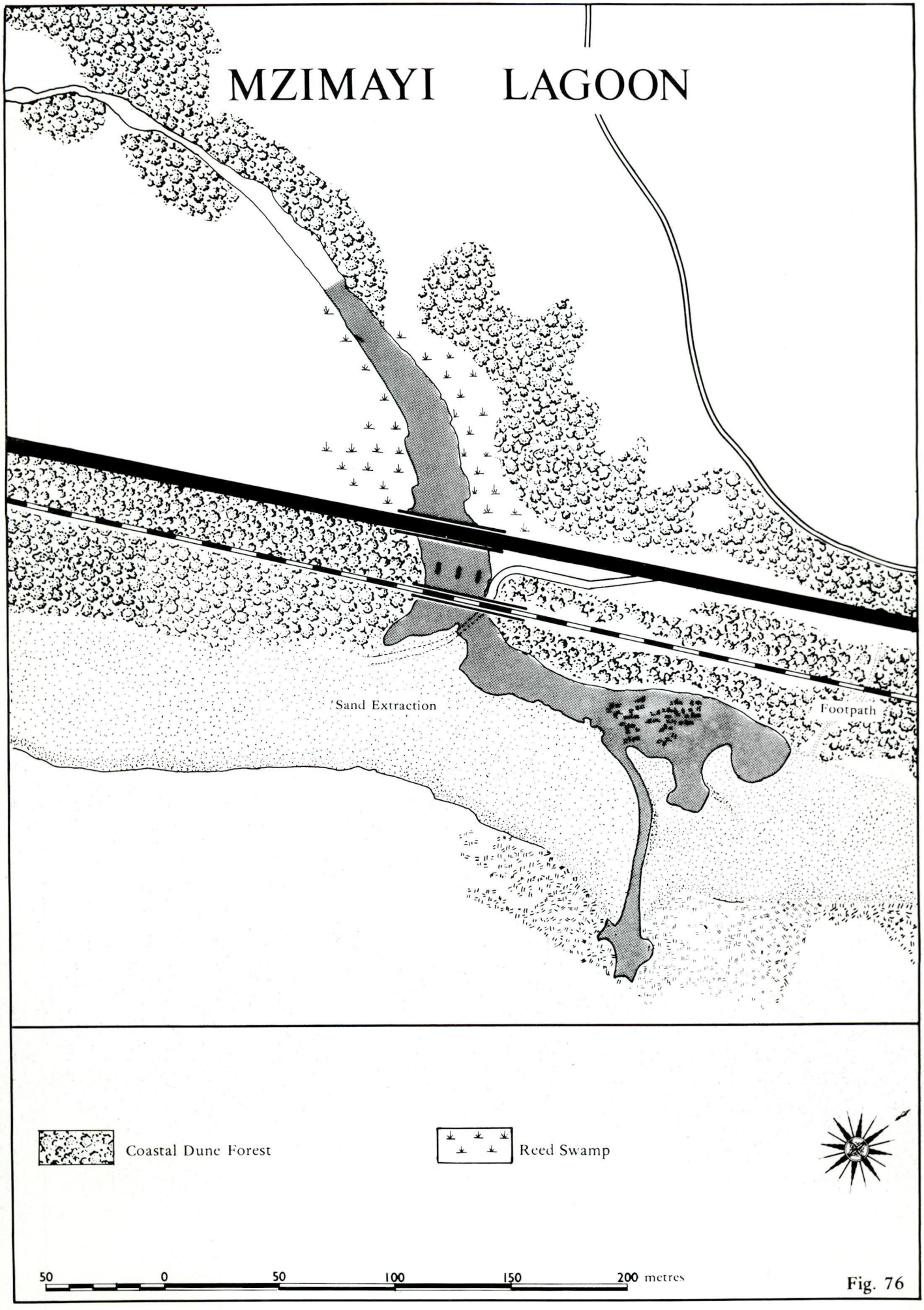

MZIMAYI LAGOON
Sand Extraction
Footpath
Coastal Dune Forest
Reed Swamp
50 0 50 100 150 200 metres

Fig. 76

BIOTIC CHARACTERISTICS

Flora

From aerial photography, the vegetation around the lagoon exhibits several signs of disturbance. Consequently nothing of great botanical value remains in the immediate vicinity of the Mzimayi lagoon. Ward's survey however, should provide clarification in this regard.

Fauna

No information is available on the fauna of the Mzimayi lagoon. Maurice (pers. comm.) reports that the lagoon supports nothing in the form of estuarine life, and no estuarine associated birds were reported as present by Nicholls after a survey in January 1977.

SYNTHESIS

Our state of knowledge of the Mzimayi lagoon is very poor. If the lagoon is to be developed as a facility for holidaymakers, a bacteriological survey should be undertaken to establish the suitability of the lagoon for this purpose.

In its present environmental condition the Mzimayi lagoon is disturbed, and unlikely to be of any significant value as an estuarine resource because of its small size. Although verification is necessary, the catchment appears to be one which would generate problems such as the organic and faecal pollution of the lagoon.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other						Flora			Fauna								Food Webs
MZIMAYI			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids															★																		
Source of Information	Summary of available information																																
Fromme	1970 to 1975	132								●																							
Dept. of Geological Survey	1978	pers. comm.						●																									
Aerial photos (SCogings)		No.																															
1:10 000 Job No. 261	1976	276		●						●														●									
1:25 000 Job No. 262	1976	484	●																														

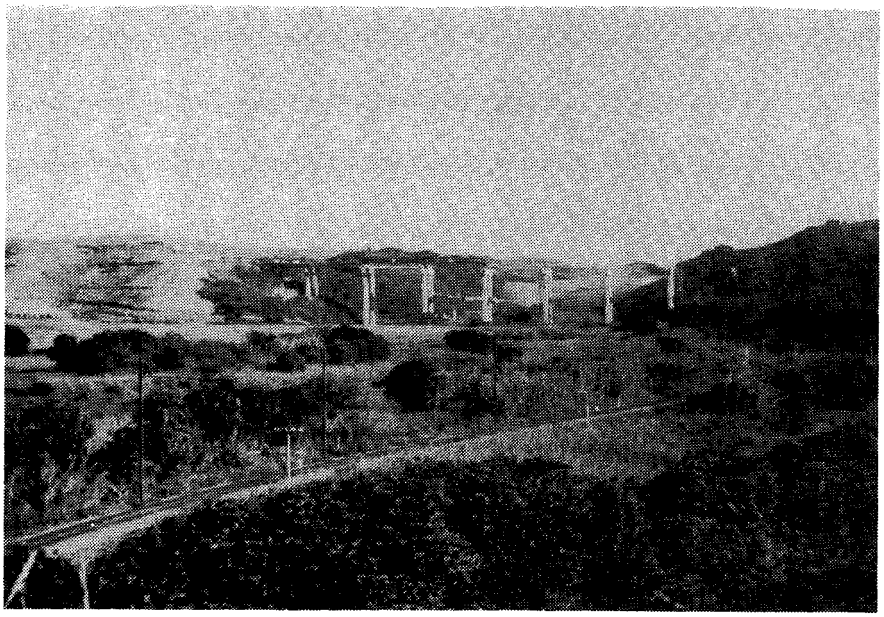
2.1.10.5 **MZINTO**

Synonyms
Umzinto

Zulu meaning
"The kraal of achievement" or alternatively "the kraal of the manufactured article" ([289]).

Location
30°22'S; 30°42'30"E.

Accessibility
The Mzinto lagoon is crossed by the national road 72,5 km south west of Durban. The inaccessibility of the lagoon as far as vehicular access is concerned, has ensured that most of the lower reaches are relatively undisturbed. However, a railway line (from Kelso junction) runs along the northern bank of the lagoon and has accounted for losses of water area through infilling and embankment construction.



A view of the freeway bridge under construction at the head of the Mzinto lagoon, and of the railway line on the northern bank. (9 June 1977).

Bridges
The railway bridge and national road bridge are 60 m and 580 m from the mouth respectively. Immediately below the road bridge are remnants of the old railway bridge. A bridge for the south coast freeway is presently under construction just above the head of the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 117 km^2 ([213]); 142 km^2 ([206, 245, 257]); 264 km^2 ([223]).

River length. 37 km ([206, 245, 257])

Mean annual run-off. 15,21 x 10^6 m^3 ([213]) to 35, 23 x 10^6 m^3 ([223]).

Flow. No record. Discharge has been described as limited by Orme ([257]), and a rough estimate of the average flow given as ,37 m^3/sec. ([206]).

Flood history. No record. Nevertheless, the breadth of the floodplain, and the artificial reinforcement that has been necessary on the sandbar, seem to indicate that the Mzinto river can flood violently.

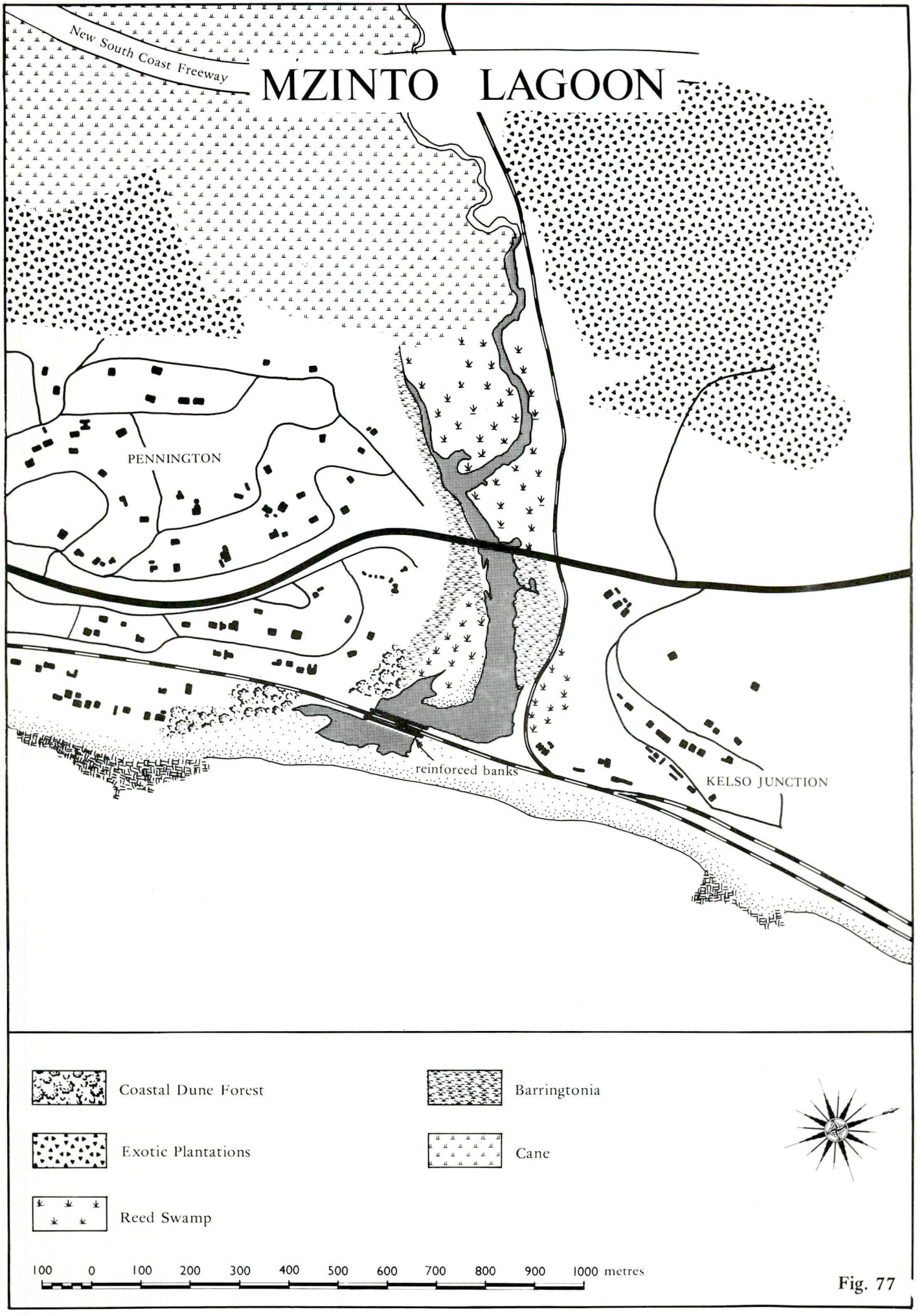

New South Coast Freeway
MZINTO LAGOON
PENNINGTON
reinforced banks
KELSO JUNCTION
Coastal Dune Forest
Exotic Plantations
Reed Swamp
Barringtonia
Cane
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 77

Dams.
Existing: None.
Proposed: A dam with a total capacity of 19,3 x $10^6 m^3$ has been proposed at the Esperanza site 8 km above the lagoon ([245]).

Siltation. The Mzinto river is said to be characterized by a proportionally high rate of siltation ([236]). Annual siltation at the proposed Esperanza dam site is 0,09 x 10^6 m^3 ([245]). Earthworks associated with construction of the freeway upstream of the lagoon, are also liable to generate silt.

Land ownership/use. The catchment primarily comprises the sugar cane estates of the Umzinto Sugar Company and C. G. Smith Sugar Ltd. Only 3% of the catchment is Bantu influenced.
On the northern bank of the lagoon are the railway marshalling yards of Kelso junction. Part of Pennington is on the southern bank. Land adjacent to the water's edge is zoned as public open space.

Local authority. Pennington.

Estuary uses. No record.

Morphometry of lagoon (see Fig. **77**).
Area. 7 ha

Axial length. 1,42 km

Shoreline length. 3,8 km

Width.
Maximum: 250 m, although given as 600 m by Orme ([257]).
Mouth: No record.
Floodplain: 300 m

Bathymetry. No record.

Geomorphology
Geology. Outcrop percentages in the catchment are given as 97% granite and 3% Dwyka conglomerates ([206]). Table Mountain Sandstone surrounds the lagoon itself (du Preez, pers. comm. ([245])).

Nature of bottom materials. At the site of the existing road bridge, boreholes drilled to a depth of 15 m failed to reach bedrock ([257]). Examination of the cores revealed coarse fluvial materials overlain by marine sand.

Sandbar characteristics. Under normal circumstances the sandbar across the mouth of the Mzinto lagoon is ± 270 m long and south extending. In view of the encroachment of sugar cane onto the floodplain and the need to minimize water levels whilst construction of the freeway bridge is in progress, the sandbar is probably artificially breached. The mouth position is therefore liable to vary according to where channels are dug.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics
Information on the physico-chemical characteristics of the lagoon is non-existent. There is however, some data on the chemistry of the river water 8,5 km above the lagoon ([206]) from which very few signs significant of disturbance were apparent in 1970 (see Table **68**).
Grindley recalls a case of insecticide pollution in the Mzinto lagoon ([137]), and complaints of pollution by the Umzinto sugar mill are also on record (Mercury Pictorial dated 28 October 1909). The latter is no longer operative.

Public health aspects.
Bacteriology. There is no information available on the bacteriology of the Mzinto lagoon. However, a limited amount of data on the bacteriology of the river water 8,5 km above the lagoon is

Table 68. Physico-chemical characteristics ([206]).

Locality: Mzinto river Distance above lagoon: 8.5km	SUMMER Jan 1970	WINTER July 1970
Hydrogen ion concentration (pH)	7.6	7.8
Saturated pH value	8.5	8.4
Conductivity micromhos/cm	291	373
Total dissolved solids ppm (calcd.)	167	223
Dissolved oxygen mg/litre	8.4	10.2
% Saturation	102	108
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	4.6	4.2
Kjedahl nitrogen mg/litre	0.8	0.2
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.15	0.20
Phosphates "	.36	.08
Total alkalinity "	66.3	74.9
Total hardness "	72.9	79.7
Calcium "	11.1	13.5
Magnesium "	11.0	11.2
Sodium "	26.3	45.5
Potassium "	2.2	1.5
Sulphates "	16.9	29.5
Chlorides "	42.3	59.8
Silica "	-	-
Iron "	-	-
Fluorides "	0.4	0.3
Free carbonic acid (as ppm carbon dioxide)	3.2	2.3
Temperature °C	25.0	17.8
Turbidity (ppm silica scale)	Turbid	Fair
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

available ([206]) (see Table 69). Organic enrichment of the water was evident, almost certainly being due to the influence of sugar cane in the catchment.

Bilharzia. There is no evidence to suggest that bilharzia snails occur either in the lagoon or the river above it. Sampling by Kemp *et al* 8,5 kms above the lagoon in 1972 was also negative in this regard ([206]).

Table 69. Bacteriology of the Mzinto river (8,5 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* 1/100 ml	
	I 6 day @ 20°C	II 6 days @ 20°C + 24 hours @ ambient	Confirmed	Presumptive
March 1971		274		4 100*
Aug 1971			169	705*
9 Feb 1972	192	**430**	50	100
23 Feb 1972	150	**416**		700
5 July 1972	106	96	120	120
2 Aug 1972	310	180		600
16 Aug 1972	80	**3 900**		
15 Jan 1973	440	**1 200**	2 100	8 400

* Total coliform counts
Values in bold are significant of disturbance.

BIOTIC CHARACTERISTICS

Flora

The hillsides on both sides of the lagoon are under township development; a portion of the lagoon has been reclaimed as Kelso junction; and most of the floodplain is under sugar cane and bananas. Consequently much botanical disruption has occurred in the vicinity of the Mzinto lagoon.



The lower reaches of the Mzinto lagoon are surrounded by undisturbed lagoonal plant communities (9 June 1977).

However, the lower reaches of the lagoon have remained fringed by *Barringtonia* and *Hibiscus tiliaceus*, and *Phragmites* swamps occur in what were formerly side channels of the system.

Fauna

There is no information available on the fauna of the Mzinto lagoon. Data collected in June 1972, 8,5 km above the lagoon, suggest that favourable conditions occurred for aquatic life at this particular point in the river system. ([206])

SYNTHESIS

Our general state of knowledge of the Mzinto lagoon is poor. However, by virtue of it being the best endowed lagoon along a 25 km stretch of the south coast (between Scottburgh and Ifafa) the Mzinto lagoon is important.

This stems from the need to try and ensure that along such a distance of coast, at least one fair-sized lagoon is maintained in a functional condition for estuarine life. There is reason to suggest therefore that the Mzinto lagoon be conserved, because of its relative inaccessibility and the fact that its lower reaches are surrounded by functional swamp communities. Such characteristics bestow upon it opportunity to maintain life. It is also recommended that an effort be made to obtain an ecological understanding of the system. The matter of pesticide pollution should be investigated.

Several problems manifest themselves in the Mzinto lagoon, these being siltation, cane encroachment, infilling, embankment construction and the artificial control of water levels.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other						Flora			Fauna						Food Webs
MZINTO ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids														★								←★→		←★→							
Source of Information	Summary of available information																														
Midgley & Pitman	1969	223	●		●																										
Grindley	1970	137												●																	
Kemp *et al*	1970 to 1972	206	●		●			●			○				○										○	○					
Loxton, Hunting & Assoc.	1971	213	●		●																										
Ninham Shand & Partners	1971	245	●					●		●																					
Orme	1971	257	●	●	●					●																					
NTRPC	1974	236						●		●																					
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 261	1976	279		●						●													●								
1:25 000 Job No. 262	1976	483	●																												

Synonyms

Inkombane; Umkombana,

Care should be taken to ensure that there is no confusion between the Mkumbane and the Inkomba river. Kemp *et al* [206] have confused the two in their survey of the rivers of southern Natal. The latter enters the sea 1,2 km south of the Mzinto, whilst the former does so 5 km south of the Mzinto. The Inkomba lagoon is sufficiently insignificant not to warrant the individual attention that has been given to the rest of Natal's estuarine systems. However the information provided by Kemp *et al* on the Inkomba river, has been incorporated into this review, because it in fact relates to the Mkumbane.

Zulu meaning

The river is named after the Nkhomba palms (*Jubaeapsis caffra*) which grow there [289].

Location

30°24'15"S; 30°41'15"E.

Accessibility

By road the Mkumbane lagoon is 80 km south west of Durban. The national road is 4 km away. A track exists on the southern bank, leading from the Sezela mill to the lagoon mouth, and thence onto the beach. It is used for launching ski-boats.

Bridges

The railway crosses over the very mouth of the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 22 km^2 to 34 km^2 [206].

River length. 13 km [206] to 15 km

Mean annual run-off. No record.

Flow. A rough estimate of the average flow has been given as ,085 m^3/sec. [206].

Flood history. No record. Nevertheless, expanses of sand deposited on the flood plain above the lagoon suggest that floods from the Mkumbane catchment can be quite dramatic.

Dams.

Existing. None.

Proposed: None.

Siltation. There is no quantitative information available, but judging from aerial photographs, siltation rates appear to be severe.

Land ownership/use. 48,6% of the catchment area (comprising the Ifafa Mission reserve) is Bantu influenced, and destined to become incorporated into KwaZulu. The remainder of the catchment is made up of the Sezela sugar cane estates.

In the immediate vicinity of the lagoon, is Umdoni Park (to the north) and the Sezela mill township owned by C. G. Smith Sugar Ltd (to the south).

Local authority. C. G. Smith Sugar Ltd.

Estuary uses. None.

Morphometry of lagoon (see Fig. **78**)

Area. 0,25 ha

Axial length. 100 m

Shoreline length. 200 m

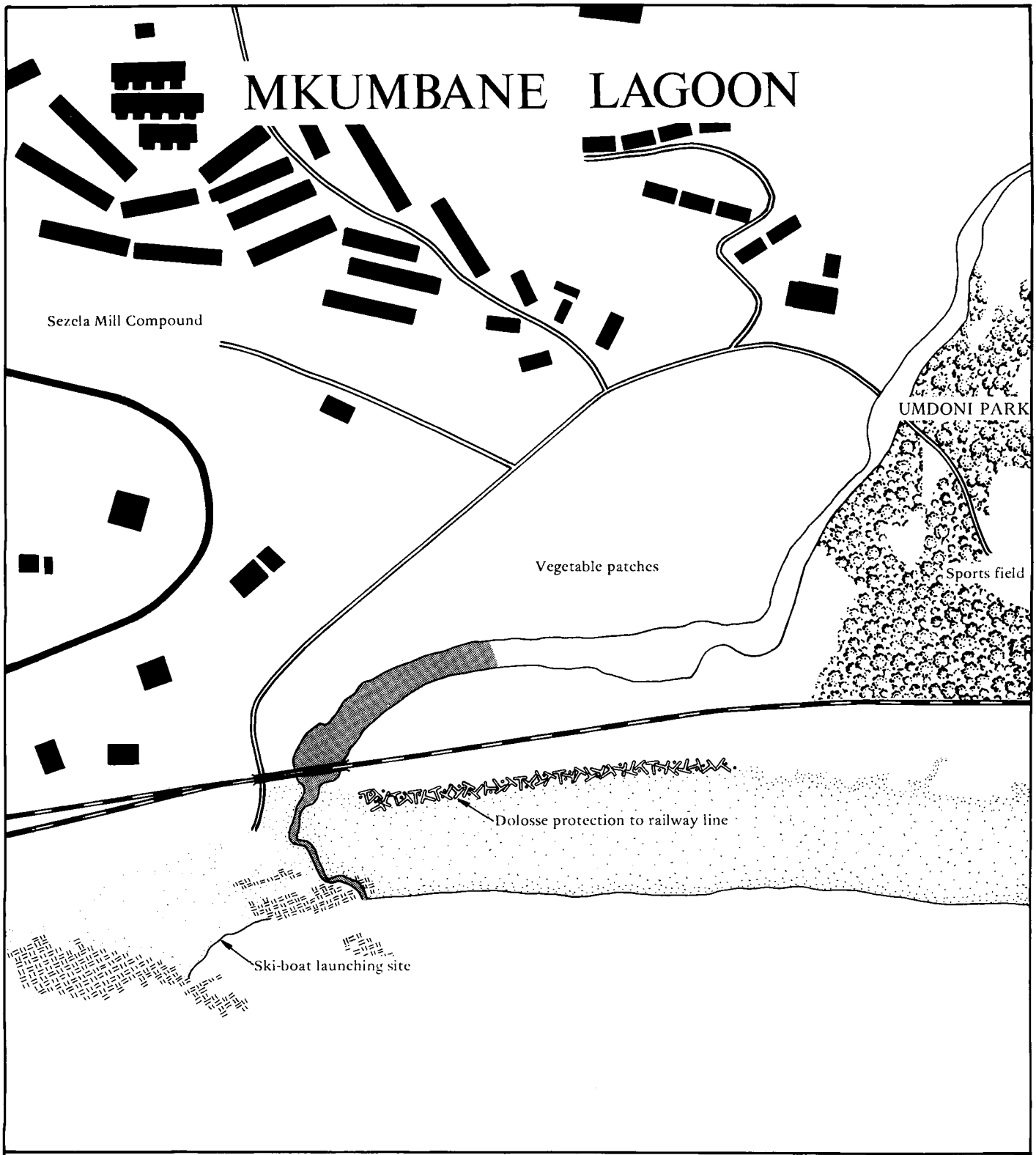

MKUMBANE LAGOON
Sezela Mill Compound
UMDONI PARK
Vegetable patches
Sports field
Dolosse protection to railway line
Ski-boat launching site
Coastal Dune Forest
50 0 50 100 150 200 250 300 metres

Fig. 78

Width.
Maximum: 20 m
Mouth: No record.
Floodplain: 150 m

Bathymetry. No record.

Geomorphology

Geology. Outcrop percentages in the catchment are 10% Table Mountain Sandstone and 90% Granite ([206]). Table Mountain Sandstone occurs along the coast north of the lagoon (du Preez, pers. comm.).

Nature of bottom materials. No record.

Sandbar characteristics. The railway line has been built upon what was once a 250 m long south extending sandbar, which is now vegetatively stable. On the seaward side, the railway has been protected by concrete blocks and rubble. The mouth of the lagoon opens across a rocky shelf.

The lagoon is permitted to open naturally, although it is closed for most of the year (Hulley, pers. comm.). The primary means of contact with the sea is through waves over-topping the bar at high tide.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

Data from the lagoon itself is non-existent. There is however, some information on the chemistry of the river water 8,5 km above the lagoon (see Table **70**) ([206]). At this point in the river, the only signs significant of disturbance in February 1971 were the relatively high values for biological oxygen demand and phosphate.

Table 71. Bacteriology of the Mkumbane river (8,5 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* 1/100 ml	
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient	Confirmed	Total Coliforms per 100 ml
March 1971			638	5 100
July 1971			58	616
8 Feb 1972	52	115		
23 Feb 1972	590	180		
5 July 1972	49	**290**	20	
2 Aug 1972	210	**310**	327	980*
16 Aug 1972	140	**8 120**		
15 Jan 1973	120	**4 000**		9 900*

* presumptive counts of *E. coli* I.
Values in bold are significant of disturbance.

Table 70. Physico-chemical characteristics.

Locality: Mkumbane river Distance above lagoon: 8.5km	SUMMER Feb 1971	WINTER June 1971
Hydrogen ion concentration (pH)	8.3	7.6
Saturated pH value	8.5	8.5
Conductivity micromhos/cm	325	431
Total dissolved solids ppm (calcd.)	193	262
Dissolved oxygen mg/litre	8.7	10.3
% Saturation	100	101
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	6.3	4.0
Kjedahl nitrogen mg/litre	0.5	0.5
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.90	1.01
Phosphates "	.35	.16
Total alkalinity "	63.5	72.5
Total hardness "	81.3	94.0
Calcium "	11.3	12.1
Magnesium "	12.9	15.5
Sodium "	40.0	55.0
Potassium "	1.4	2.0
Sulphates "	28.2	33.0
Chlorides "	56.9	80.3
Silica "	-	-
Iron "	-	-
Fluorides "	0.1	0.2
Free carbonic acid (as ppm carbon dioxide)	0.6	2.5
Temperature °C	23.0	15.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

Public health aspects.

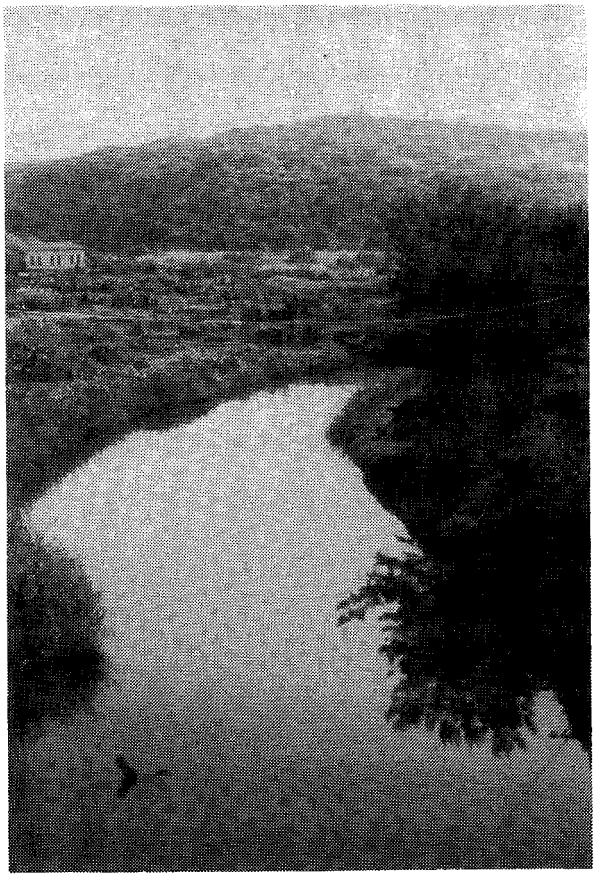
Bacteriology. Data from the lagoon itself is completely lacking. However, as a result of the organic enrichment evident 8,5 km above the lagoon (see Table **71**) the river was classified as verging on public nuisance levels ([206]). In the lagoon itself, faecal pollution is probable because of the proximity of the Sezelá mill compound.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

There are no noteworthy plant communities adjacent to the lagoon. Potential wetland communities on the floodplain have been replaced by vegetable patches. The only element of the Mkumbane system worth any attention is the thickly forested slopes of the Mkumbane river above the lagoon. These valley slopes form an impressive relic of coastal forest, which could well be incorporated into Umdoni Park ([189]) and placed under the care of the Reynold's Trustees.



A view of the Mkumbane lagoon, showing the well preserved forest areas above it (19 May 1977).

Fauna

Data from the lagoon is non-existent. However, a certain amount of information on the aquatic fauna of the river 8,5 km above the lagoon is available ([206]) from a survey undertaken in 1972. Conditions appeared to be highly favourable for aquatic life at this point in the system.

SYNTHESIS

We have no knowledge at all about the Mkumbane lagoon. From what can be seen, the lagoon is in a very degraded state and of no resource value. However the lower reaches of the Mkumbane river are in good condition, especially from a botanical point of view. The forested slopes through which the river runs should be protected and conserved. Investigations of the lagoon itself are not warranted. Of the various influences which have affected the lagoon, siltation has probably been the most severe. Pollution from the Sezela mill township is also likely.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other							Flora			Fauna								Food Webs
MKUMBANE ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																																		
Source of Information	Summary of available information																																	
Kemp *et al*	1971 to 1973	206	●		●			●			○				○										○	○							
Hulley	1977	pers. comm.					●													●													
Hopwood	1978	189						●															○										
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	284		●						●																							
1:25 000 Job No. 262	1976	481	●																														

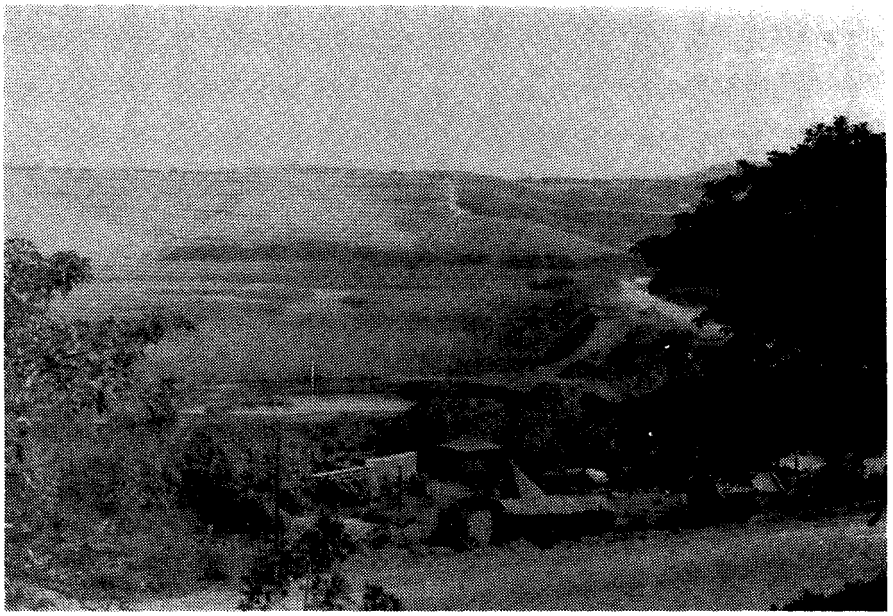
2.1.10.7 **SEZELA**

Synonyms
Isizela (Mercury Pictorial).

Zulu meaning
No record.

Location
30°25'S; 30°41'E.

Accessibility
By road the Sezela lagoon is 79 km south west of Durban. The national road is 4 km from the lagoon. An extensive reed swamp around the edges of the lagoon, renders much of it inaccessible. A dirt road runs along the northern bank of the lagoon, serving to connect the Sezela mill and the Sezela sugar estates.



A view of the Sezela lagoon from the sugar mill (24 May 1977).

Bridges. The railway line crosses the lagoon 70 m from the mouth. A causeway has been built to act as a bridge across the head of the lagoon 1,8 km from the mouth.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 19 km^2 to 21 km^2 ([206]).

River length. 10 km ([206]) to 14 km.

Mean annual run-off. No record.

Flow. No record. A rough estimate of the average flow is ,14 m^3/sec. ([206]).

Flood history. Flooding is never severe (Hulley, pers. comm.) although the whole area (including all the peripheral reed swamps) can form into one large sheet of water when flooding occurs.

Dams.
Existing. There is a small dam 3,5 km above the lagoon, with a total capacity of 151 000 m^3. Its function is to supply Sezela township (Hulley, pers. comm.).

Proposed: None.

Siltation. The Sezela lagoon is unaffected by siltation because of the dam upstream. In 1961 this dam was drained for de-silting, and the wall raised (Hulley, pers. comm.). By 1977 it had lost 15% of its capacity — largely due to silt coming off the south coast freeway, then under construction. Run-off from the Ifafa Mission reserve also contributes to siltation of the dam.

Land ownership/use. The Ifafa mission reserve comprises 47% of the catchment, and is destined to become part of KwaZulu. The rest of the catchment area comprises sugar cane estates belonging to C. G. Smith Sugar Ltd (formerly Reynolds Bros. Sugar Company).

On the northern bank of the lagoon is the Sezela mill and township, with a population of 3 350 (Menné, pers. comm.).

The land which surrounds the lagoon is all under sugar cane. Only the floodplain has remained intact and undisturbed.

Local authority. C. G. Smith Sugar Ltd.

Estuary uses. The lagoon is used for no purpose other than providing water for the Sezela sugar mill.

Morphometry of lagoon (see Fig. **79**).

Area. ± 9 ha, **excluding** a 3 ha island in the centre of the lagoon, and peripheral reedswamp areas.

Axial length. 1,8 km

Shoreline length. The shoreline length is in excess of 6,4 km.

Width.
Maximum: 100 m
Mouth: No record.
Floodplain: 350 m

Shape. The dendritic shape of the Sezela lagoon is an outstanding characteristic. There is no other estuarine system in Natal in which this characteristic is quite as marked. There are many backwaters, side channels and creeks, each of which add considerably to the effective shoreline length. Were it not so severely polluted, the Sezela lagoon would be an excellent estuarine environment.

Bathymetry. Parts of the lagoon are in excess of 4 m deep (Hulley, pers comm.). The average depth is approximately 3 m.

Geomorphology

Geology. Underlying the alluvium, in which the Sezela lagoon is cradled, there is Table Mountain Sandstone to the north of the lagoon and Dwyka tillite to the south (du Preez, pers. comm.).

Nature of bottom materials. The bottom of the Sezela lagoon comprises a black, anaerobic, highly organic sludge (Hulley, pers. comm.).

Sandbar characteristics. At the mouth of the Sezela lagoon a sandbar (± 125 m long) closes the lagoon off from the sea. Without rock protection from the south easterly swells, the bar is north extending.

The lagoon is normally permitted to open naturally, and does so after heavy rains (Hulley, pers. comm.) although it does not remain open for long. Workers at the Sezela mill occasionally breach the bar in order to repair the foot valves on the pump intakes. Pump repairs are generally undertaken in the off season (i.e. mid-January to mid-April). In the past the South African Railways have also been known to breach the bar.

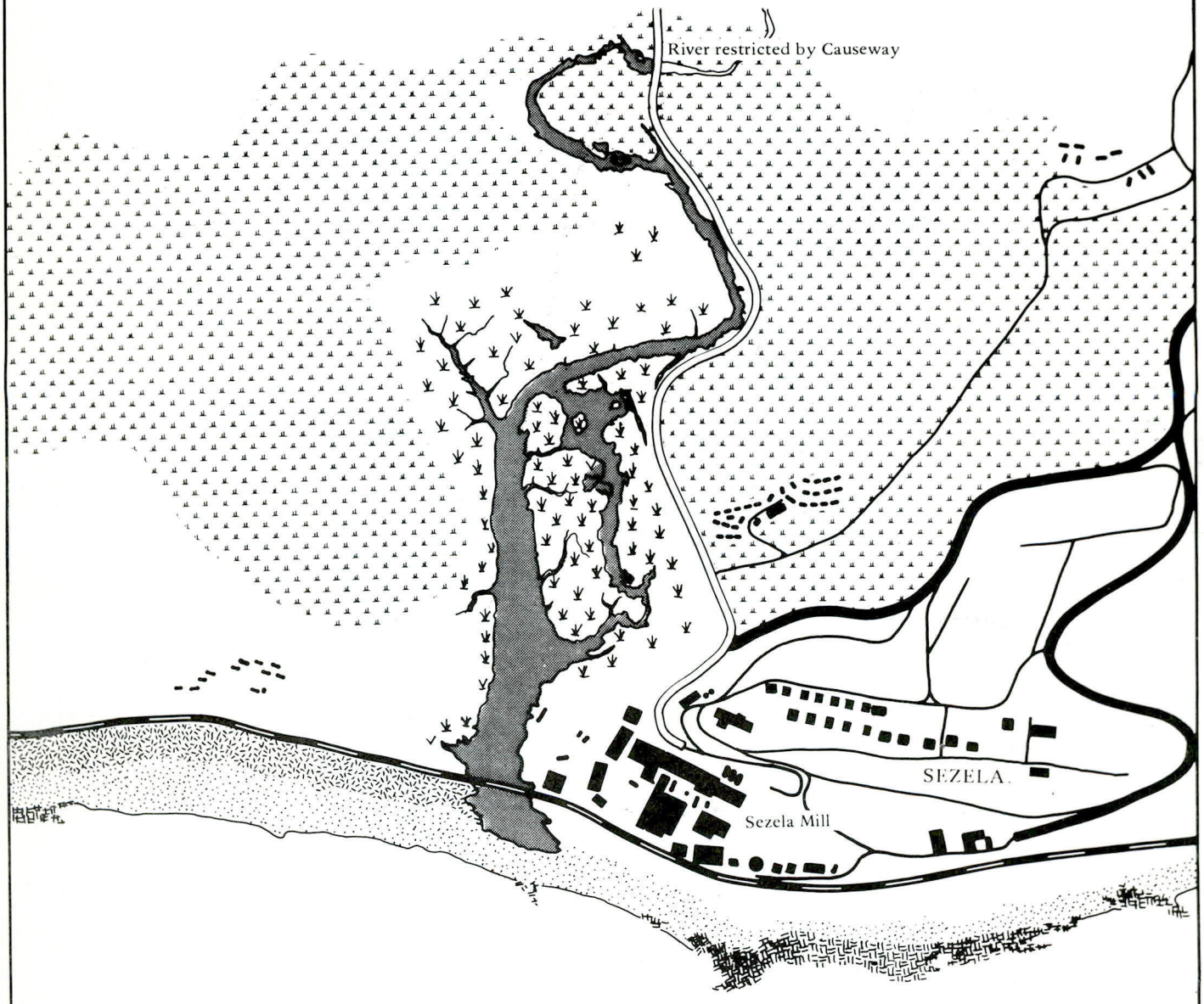
Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

The Sezela lagoon is the most grossly polluted lagoon in Natal. An average chemical oxygen

SEZELA LAGOON



Coastal Dune Pioneer

Cane

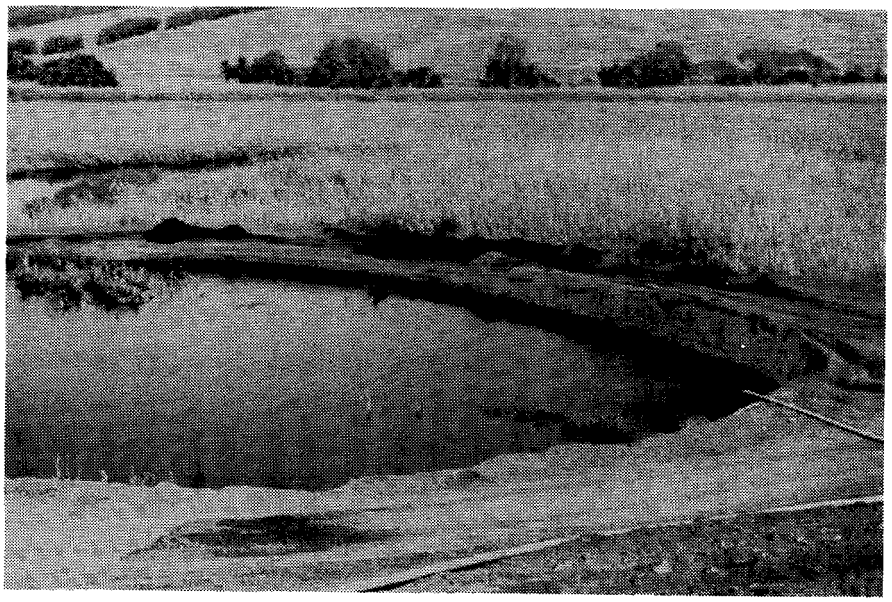
Reed Swamp

100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 79

demand value from the lagoon is 600 milligrams/litre (van der Riet, pers. comm.). (The general standard laid down for industrial effluents is 75 milligrams/litre). Being classified as "end users", the Sezela mill has no obligation to meet any effluent standards. They are permitted to use and treat the lagoon in any manner they desire. Consequently pollution of the lagoon has transformed it into a foul-smelling, filthy black cesspool.

After complaints from Pennington and Bazley, attempts to reduce air pollution by screening and washing the factory stacks has transferred an additional load of black filth into the water of the lagoon. The stack washings are led to ash dams which have been created alongside the lagoon to receive such material. The ash dams overflow into the lagoon, although they are periodically emptied of ash when too full.



Ash dams alongside the Sezela lagoon are used to collect the soot removed from the factory stacks.

Although totally unrepresentative, some information on the chemical characteristics of the river water 3,5 km above the lagoon is available ([206]) (see Table **72**).

Public health aspects

Bacteriology. There is no information available on the bacteriology of the Sezela lagoon, and a study thereof is likely to be extremely alarming. Organic enrichment of the lagoon is obviously severe. Sewerage from the Sezela mill township runs into septic tanks (Menné, pers. comm.). The only information available (although obviously unrepresentative) is that from the Sezela river, and is based on samples taken 3,5 km above the lagoon in the early 1970's. The results are expressed in Table **73**. Sporadic organic enrichment and faecal pollution was evident. ([206])

Bilharzia. No record.

Mosquitoes. An outbreak of mosquitoes from the Sezela lagoon was reported on the 25 January 1978. Considering the ability of mosquito larvae to live in water in which there is no oxygen, and the lack of predators in the lagoon which would normally control them, an outbreak of this sort is not surprising. The State Department of Health advised control by the application of malathion (van der Elst, pers. comm.).

BIOTIC CHARACTERISTICS

Flora

An outstanding characteristic of the Sezela lagoon is the extensive wetland (reed swamp) areas which surround it. These are comprised mainly of *Phragmites*, and occupy approximately 15 ha. In the 1940's an unsuccessful attempt was made to replace the swamp by eucalyptus plantations (Hulley, pers. comm.). Besides this, the extent and quality of these reed beds has remained unchanged over the last 20 years.

Table 72. Physico-chemical characteristics.

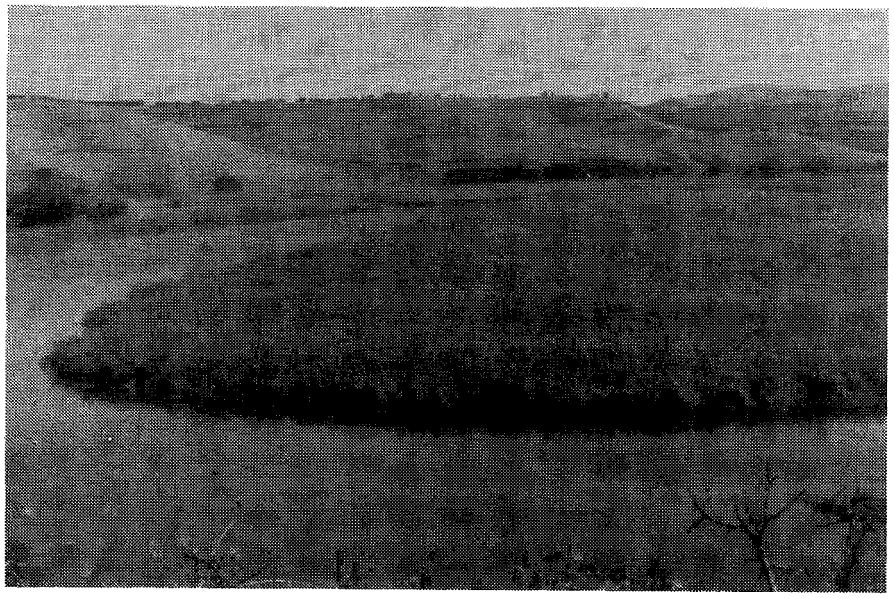
Locality: Sezela river Distance above lagoon: 3.5km	SUMMER Feb 1971	WINTER July 1971
Hydrogen ion concentration (pH)	8.1	7.8
Saturated pH value	-	-
Conductivity micromhos/cm	275	328
Total dissolved solids ppm (calcd.)	182	201
Dissolved oxygen mg/litre	8.6	10.9
% Saturation	102	100
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	2.0	3.7
Kjedahl nitrogen mg/litre	0.7	0.2
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	1.4	0.7
Phosphates "	.35	.19
Total alkalinity "	76.4	87.3
Total hardness "	69.7	74.1
Calcium "	9.5	11.1
Magnesium "	13.6	11.3
Sodium "	38.3	39.0
Potassium "	0.9	1.1
Sulphates "	20.5	16.9
Chlorides "	46.5	49.7
Silica "	-	-
Iron "	-	-
Fluorides "	0.3	0.4
Free carbonic acid (as ppm carbon dioxide)	1.2	2.6
Temperature °C	24.5	12.5
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	poor	poor
Odour	-	-

Values underlined significant of disturbance.

Table 73. Bacteriology of the Sezela river (3,5 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* I/100 ml	Total Coliforms per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient	Confirmed	
March 1971			**4 380**	26 500
July 1971			391	1 600
8 Feb 1972	224	**990**	2 300	
23 Feb 1972	600	240	1 100	
3 July 1972	10	40	**5 850**	11 700*
1 Aug 1972	160	82		2 420*
16 Aug 1972	80	**3 400**		
15 Jan 1973	**2 500**	1 280		34 200*

* = Presumptive counts of *E. coli* I.
Values in bold significant of disturbance.



The reed swamps surrounding the Sezela lagoon are its major attribute.

There is an occasional outbreak of water hyacinth (*Eichornia crassipes*) in the lagoon, during which the water area can become completely covered. The herbicide 2.4D has been applied in the past as a spray, although breaching of the lagoon (to flush the hyacinth out to sea) is the easiest control technique (Hulley, pers. comm.).

Fauna

Some details on the aquatic fauna of the Sezela river at a point 3,5 km above the lagoon is available ([206]). From the diversity of animals present, conditions appeared favourable. Information

on the fauna of the Sezela lagoon is totally lacking, although it is doubtful whether any forms of estuarine animals can tolerate its polluted condition.

Birdlife. Waterfowl such as various herons, egrets, ducks and geese appear to utilize the lagoon quite extensively, deriving much benefit from the extensive reed beds which surround it.

Fish. Mud-bream (*Sarotherodon mossambicus*) are reported to be present, which says a lot for the ability of these fish to survive. A fish kill (in April 1977) caused some adverse publicity in the press for the milling company.

SYNTHESIS

Our state of knowledge of the Sezela lagoon is poor, because the lagoon is privately owned and because from the owners point of view, there has been no reason to study the lagoon. They themselves maintain certain checks on water quality. Nowhere else in Natal has an industry been permitted to become established alongside a lagoon, and remain unrestricted in the manner in which they treat it.

The Sezela lagoon has a scientific value in that for comparative purposes, it serves as a classical example of what a polluted lagoon really is like. A study of the lagoon would be extremely revealing from a scientific point of view. Thus an attempt should be made to establish exactly what the chemical, bacteriological and biotic characteristics of the lagoon are. This would provide information on tolerance levels and biological indicators of pollution, which could be usefully compared with values obtained from lagoons elsewhere.

In its present environmental condition the lagoon, **as a water body,** is in a very severely degraded condition. **Marginally** however, the Sezela lagoon supports a reed-swamp community, which gives the appearance of being in a very satisfactory condition. There are no lagoons on the south coast of Natal which are surrounded by such extensive reed-swamps. However, in this instance they are probably of no benefit to the lagoon because the water body they serve is so polluted. Were it not so polluted, the Sezela lagoon would have considerable potential as an estuarine resource.

| ESTUARY/LAGOON | | |

2.1.10.8 **MDESINGANE**

Synonyms
Mdezingane

Zulu meaning
No record.

Location
30°25'30"S; 30°40'15"E.

Accessibility
The nearest settlement to the Mdesingane lagoon is Bazley Beach, 85 km south west of Durban. Access to the lagoon is poor. The road is bad, sometimes impassable, and restricted by a locked gate.

Bridges
A high bridge carries the railway line across the mouth of the lagoon. With the approach to the bridge on the northern bank comprising a massive embankment, a loss in water area since its construction is suspected.

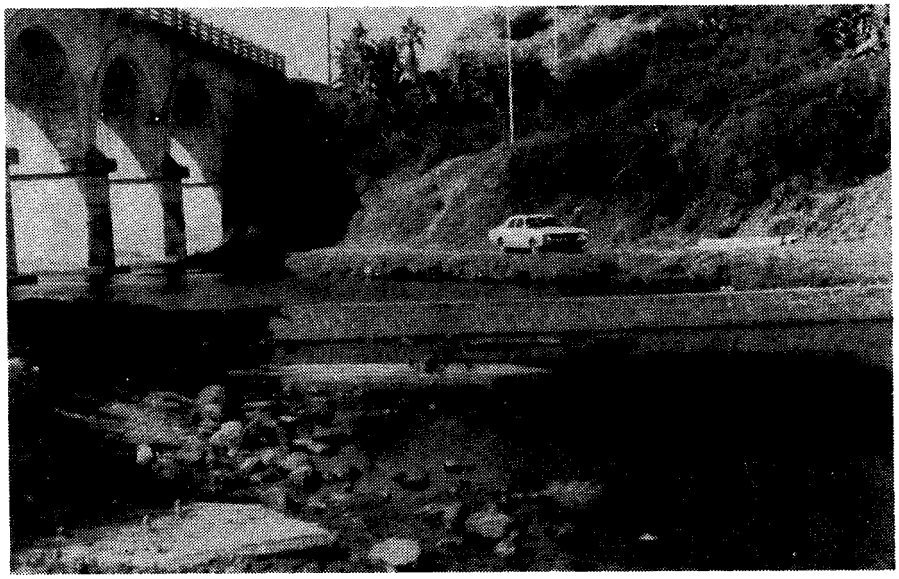
ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 6 km^2

River length. 5,25 km

Mean annual run-off. No record.

Flow. No record.

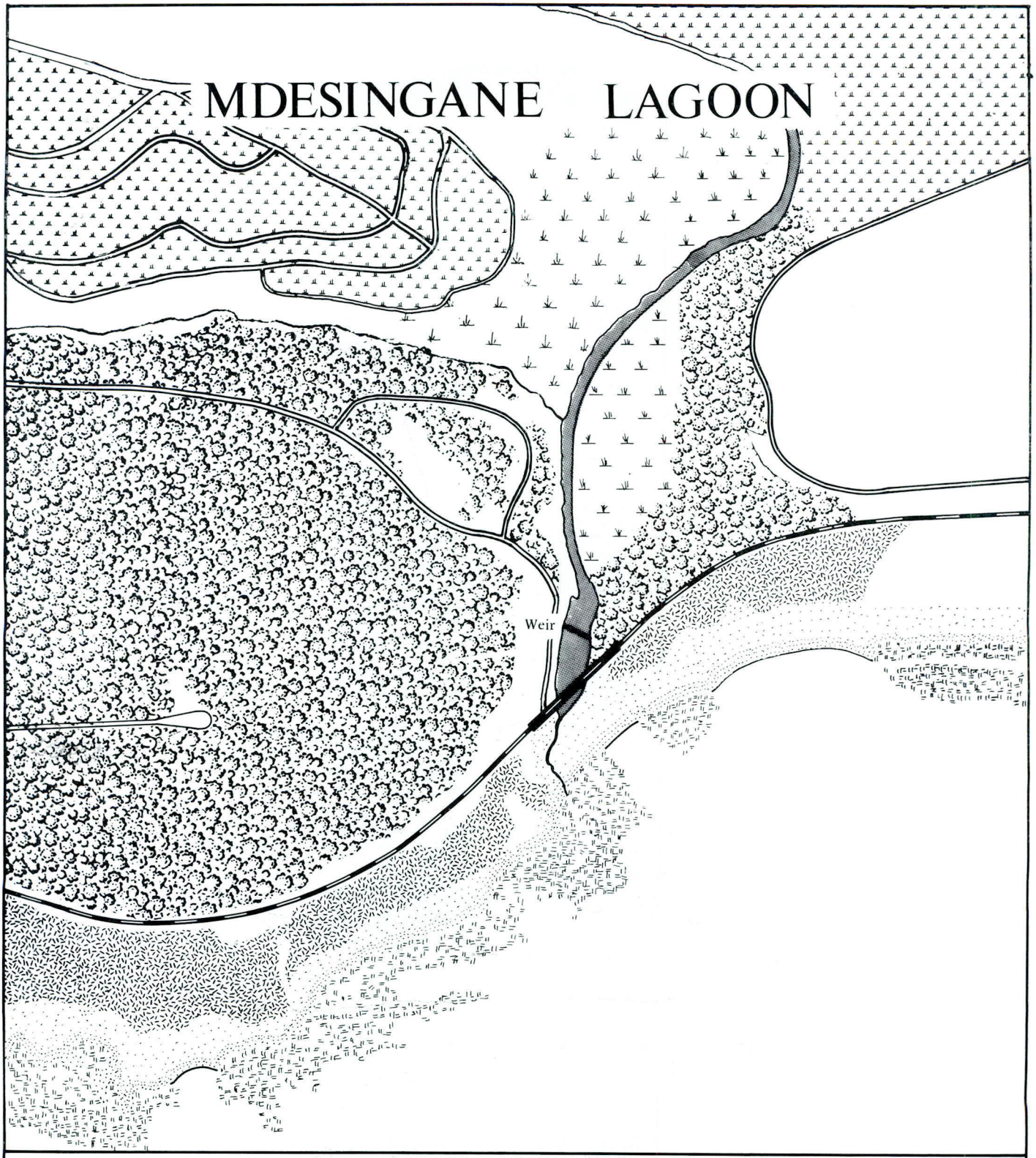
Dams. No dams exist, nor have any been proposed. However, a weir was built across the lagoon in order to impound sufficient water to supply Bazley Beach (Hulley, pers. comm.). Although the lagoon is no longer used for this purpose, the weir now carries the main regional water supply pipe line to Bazley Beach.



Weir construction across the Mdesingane lagoon adversely affects the system (24 May 1977).

Siltation. No record.

Land ownership/use. The entire catchment, including the surrounds of the lagoon are owned by the sugar company C. G. Smith Sugar Ltd., and is used for the production of sugar cane. The land in the vicinity of the lagoon is in a totally undeveloped, undisturbed state.



Coastal Dune Forest

Coastal Dune Pioneer

Reed Swamp

Cane

50 0 50 100 150 200 250 300 350 300 450 500 metres

Fig. 80

Local authority. C. G. Smith Sugar Ltd.

Estuary uses. No use is made of the Mdesingane lagoon.

Morphometry of lagoon (see Fig. **80**)

Area. ,39 ha

Axial length. 0,5 km

Shoreline length. 1,0 km

Width.

Maximum: 25 m

Mouth: 2 m during normal flow periods.

Floodplain: 100 m

Bathymetry. No record.

Flood history. No record.

Geomorphology

Geology. The lagoon is entirely surrounded by hills made up of Dwyka tillite, capped by Berea red sand (du Preez, pers. comm.). Granite outcrops in the upper part of the catchment.

Nature of bottom materials. No record.

Sandbar characteristics. The Mdesingane sandbar is south extending and only 50 m long, however, it effectively closes the lagoon off from the sea for most of the year. The old barrier across the lagoon is now stabilized and carries the railway line. The channel to the sea opens across rocks and is well protected to the south from the prevailing swell by a rocky headland, which protrudes from the coast. At high tide the sea overtops the bar and enters the lagoon (Hulley, pers. comm.). Breaching is not necessary. The lagoon opens naturally whenever heavy rain falls in the catchment area.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

No record. However, being artificially impounded behind a weir, it is almost certain to be very fresh in its basic characteristics.

Public health aspects.

Bacteriology. No record. With sugar cane in close proximity to the lagoon, the water is likely to be organically enriched.

Bilharzia. No record. With water levels having been raised behind a weir, the presence of bilharzia snails is very probable.

BIOTIC CHARACTERISTICS

Flora

Botanically speaking the Mdesingane lagoon is well endowed. Reedswamp communities on the floodplain are intact, and immediately south of the lagoon, and upstream of the lagoon are thickly forested hills and valley slopes, amongst which *Strelitzia* are conspicuous. Attention has already been drawn to these resources by Hopwood ([189]), and Ward's survey should be enlightening in this respect.

Fauna. No record.

SYNTHESIS

Very little is known about the Mdesingane lagoon. However, in its present environmental condition the lagoon surrounds and the lower reaches of the river system appear to be in a fair condition, and worthy of protection ([189]). By conserving the floral resources of the area, any fauna present will simultaneously derive protection. A botanical survey of the area is justified.

As a lagoon however, the Mdesingane does not have much potential, particularly with a weir across its lower reaches. This prevents any movements of estuarine animals, and transforms the lagoon from a brack water to a fresh water condition.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other					Historical	Flora		Fauna							Food Webs
MDESINGANE ○= denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization		Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																							★								
Source of Information	Summary of available information																															
Hulley	1977	pers. comm.					●													●											
du Preez	1977	pers. comm.						●																							
Hopwood	1978	189						●											●				○								
Aerial photos (Scogings)		No.																													
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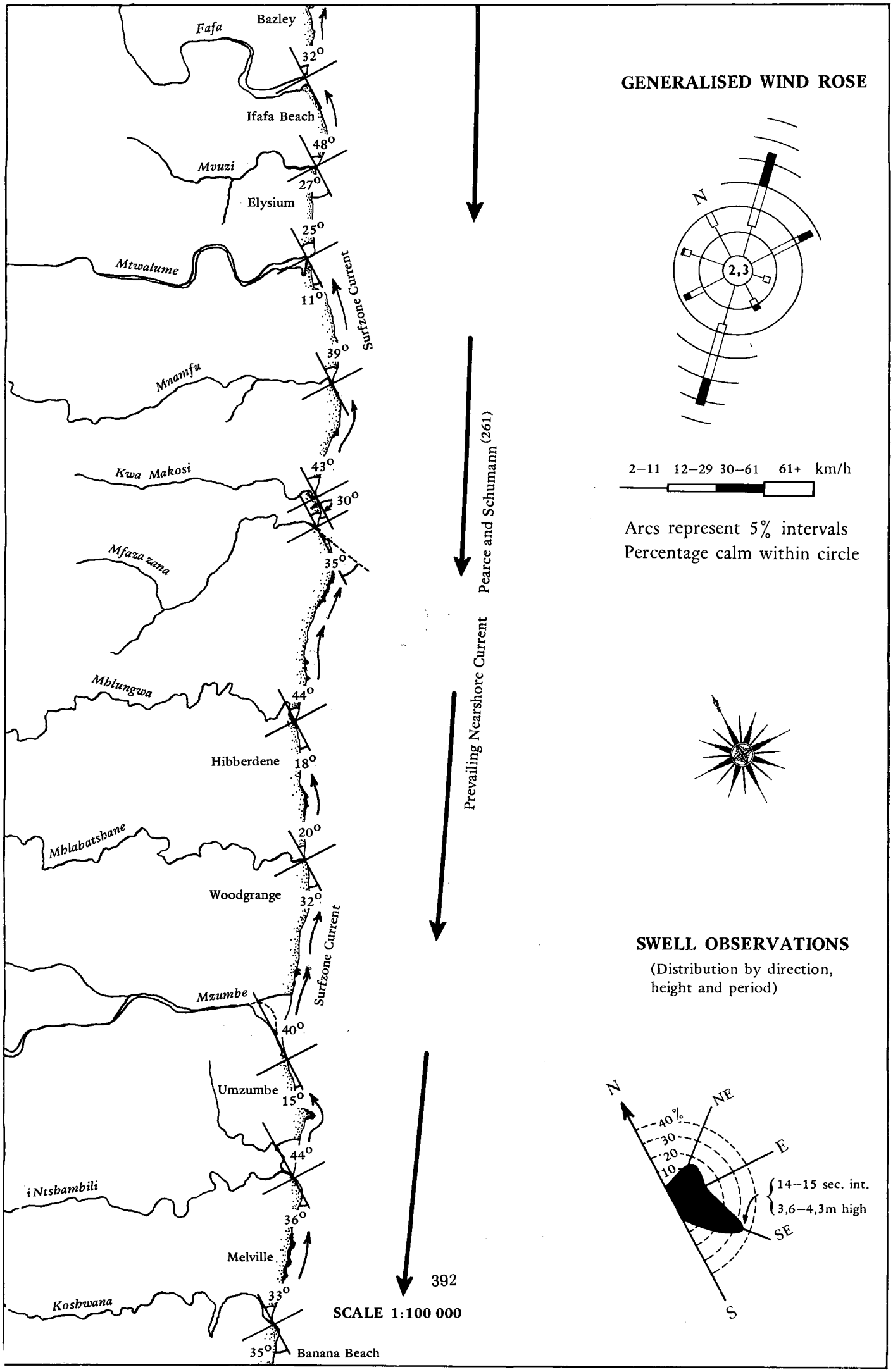
1:25 000 Job No. 262	1976	479	●																												

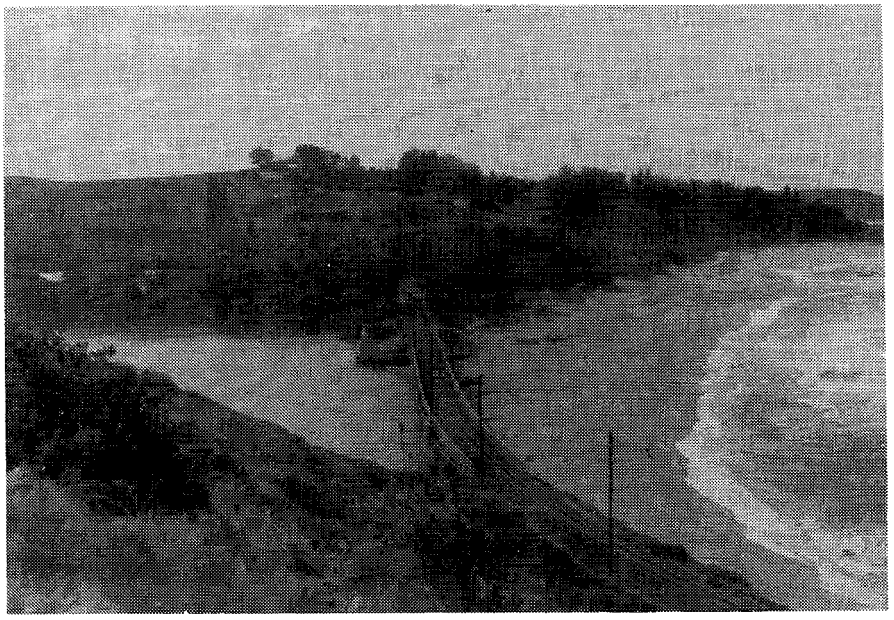

Fafa
Bazley
32°
Ifafa Beach
48°
Mvuzi
27°
Elysium
25°
Mtwalume
11°
Surfzone Current
39°
Mnamfu
43°
Kwa Makosi
30°
Mfaza-zana
35°
Mhlungwa
44°
Hibberdene
18°
Mblabatshane
20°
Woodgrange
32°
Surfzone Current
Mzumbe
40°
Umzumbe
15°
44°
iNtshambili
36°
Melville
33°
Koshwana
35°
Banana Beach
Pearce and Schumann (261)
Prevailing Nearshore Current
392
SCALE 1:100 000
GENERALISED WIND ROSE
N
2,3
2–11 12–29 30–61 61+ km/h
Arcs represent 5% intervals
Percentage calm within circle
SWELL OBSERVATIONS
(Distribution by direction, height and period)
N
NE
E
SE
S
40%
30
20
10
14–15 sec. int.
3,6–4,3m high

Synonyms
Ifafa

Zulu meaning
efafa is an onomatoepeic word meaning the river which flows with the sound of "fa-fa" ([289]). Robertson ([271]) infers that the river is named after the dense clumps of Ifafa lilies (*Cyrtanthus mackenii*).

Location
30°27'15"S; 30°39'15"E.

Accessibility
Since construction of the south coast freeway, the Fafa lagoon is 90 km south west of Durban by road. From the freeway (2 km away) there are secondary roads which lead to both the upper and lower reaches of the lagoon.



The mouth of the Fafa lagoon, showing the railway line on the sandbar.

Bridges
The south coast railway line crosses the lagoon within 40 m of the mouth. The remains of the old railway bridge are still evident, approximately 150 m from the mouth, although some of this has been washed away. The old bridge used to take a diagonal course across the lagoon, early photos of which are provided by Orme ([257]).

ABIOTIC CHARACTERISTICS
Catchment characteristics

Area. 246 km^2 ([213]); 251 km^2 ([223]); 259 km^2 ([206, 245, 257]).

River length. 64 km ([157]); 68 km ([206, 245, 257]).

Mean annual run-off. 25,6 x 10^6 m^3 ([223]); 26,8 x 10^6 m^3 ([213]); 40,7 x 10^6 m^3 ([157]).

Flow. Estimates of the mean annual flow are ,62 m^3/sec. ([206]) to 1,5 m^3/sec. ([85]). Seasonal flows at the 'Nil Desperandum' bridge, 10 km above the lagoon, were estimated to range from 1,4 m^3/sec. in August 1970 (dry season) to 5,6 m^3/sec. in February 1970 (wet season) ([157]).

Flood history. On 6 December 1970, with the Fafa river in flood, 60 cms of water was spilling over the weir ([157]). The weir was damaged by floods in 1976 and on this occasion several caravans were carried out to sea. Similar flood risks still exist.

Level fluctuations. As a weir blocks the mouth of the lagoon, the normal wet season level is governed by the crest level of the weir. After heavy rainfall the lagoon level may go up 0,60 m ([157]). The weir generally prohibits any tidal effects in the lagoon, and consequently the development of true estuarine characteristics. It also limits the distance to which salt water can penetrate. At present these limits are in the vicinity of Station 4 (see Fig. **81**). Should the sandbar be breached, water levels in the lagoon drop to below sea level. Orme ([257]) provides a particularly interesting aerial photo of the lagoon in such a condition. Under these circumstances, there is a movement of sea water into the lagoon at high tide. It has also been suggested that even with the sandbar intact, a difference in hydrostatic head may lead to sea water moving through the bar into the lagoon at high tide, especially if lagoon levels are low ([157]).

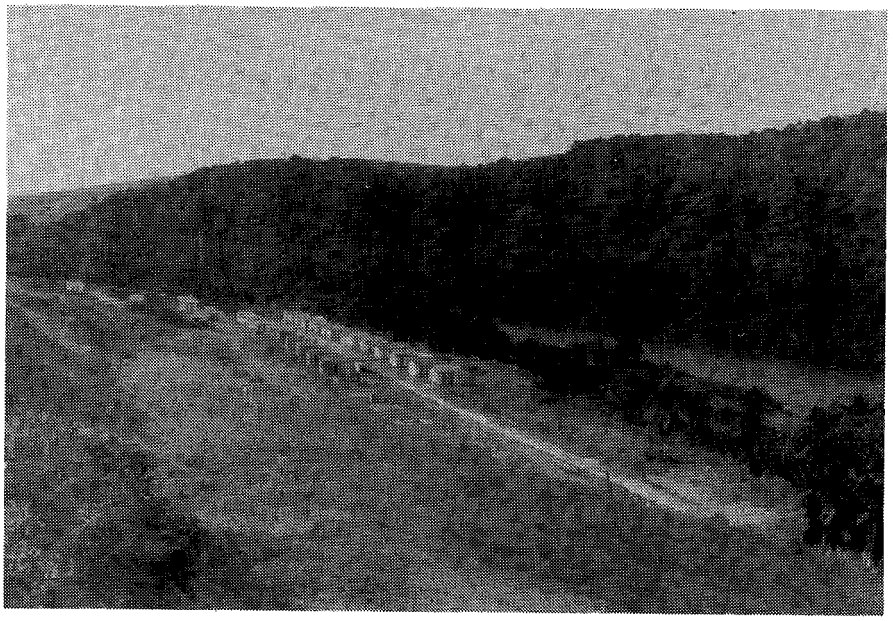
Interested parties (such as the Ifafa Lagoon Holiday Gardens, the Ifafa Marina (Pty) Ltd. and others) consider it essential to keep the level of the lagoon constant, so as to facilitate boating and water skiing. Emptying of the lagoon after floods have burst through the sandbar, is considered to be unacceptable. A proposal has therefore been made to the Department of Water Affairs to build a spillway 1,37 m high with sluice gates to control the height of the water in the lagoon (Munroe, pers. comm.).

Dams.
Existing: None.

Proposed: Although rated very low in terms of economic viability ([236]), a dam site located at Kingsdale 6 km above the lagoon has been proposed ([245]). The dam would have a total capacity of 40×10^6 m^3.

Siltation. Annual siltation at the proposed Kingsdale dam site was estimated to be $0,23 \times 10^6$ m^3 ([245]), which was considered to be a proportionately high rate of siltation ([236]). However Hemens *et al* ([157]) considered siltation to be low because of the presence of sand and gravel bottom deposits in the lagoon, the well vegetated river valley above the lagoon, and because of the geology of the catchment (Archaean granites). Information on the amount of suspended solids in the water is presented in Table **74**.

Land ownership/use. The catchment area is almost entirely comprised of European owned farmland most of which is used for the production of sugar cane. 8% of the catchment is influenced by the Mtwalume Mission reserve. The Sezela estates abstract water ($2,8 \times 10^6$ m^3 annually) from the Fafa river ([213]) for irrigation purposes.



The "Ifafa Marina" — a "five star" caravan park on the southern bank of the Fafa lagoon.

On the southern bank of the lagoon, near the mouth is the partly developed residential area of Ifafa Beach. Upstream is the "Ifafa Marina", which comprises a caravan park with restaurant, shops, chalets and swimming pool. The park is 48,5 ha in size. The hillside has been terraced so as

to provide ± 800, 150 m² plots for caravans. Each plot is provided with piped water, a toilet, bathroom/shower and kitchen/scullery. When fully operational it is envisaged that 3 000 to 4 000 people will be catered for. Bowling greens, tennis courts etc. are to be provided. Although presently using septic tanks, a sewage treatment plant is envisaged, the effluent from which is to flow into the lagoon at a rate of 454 m³ per day ([157]).

On the northern bank of the lagoon is the sparsely populated residential area of Bazley.

Local authority. The Development Services Board of Ifafa Beach, Ifafa Lagoon, Darlington and Bazley are all involved in control of the lagoon.

Estuary uses. The Fafa lagoon is one of the prime resort areas on the south coast of Natal. The lagoon is ideal for water skiing, being obstruction free, sufficiently deep and protected from the wind. It is considered as the finest skiing water on the Natal coast. Boating on the lagoon is also a popular pastime.

Morphometry of lagoon (see Fig. **81**)

Area. The lagoon encompasses between 27,8 ha (pers. est.) and 32,4 ha ([157]) if station 8 (see Fig. **81**) is accepted as the upper limits of the lagoon.

Axial length. 2,85 km ([157]) to 3 km ([22]).

Shoreline length. 6,5 km

Width.

Maximum: The maximum width of the lagoon is almost 300 m. Other estimates made, range from 200 m ([157]) to 600 m ([257]).

Mouth: The mouth of the lagoon is obstructed by a weir.

Floodplain: Being confined in a steep-sided valley there is no floodplain as such.

Shape. S shaped and uninterrupted by islands.

Bathymetry. With the sandbar intact, the mean depth of the lagoon is 1,6 m ([22]), and 1,3 m if the sandbar is breached.

In places the lagoon is 3 m deep, when 15 cm of water is spilling over the weir ([157]). Transverse depth profiles at each station are available ([157]). The bottom profile is fairly constant and the banks shelve steeply.

Volume. The approximate volume of the lagoon is 480 000 m³ ([157]), but is extremely variable ([22]).

Geomorphology

Geology. The Fafa river traverses Table Mountain Sandstone, Dwyka formations and rocks of the Basement complex during the course of its passage to the sea ([245]); although Hemens *et al* ([157]) consider the river flows "over Archaean granites for most of its course". According to the Department of Geological Survey, the lagoon is completely surrounded by Dwyka tillite (du Preez, pers. comm.).

The northern bank of the lagoon is very steep and at one spot forms an almost vertical cliff 80 m high. Near the mouth of the lagoon, the banks are much less steep.

Nature of bottom materials. The bottom material of the Fafa lagoon is said to consist largely of undifferentiated river sand and gravel ([257]) with no more than 17,4% fine silt present ([157]). It contrasts in this respect with other estuaries such as Richards Bay, where pre-development, 95% of the bottom was composed of fine silt. The flocculation of fine silt and clays carried by the river water, would not occur in the Fafa lagoon because of the lack of mixing with the sea. It is not surprising therefore that the bottom materials are deficient in organic matter and characterized by low nitrogen and phosphorus values.

Sandbar characteristics ([22, 85, 157]). The sandbar at the mouth of the Fafa lagoon is 400 m long and south extending. The extent and height of the sandbar varies throughout the year. It is normally 1 m to 1,5 m high, but may become raised by the sea to 3 m and completely bury the weir. The stability of the lagoon is normally dependent on the sandbar, although an artificial weir on the southern side of the sandbar acts as the mouth of the lagoon. It is only very rarely that there is real contact between the lagoon and the sea. There are three possible ways in which the sandbar may

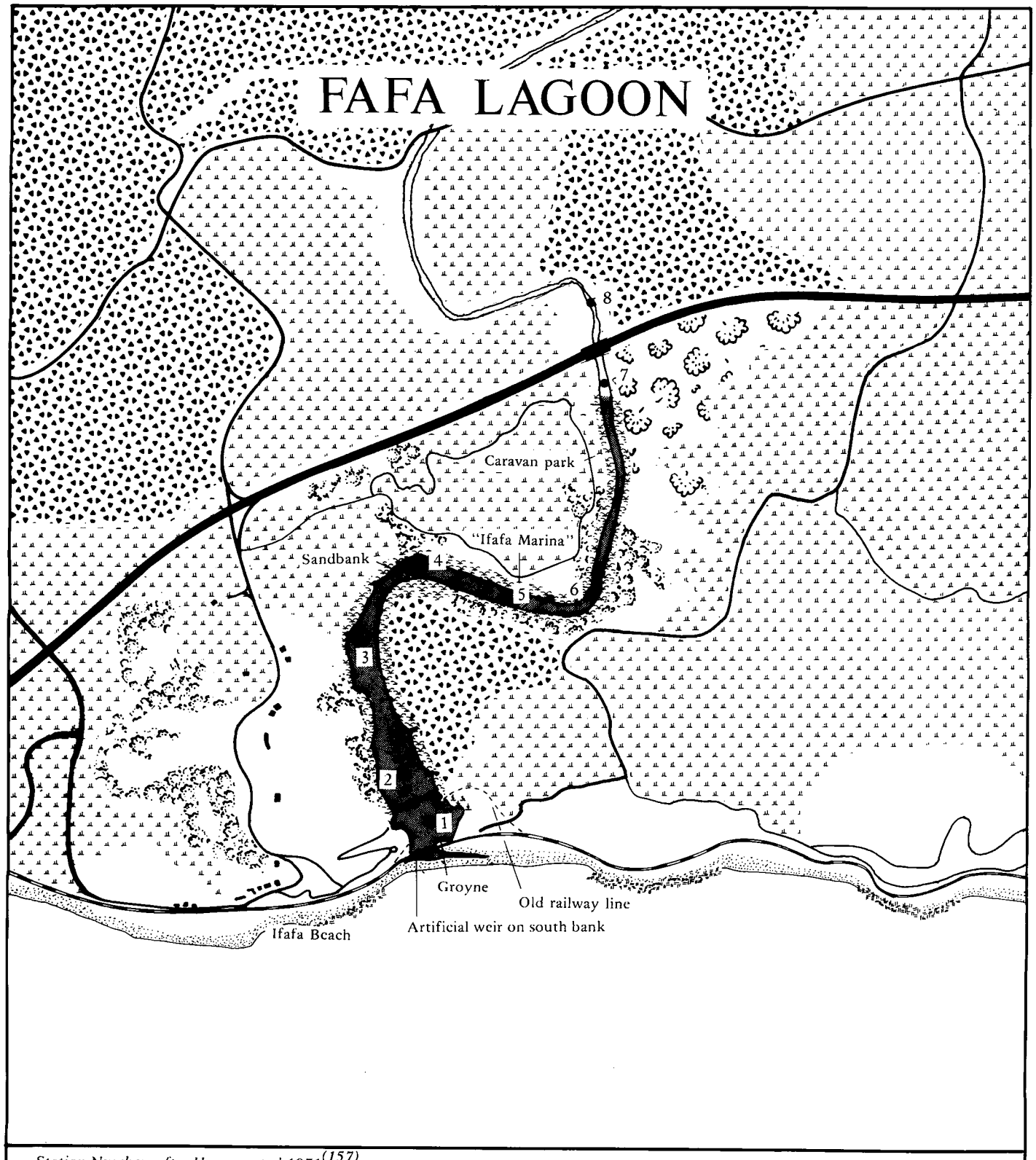

FAFA LAGOON
8
7
Caravan park
"Ifafa Marina"
Sandbank
4
5
6
3
2
1
Groyne
Old railway line
Artificial weir on south bank
Ifafa Beach
Station Numbers after Hemens et al 1971(157)
Coastal Dune Forest
Exotic Plantations
Transitional Forest
Barringtonia
Cane
Reed Swamp
500
0
500
1000
1500
2000 metres

Fig. 81

be breached ([22]). It may be opened by floods, by wave action (or high seas) or artificially by man for flushing purposes. In the latter case, a breach is made north of the weir position. Breaching has important implications should the lagoon quality deteriorate (i.e. become eutrophic) in the future.

Configuration of adjacent shore. ([132])
Beach type — bight, suitable (with reservations) for bathing.

Average beach slope — 8°
Average beach width — 61 m
Average sand grain size — 790 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents in the vicinity of the lagoon are present.

Physico chemical characteristics (see Table **74**).

Thermal properties. Breaching of the bar causes a lowering of lagoon temperatures as river water flowing into the lagoon becomes more prominent. River temperatures can range from 14,2°C in winter (July 1972) ([23]) to 29°C in summer (February 1970) ([204]).

Water transparency. Judging from the various surveys made in the lagoon over the period 1971 to 1974 ([22, 23, 24]) Secchi values range from 0,10 m to 1,85 m.

Salinity. The Fafa lagoon generally has characteristics very similar to river water even if river flow is minimal ([22]). Although the conductivity of the water increases towards the mouth, the salinity is generally less than 1‰ throughout the lagoon, and stratification does not normally occur. Surface salinities on 20 January 1975, ranged from 0,05‰ to 5,05‰. However, with the sandbar breached (as in June 1971) salinity stratification in the lower reaches of the lagoon became evident. For example salinities at Station 3 were 2,4‰ at the surface and 12,8‰ at the bottom. With the bar breached in 1972, sea water in the lagoon (with a salinity of 20‰) was overlain by water with a salinity of 4‰ ([23]). Salinities of 6,7‰ (on 18 April 1972) at the mouth of the lagoon with the bar **closed**, could be indicative of percolation through the sandbar ([157]). Less explicable is the fact that on 14 December 1970 salinities were 0,19‰ throughout, but 2‰ — 3,5‰ at the extreme head of the lagoon.

Nutrients. The Fafa lagoon is basically an oligotrophic system, well oxygenated and low in nutrients (average phosphorus = 0,07 milligrams/litre; average nitrogen = 0,6 milligrams/litre). The amounts of oxygen in the water tend to become lowered when temperature or salinity increases in the lagoon. In 1972 oxygen saturation dropped to 49,3% in a wedge of saline water at the bottom of the lagoon ([23]). At one stage no wastes were considered to reach the lagoon, with the net result that the water in the Fafa lagoon was of good quality. Much concern has thus been expressed about the establishment of the Ifafa Marina (see under land ownership/use).

Public health aspects

Bacteriology. From the bacteriological information available on the Fafa river ([206]) and the lagoon ([22, 157]) it would appear that the river water is faecally contaminated before it enters the lagoon (see Table **75**).

With the lagoon being used for water skiing, such characteristics are undesirable. Additional sources of faecal pollution are anticipated — these being a treated sewage effluent from the Ifafa Marina, and from septic tanks alongside the lagoon. Such additions would naturally result in nutrient enrichment and the increased likelihood of algal blooms.

Bilharzia. Although none of the vector snails of bilharzia have been found in the lagoon, Hemens *et al* acknowledge that at the time of sampling, floodwaters may have caused snails to have retreated from the main current flow ([157]). By the same token, floodwaters often dislodge snails upstream and carry them into the lagoon. In many respects, the lagoon is an ideal environment for such snails. It is impounded, fresh in its characteristics, and likely to become enriched by sewage. The question of bilharzia in the Fafa lagoon (and thus the risk of infection) should be re-examined because of the degree of human contact with the water.

BIOTIC CHARACTERISTICS

Flora

Terrestrial. A mangal community comprising *Barringtonia racemosa* and *Hibiscus tiliaceus*, occurs as a fringe, 2 m to 40 m wide, along the edge of the lagoon. Behind this the hill-slopes

Table 74. Physico-chemical characteristics.

FAFA LAGOON	SPECIFIC VALUES		RANGE IN VALUES						
	(206) At Nil Desperandum Bridge 10km above lagoon		(157)	(22)	(23)	(24)			
	1970		1970	1971	1972	1973	1974		1975
	February	August	December	December	April - July	December	April	October	January
Hydrogen ion concentration (pH)	8.62	7.41	7.3-7.7	6.8-8.05	6.4-7.7		7.7-7.8	8.1	
Saturated pH value	8.91	8.58							
Conductivity micromhos/cm	2 34	311	240-350	200-1000 (very rarely 5 000)		229-3670	236-2720	293-3270	250-8600
Total dissolved solids mg/l (calc.)	130	154				153-2447	157-1817		167-5733
Suspended solids "						8-20	1.4-10.9		15-118
Dissolved oxygen mg/litre	9.7	9.5	6.91-8.17	6.02-9.05	5.4-9.7	8.0-9.2		6.9-8.0	
% Saturation	126	98	70-96	80-100	75-100	96-114		81-92	
Biological oxygen demand mg/litre (5 day)	0.8	Nil							
Oxygen absorbed mg/litre			6.1-7.6						
Ammonia mg/litre			.04-.07	.02-.08	.04-.15	.050-.065	.024-.046	.030-.088	.057-.086
Kjedahl nitrogen mg/litre	.80	.40	.42-.58	.05-.66	.10-.50	.222-.572	.396-.405	.160-310	.224-.405
Nitrites "			.01-.10						
Nitrates "	.21	.32	.85-.94	.28-1.13	.30-.53	.065-.107	.247-.431	.194-.454	.073-.194
Total nitrogen "						.305-.637	.643-.836	.395-.764	.297-.599
Phosphate "	0.29	0.07				.004-.005	.012-.020	.005	.003-.004
Total Phosphorus "			.012-.02	.01-.14	.01-0.1	.08-.11	.23-.30	.011	.003-.012
Total alkalinity "	39	62		30-68		46-59	56-59		
Total hardness "	51.8	62.2							
Calcium "	7.7	10.3							
Magnesium "	7.9	8.9							
Sodium "	22.8	38.0							
Potassium "	1.4	1.7							
Sulphate "	8.0	18.1							
Chloride "	40.9	55.5							
Silica "				5.4-7.1					
Fluoride "	0.32	0.24							
Free carbonic acid (in ppm CO_2)	0.2	4.7					2		
Total inorganic carbon mg/litre				8.05-22.67					
Temperature ^{o}C			22.9-24.8	16.2	25.0				
Colour hazen units			30-40						
Turbidity mg silica per litre				73	5.3				
Visibility %				16-100	20-100				

alongside the lagoon are well vegetated by indigenous trees and shrubs. On the hilltops are sugar cane lands and gum plantations.

Table 75. Bacteriology of the lower Fafa.

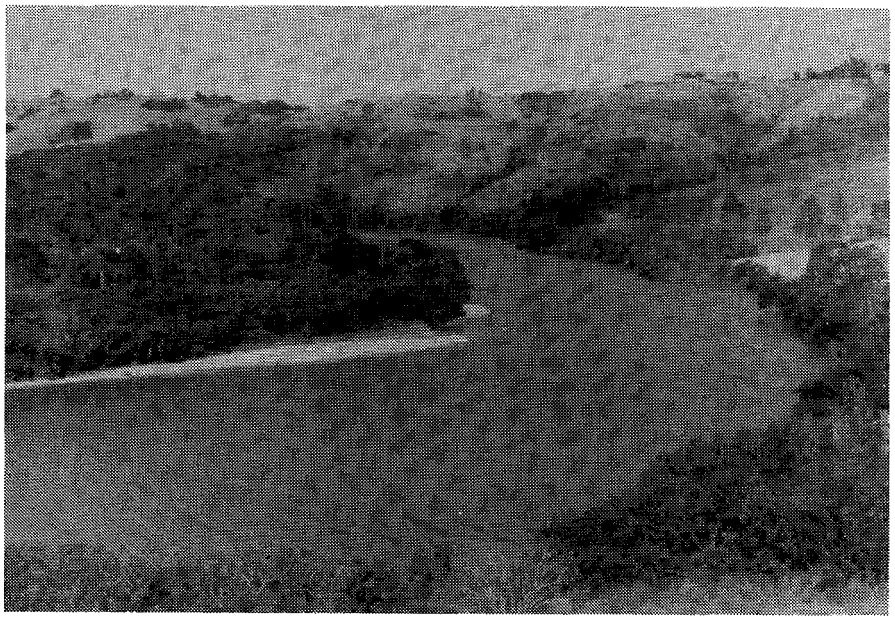
	Date	Total Plate Count per ml x 10^3		*E. coli* I per 100 ml	*Salmonella* per 250 ml
		I 6 days @ 20°C.	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed	
In river 10 km above the lagoon (206)	March 1971				+
	July 1971			47	
	5 Feb 1972	7	**144**	282	
	23 Feb 1972	240	184	600	
	5 July 1972	960	112	126	
	16 Aug 1972	30	**1 160**		
	15 Jan 1973	**2 500**	1 280		
Range in lagoon (22)	14 Dec 1970		36—509		+ (@ station 1)
	27 Sept 1971		34—189		
	21 Oct 1971		71—149		+
	16 Nov 1971		5—1 360		+
	20 Dec 1971		0—640		+

+ and values in bold significant of disturbance.

Aquatic. In the early 1950's reference is made to *Potamogeton* (a rooted macrophyte) at the upper end of the lagoon ([110]).

There is considerable information on algae and primary production within the Fafa lagoon ([22, 23]). During the study period 12 August 1971 to 21 December 1971, the maximum number of algae/ml of water were only 37. The low chlorophyll "a" concentration (average 1,9 milligrams/m^3; range 0,2 milligrams/m^3 to 4,1 milligrams/m^3) placed the lagoon in an oligotrophic range. On 29 April 1974, chlorophyll "a" concentrations in the lagoon ranged from 2 milligrams/m^3 to 2,3 milligrams/m^3 ([24]). Primary production was low in winter, and increased at the onset of summer, especially in the lower reaches of the lagoon. In terms of carbon assimilation, the maximum rate of uptake was shown to be 29,9 milligrams carbon/m^3/hour (using the oxygen uptake method) or 6,5 milligrams carbon/m^3/hour (using the carbon 14 method).

During the period 18 April 1972 to 21 July 1972, algal counts increased to 300—726 algal cells/ml, although such numbers still do not constitute a bloom. Amongst the species present were 10 genera of green algae (Chlorophyta) 16 diatom genera (Chrysophyta) and only three blue green genera (Cyanophyta). The absence of Cyanophytes is noteworthy, as is the high species diversity, because these accentuate the oligotrophic characteristics of the system. Dominant genera (comprising 50% — 70% of the community) were the diatoms *Navicula* and *Nitzchia*. The small range in the amounts of silica in the water (see Table **74**) ensure that diatom blooms do not occur.



A view of the Fafa lagoon (on 24 May 1977) from which the well preserved mangal fringe at the water's edge can be seen.

Fauna

Low uniform salinites in the Fafa lagoon limit the range of ecological niches available. The coarse, nutrient poor bottom materials also limit productivity.

Lower trophic levels.

Zooplankton: On 20 January 1975, the zooplankton community of the Fafa lagoon was shown to be completely dominated by *Acartia natalensis* ([252]). In all, 18 taxa were present. The maximum numbers were 65 000 per 50 m haul of a sled net (excluding fish eggs and larvae). These represented a settled volume of 7,7 ml, and a moderately rich community.

Benthos: In 1970 the benthos of the Fafa lagoon comprised 24 species ([157]). Those listed as abundant were *Ceratonereis hircinicola* (a polychaete); *Thiara* (a gastropod) *Corophium* (an amphipod), nematodes and Chironomids. In many respects these results were surprisingly similar to those attained by Day in the early 1950's ([110]). However, where amphipods and isopods (beneath stones) such as *Chiltonia*, *Parochestia*, *Melita* and *Grandidirella*, were listed as present by Day, these animals did not feature in the 1970 survey by Hemens *et al* ([157]).

Marginal vegetation: 17 species (primarily insects) were recorded in this niche in 1970 ([157]).

Higher trophic levels.

Fish: From gill netting and seine netting in 1970, nine species of fish tolerant of low salinities were shown to be present. ([157])

	Average size (cms)
Liza macrolepis (mullet)	18—25
Ambassis commersoni (glassy)	11,5
Caranx stellatus (kingfish)	25
Gerres rappi (evenfin pursemouth)	22
Glossogobius giurus (goby)	4—6
Monodactylus falciformis (moony)	3
Pomadasys operculare (spotted grunter)	13
Rhabdosargus tricuspidens (silver bream)	12
Sarotherodon mossambicus (mud bream)	3—6

Angling in the Fafa lagoon is however regarded as an unrewarding pastime.

Bird and mammal life: Both are associated with the vegetated slopes alongside the Fafa lagoon, and are reported to be prolific ([157, 208]).

In terms of estuarine dependent species of birds (*sensu stricto*) the Fafa lagoon is poorly endowed (Nicholls, pers. comm.).

SYNTHESIS

When compared to other lagoons on the south coast of Natal, our general state of knowledge of the Fafa lagoon is highly satisfactory. The understanding achieved during the years 1970 to 1972 will serve as a very useful background against which any detectable changes can be assessed in the future. A good knowledge of the Fafa lagoon only developed once the Ifafa Marina project was proposed. As this project is still being developed and as no work has been done since 1975 in the Fafa lagoon, it is time that further surveys were conducted. This is because our understanding of a lagoon system such as the Fafa, should not be allowed to lapse.

In its present day environmental condition the Fafa lagoon is of considerable resource value, from both a botanical and recreational point of view. The whole lagoon has an unspoilt, very pleasing appearance. Every effort should be made to ensure that this characteristic is not altered by "cultural eutrophication" — or the process of nutrient enrichment. Eutrophication of recreational waters (or deterioration of water quality) is aesthetically distasteful, and generally impairs water use. It has been estimated that if sewage enters the lagoon at a rate of 454 m^3 per day, in terms of nutrient addition this represents 2 050 kg of nitrogen and 820 kg of phosphorus over 6 months ([157]).

From an estuarine point of view, weir construction at the mouth of the Fafa lagoon has created several unfavourable effects. The penetration of sea water, tidal effects, and the degree of contact with the sea have all been restricted. Its value as an estuarine resource is therefore significantly reduced. Because the lagoon is dominated by river water, it maintains a flora and fauna which are themselves more normally associated with fresh water.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora			Fauna							Food Webs
FAFA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids			-									★			★							★		◄——★——►								
Source of Information	Summary of available information																																
Day	1950	110		●			●																	●			●	●					
Midgley & Pitman	1969	223	●																														
Kemp *et al*	1970	204	●					●				○			○										○	○							
Hemens *et al*	1970	157	●	●	●		●	●		●	●				●					●		●		●	●	●	●	●	●				
Kemp *et al*	1970 to 1972	206	●		●							○			○										○	○							
Fromme	1970 to 1975	132								●																							
Ninham Shand & Partners	1971	245	●					●																									
Loxton, Hunting & Assoc.	1971	213	●																○														
Orme	1971	257	●	●						●																							
Archibald	1971	22		●	●	●	●				●				●				●			●										
Archibald	1972	23									●	●										●											
Archibald	1973 to 1975	24				●	●				●	●										●											
NTRPC	1974	236								○																							
Cloete & Oliff	1976	85	Review of NIWR contribution																														
Oliff *et al*	1977	252				●																		●									
du Preez	1977	pers. comm.						●																									
Hopwood	1978	189						●															●										
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	291		●																			●										
1:25 000 Job No. 262	1976	478		●																			●										

Synonyms
Uvuzi

Zulu meaning
No record.

Location
30°28'15"S; 30°38'45"E.

Accessibility
The Mvuzi lagoon is 87 km south west of Durban. Although the road into Ifafa Beach sweeps past the lagoon, immediately above it, there is no direct access down to the Mvuzi lagoon.

Bridges
The railway line crosses the lagoon at its mouth. The remains of the old railway bridge are evident 200 m from the mouth. The freeway and interchange serving Ifafa Beach and Elysium have greatly altered the path of the river above the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 8 km^2

River length. 6,5 km

Mean annual run-off. No record.

Flow. No record.

Flood history. No record.

Dams.
Existing: None.
Proposed: None.

Siltation. No record.

Land ownership/use. The Mvuzi catchment is entirely influenced by sugar cane lands of the Sezela Estates (C. G. Smith Sugar Ltd). Although the land in the immediate vicinity of the lagoon is undeveloped, to the north is Ifafa Beach, whilst to the south is Elysium. The development of a resort complex on the hillside immediately north of the Mvuzi lagoon has been proposed (NTRPC, pers. comm.).

Local authority. Elysium.

Estuary uses. None.

Morphometry of lagoon (see Fig. **82**)
Area. 0,8 ha

Axial length. 0,70 km

Shoreline length. 1,5 km

Width.
Maximum: 30 m
Mouth: No record.
Floodplain: 120 m

Bathymetry. No record.

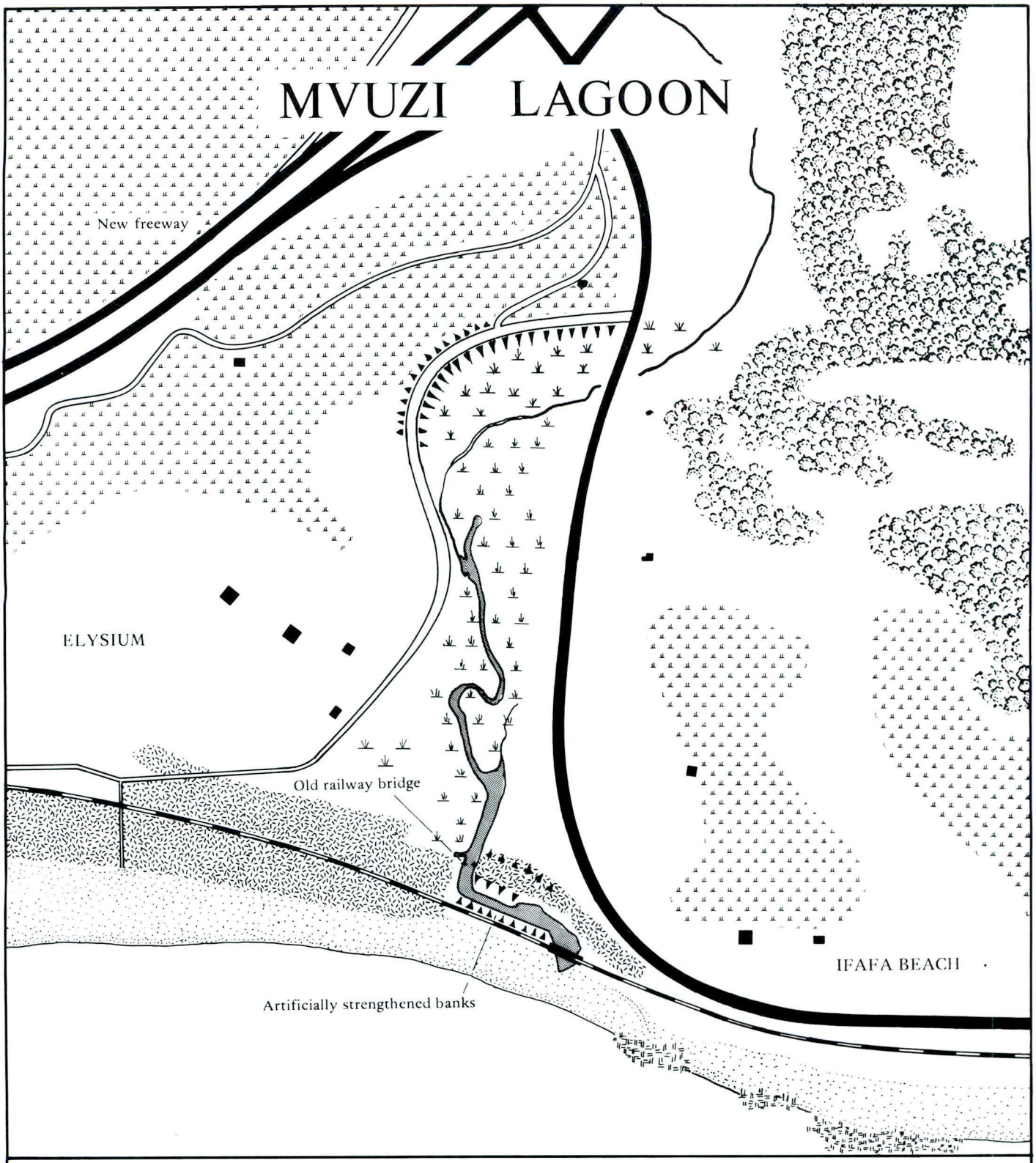

MVUZI LAGOON
New freeway
ELYSIUM
Old railway bridge
Artificially strengthened banks
IFAFA BEACH
Coastal Dune Forest
Coastal Dune Pioneer
Reed Swamp
Cane
100 0 100 200 300 400 500 600 700 800 metres

Fig. 82

Geomorphology

Geology. Both the catchment of the Mvuzi river and the Mvuzi lagoon itself are surrounded by Dwyka tillite (du Preez, pers. comm.).

Nature of bottom materials. No record.

Sandbar characteristics. The lower reaches of the Mvuzi lagoon are deflected northwards behind a sandbar on which the railway line now runs. The lack of rock protection south of the lagoon, means that the mouth is directly exposed to the prevailing swell. The mouth position is fixed, having become semi-canalized by the railway bridge. On the landward edge of the sandbar artificial reinforcement has been necessary. Contact with the sea is presumably a very infrequent event.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics. No record.

Public health aspects

Bacteriology. No record.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

The only plant community of any value remaining in the vicinity of the Mvuzi lagoon is some 6 ha of wetland and reed swamps which surround it. Swamps of this nature are particularly well developed in the upper reaches.

Fauna

There is no information available on the fauna of the Mvuzi lagoon.

SYNTHESIS

In terms of our present state of knowledge, virtually nothing is known about the Mvuzi lagoon. There also seems very little justification in trying to rectify this situation. The lagoon has been modified at its mouth by the process of railway construction, whilst the river above the lagoon has been much modified by the process of freeway construction. The only component of any potential resource value is the extensive swamp community surrounding the lagoon.

| ESTUARY/LAGOON | | |

2.1.11.3 **MTWALUME**

Synonyms
Umtwalumi.

Zulu meaning
The name is derived from the words uMtwalo ume, which means "carry me". It refers to a person who, when crossing the river, was suddenly swept away in a flood (Thorpe, pers. comm.).

Location
30°29'S; 30°38'E.

Accessibility
The Mtwalume lagoon is 91 km south west of Durban and 36 km north of Port Shepstone. Only since the construction of the south coast freeway, has the lagoon become crossed by the national road. There is a railway track for transporting sugar cane along the southern bank, and a road alongside the northern bank.



The lower reaches of the Mtwalume lagoon have been considerably changed since construction of the present railway bridge.

Bridges
The Mtwalume lagoon is crossed by the railway and the freeway 230 m and 500 m from the mouth respectively. Upstream of the freeway are the remains of the old railway bridge. The latter was moved to its present position in the 1940's. It is clear from early photographs taken in the 1930's, that since this event took place, significant losses in water area due to sedimentation have occurred.

ABIOTIC CHARACTERISTICS
Catchment characteristics

Area. 505 km^2 ([213]); 569 km^2 ([223]); 580 km^2 ([206, 245, 257]).

River length. 85 km ([206, 245, 257]).

Mean annual run-off. 60 x 10^6 m^3 ([223]) to 76 x 10^6 m^3 ([213]).

Flow. A rough estimate of the average flow is 1,7 m^3/sec. ([206]).

Flood history. The highest flood levels recorded are 5 m above mean sea level ([257]). The railway bridge was washed away by floods in May 1959 ([220, 257]). From aerial photos, sand deposition above the lagoon is indicative of violent flood characteristics. It is significant to note that a flood in 1917 did not apparently impart any real change to the estuary from the point of view of siltation (Thorpe, pers. comm.).

Dams.
Existing: None.

Proposed: A dam site has been located 56 km above the lagoon at Forest Hills ([245]). If built the dam would have a total capacity of 33 x 10^6 m^3.

Siltation. Annual siltation at the Forest Hills dam site was estimated to be 0,14 x 10^6 m^3 ([245]). The expansion of sugar farming on a large scale in the late 1930's by the Reynolds Bros, (or Umtwalumi Valley Estates) resulted in severe siltation of the entire system. Since this event, each flood brings with it mud, silt, trees and debris. Deep pools which occurred above the old national road bridge, no longer exist today. In the 1930's a fairly large boat (capable of carrying 17 people) could be taken up to this point, and people used to dive off the old railway bridge into the estuary (Thorpe, pers. comm.). Descriptions such as these, indicate to what extent the estuary has been ruined by siltation.

Land ownership/use. 17% of the catchment area, (comprising the Umtwalumi Mission reserve and Location No.7) is Bantu influenced. Both these areas are destined to become incorporated into KwaZulu in the near future. The lower regions of the catchment are influenced principally by sugar estates.

Around the lagoon is the sparsely developed township of Elysium (to the north) and the holiday resort of Mtwalume (to the south). The latter comprises privately owned dwellings, holiday chalets and a caravan park. More holiday accommodation has been proposed, as well as a sewage works. The land along the banks of the river is zoned as an amenity reserve (NTRPC, pers. comm.).

Local authority. Mtwalume.

Estuary uses. In its present condition the Mtwalume lagoon is no longer put to any use. Water is pumped from the river above the lagoon to a reservoir which supplies the Mtwalume resort.

Morphometry of lagoon (see Fig. **83**)
Area. 24,8 ha

Axial length. 0,7 km (when open) — 1,7 km (when closed). Pre-1940, the Mtwalume estuary used to extend 4 km inland to a set of rapids, which occurred at the site of the old national road bridge (Thorpe, pers. comm.).

Shoreline length. ± 6 km, including the periphery of sand banks, mud flats and side channels.

Width.
Maximum: 400 m, although Orme ([257]) suggests that the Mtwalume is 600 m wide.
Mouth: 10 m to 15 m wide at normal low flow periods; 50 m to 100 m wide during high flow periods.
Floodplain: 500 m

Bathymetry. Pre-1940, certain places within the estuary were 6 m deep. Seaward of the old railway bridge, depths were in excess of 2,5 m. One could not wade across the estuary even at low spring tide (Thorpe, pers. comm.). The present depths are not known but probably do not exceed 1,5 m.

Geomorphology
Geology. The Mtwalume river traverses granite, Table Mountain Sandstone and Dwyka conglomerates in its drainage basin (du Preez, pers. comm.), ([189, 245]). Bedrock lying below 27 m of sediments, is composed of Dwyka tillite and sandstone ([257]).

Nature of bottom materials. Boreholes 1 km inland from the sea have revealed interesting estuarine successions ([257]) (see Fig. **84**). The bedrock is overlain by typical basal sands and boulders, by a complex of silty sands and sands of fluvial origin. Occasional lenses of black silt (lagoonal sediments) occur. It is interesting to note that after the 1959 floods, the mouth moved into a northerly position and exposed a 2 m wide layer of large round river stones, which lay parallel to the beach at the low tide mark (Thorpe, pers. comm.). Although described as a sand choked river by Kemp *et al* ([206]), van Heerden ([316]) has pointed out that the Mtwalume is a valuable feeder of sand to adjacent beaches.

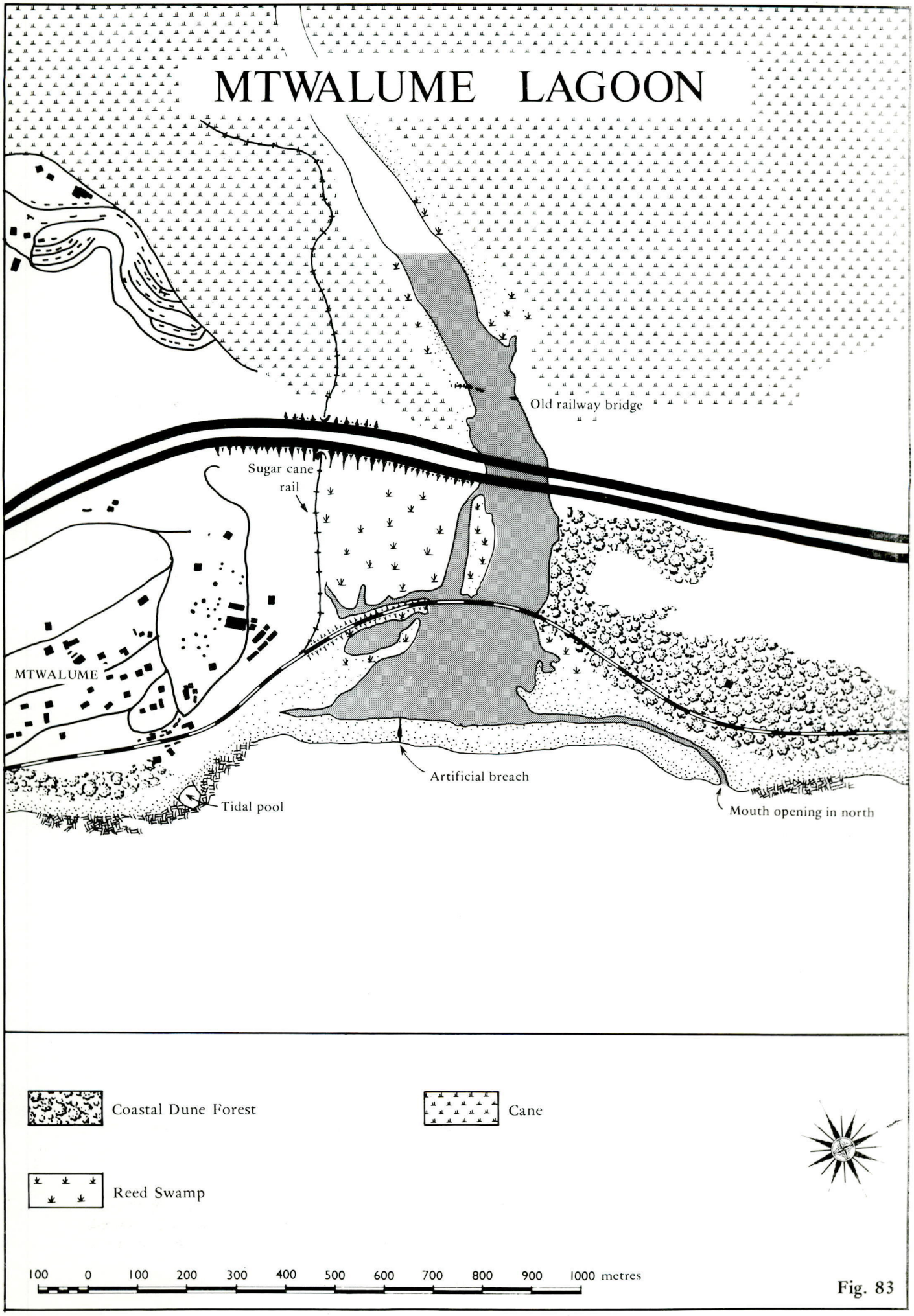

MTWALUME LAGOON
Old railway bridge
Sugar cane rail
MTWALUME
Artificial breach
Tidal pool
Mouth opening in north
Coastal Dune Forest
Cane
Reed Swamp
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 83

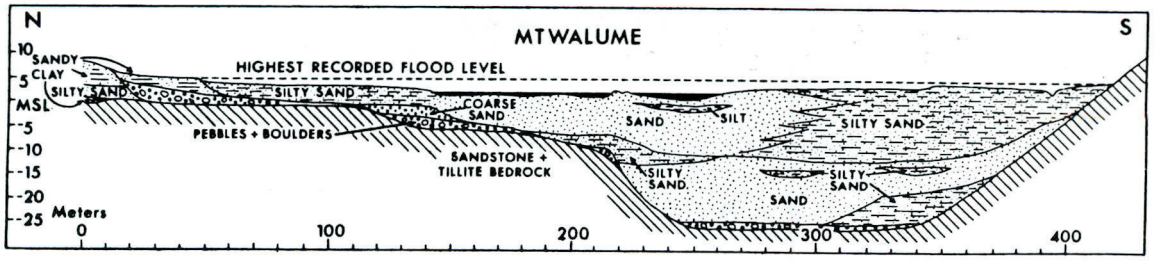


Fig. 84. Cross section through the Mtwalume lagoon after Orme ([257]).

Sandbar characteristics. The Mtwalume sandbar can be almost 1 000 m long, and, in June 1976, was deflected north. Van Heerden ([316]) compares the north directed spit growth of the Mtwalume to that of Mkomazi, and considers the two to be similar, in that offshore sediments (of fluvial origin) are necessary in both cases. The National Research Institute for Oceanology estimated on one occasion, that during a river breakout, 10 000 m^3 of sand became deposited in the surf zone ([238]). During flood periods, scour in the order of 3 m to 4 m below the average crest level of the beach, occurs several times a year.

According to Orme ([257]) the mouth of the Mtwalume is commonly closed by littoral drift. However, the mouth position alters very considerably as can be seen in Fig. **85**. During the period 12 June 1972 to 13 July 1974 migration of the mouth occurred over a distance of 560 m ([238]). In its original condition (pre-1940) the mouth of the estuary was always at the extreme southern corner of the system (Thorpe, pers. comm.). It is only since the estuary has become silted up and influenced by road and rail bridges, that the mouth has wandered about from one position to another.

A channel cut into the centre of the bar is evident from aerial photos (dated 12 June 1976) but whether the bar is commonly breached in this manner, has not been ascertained. However, even in the 1930's the lagoon used to be opened artificially by cane farmers, because of the flooding of their crops (Thorpe, pers. comm.).

Configuration of adjacent shore ([132]).
Beach type — bight, highly suitable for bathing.

Average beach slope — 5°
Average beach width — 82 m
Average sand grain size — 455 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Orme ([257]) considers the longshore (probably surf zone?) current to be north directed, with reversals occurring in summer. Pearce and Schumann ([261]) consider the nearshore current to be south directed. Rip currents in the near vicinity of the lagoon are absent.

Physico-chemical characteristics

Data from the lagoon itself is non-existent. With this being the case, the only data available relates to conditions in 1970 in the Mtwalume river, 12 km from the lagoon ([206]). This information is presented as Table **76**. At that particular time the water quality of the Mtwalume river was good.

Public health aspects

Bacteriology. There is no information available on this subject from the lagoon itself. The only data available which may give some idea as to expected conditions in the lagoon, is that from samples of river water taken 12 km above it in the early 1970's ([206]).
From these results (presented as Table **77**) sporadic faecal pollution and periods of organic enrichment were evident.

Bilharzia. On 28 February 1972 inspection of the lagoon by Jackson (pers. comm.) showed no bilharzia snails to be present. *Physopsis* was however located in the river above the lagoon.

BIOTIC CHARACTERISTICS

Flora

Sugar cane encroachment onto the banks of the river and the floodplain, has destroyed most of the vegetation in the vicinity of the Mtwalume lagoon. Only near the mouth on the northern bank of the lagoon, has a patch of coastal dune forest been retained, amongst which a few houses are

Fig 85. Migration in mouth positions — Mtwalume estuary.

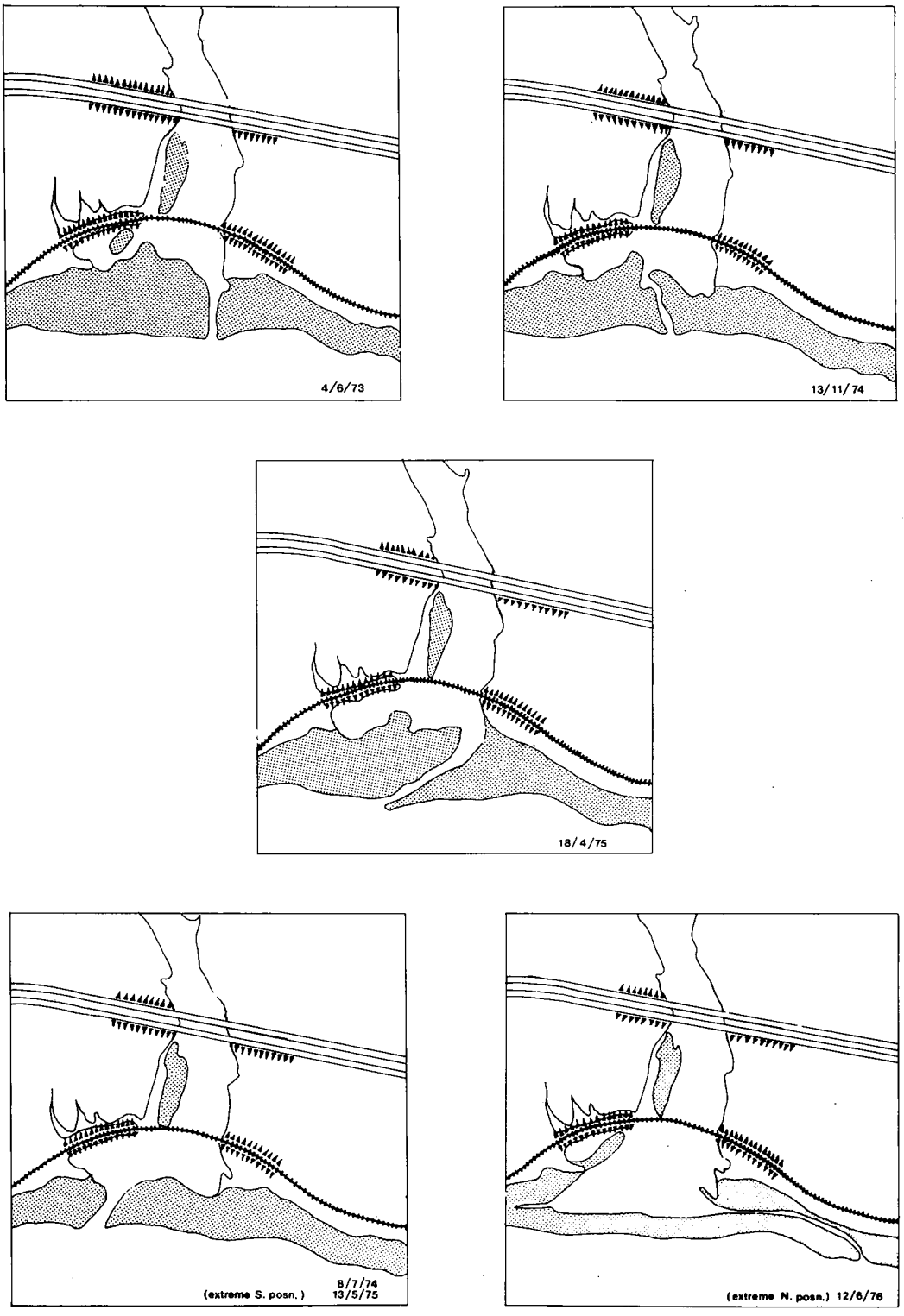


Table 76. Physico-chemical characteristics.

Locality: Mtwalume river Distance above lagoon: 12km	SUMMER Jan 1970	WINTER July 1970
Hydrogen ion concentration (pH)	7.7	7.7
Saturated pH value	9.1	8.9
Conductivity micromhos/cm	146	193
Total dissolved solids ppm (calcd.)	88	124
Dissolved oxygen mg/litre	7.8	9.6
% Saturation	104	100
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.4	2.7
Kjedahl nitrogen mg/litre	0.1	0.2
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.21	0.40
Phosphates "	.36	.10
Total alkalinity "	30.1	45.7
Total hardness "	37.1	39.8
Calcium "	5.6	7.3
Magnesium "	5.6	5.2
Sodium "	13.7	24.0
Potassium "	1.3	1.7
Sulphates "	3.8	10.0
Chlorides "	21.9	30.6
Silica "	-	-
Iron "	-	-
Fluorides "	0.3	0.2
Free carbonic acid (as ppm carbon dioxide)	1.3	1.8
Temperature °C	30.2	17.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	good	good
Odour	-	-

Values underlined significant of disturbance.

situated. On the southern side of the lagoon (between the railway bridge and the freeway) the mud flats are becoming colonized by halophilous herb communities.

Table 77. Bacteriology of the Mtwalume river (12 km above lagoon)

Date	Total Plate Count per ml x 10^3		*E. coli* I per 100 ml	*Salmonella* per 250 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient	Confirmed	
March 1971	—	—	54	
July 1971	—	—	98	+
5 Feb 1972	130	74	100	
23 Feb 1972	480	228	1 900	
4 July 1972	40	**640**		
1 Aug 1972	320	160	87	
16 Aug 1972	60	**920**		
15 Jan 1973	**1 200**	960		

+ and values in bold are significant of disturbance.

Fauna

Lower trophic levels.

Benthos: Pre-1940 Thorpe, (pers. comm.) describes the benthic fauna of the Mtwalume estuary as follows:- "Big jellyfish came up with the spring tides . . . and oysters and barnacles grew on all the rocks. The banks were rich in mud prawns (*Upogebia*) and nearer the sea where the banks become sandy there were white crackers (*Callianassa*) on both sides. Frequently swimming prawns including the black or tiger variety (*Penaeus monodon*) were common and seemed to come in vast shoals at Easter when we caught them with a cast net or hand net". Such descriptions adequately illustrate how conditions in the estuary have deteriorated, because in its present condition the Mtwalume lagoon is considered to be very poorly endowed in estuarine forms of life. According to Maurice, (pers. comm.) this is attributable to the scouring action of floods and the coarse fluvial sand which comprises the floor of the lagoon.

Data on some of the animal communities in the river, 12 km above the lagoon is available after a survey done in 1972 ([206]). Indices such as species diversity and the number of animals present, were indicative of good water quality.

Higher trophic levels.

Birds: Although kingfishers, cormorants and fish eagles used to be common 30 to 40 years ago (Thorpe, pers. comm.) a survey of the bird life utilizing the lagoon in January 1977, revealed only 4 species of estuarine dependent birds (Nicholls, pers. comm.). These are various species of terns which roost on the sandbar.

Fish: Thorpe (pers. comm.) has records of fish taken by angling in the estuary in the 1930's. At that time species such as brindle bass, honeycomb rays, blacktail and shad could be caught, which is a virtually unheard of situation in Natal today. "Mullet also came into the estuary in such shoals

that we used to jig them with a single hook and trout rod from the bridge". In addition to these he lists the following species as once being present:-

Springer	River bream (both varieties)
Kob	Mullet (four varieties)
Grunter	Flathead
Cock grunter	Goby
Silver grunter	Glassy
White steenbras	Rock cod
Kingfish	Slimy
Ox-eye tarpon	Mud bream
River snapper	Eels
Spot snapper	Pipefish
Tigerfish	Lesser sandy
Kitefish	Striped goatfish
Stumpnose	Long finned pompano

SYNTHESIS

Our present state of knowledge of the Mtwalume lagoon is poor. However, as one of the larger systems on the south coast of Natal, a series of surveys should be undertaken to improve our understanding of the Mtwalume lagoon. These will lead to a more precise understanding of the degree to which the lagoon has deteriorated in the past 40 years.

Having been transformed from a very fine estuary, into a lagoon of dubious resource value, it is more important that the implications of large scale sugar farming be realised. There is very little doubt that deterioration of the estuary commenced as soon as sugar farming became practised on a large scale in the catchment area. This led to the generation of silt, and it is the latter that has ruined the Mtwalume estuary. The consequences of bridge construction are also one of the most obvious of the various man-made impacts apparent in the lagoon.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other							Flora			Fauna								
MTWALUME ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	Food Webs
Data Voids																									◄	★	►						
Source of Information	Summary of available information																																	
Meinecke	1959	220			●																												
Midgley & Pitman	1969	223	●		●																												
Kemp *et al*	1970 to 1972	206	●		●					○	○				○										○	○							
Fromme	1970 to 1975	132								●																							
Ninham Shand & Partners	1971	245	●					●		●																							
Loxton, Hunting & Assoc.	1971	213	●		●																												
Orme	1971	257	●	●	●			●		●																							
NRIO	1972 to 1974	238		●						●																							
van Heerden	1976	316								●																							
du Preez	1977	pers. comm.						●																									
Nicholls	1977	pers. comm.																									●						
Thorpe	1978	pers. comm.		●	●					●											●				●	●	●	●	●	●			
Hopwood	1978	189								●													○										
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	295		●						●													●										
1:25 000 Job No. 262	1976	475	●																														

Synonyms
Unamfu

Zulu meaning
No record.

Location
30°30'30"S; 30°37'30"E.

Accessibility
By road, the Mnamfu lagoon lies 94 km south west of Durban. No provision has been made for vehicular access to the edge of the lagoon.

Bridges
The Mnamfu lagoon has only recently been straddled by the twin bridges of a double carriageway 300 m from the mouth. In addition there is a railway bridge across the mouth and the remains of the old railway bridge 150 m from the mouth.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 15 km^2

River length. 9 km

Mean annual run-off. No record.

Flow. No record.

Flood history. No record.

Dams.
Existing. None.
Proposed: None.

Siltation. No record.

Land ownership/use. 80% of the catchment (comprising Location No.3) is Bantu influenced and destined to become incorporated into KwaZulu.
Being surrounded by a Bantu reserve, both banks of the lagoon are undeveloped.

Local authority. Temporarily under the control of the Department of Bantu Administration.

Estuary uses. No record.

Morphometry of lagoon (see Fig. **86**).
Area. 1,26 ha

Axial length. 500 m

Shoreline length. 1 km

Width.
Maximum: 60 m
Mouth: No record.
Floodplain: 120 m

Shape. There is an interesting similarity in shape between the Mnamfu lagoon and the KwaMakosi lagoon, 4 km to the south.

Bathymetry. No record.

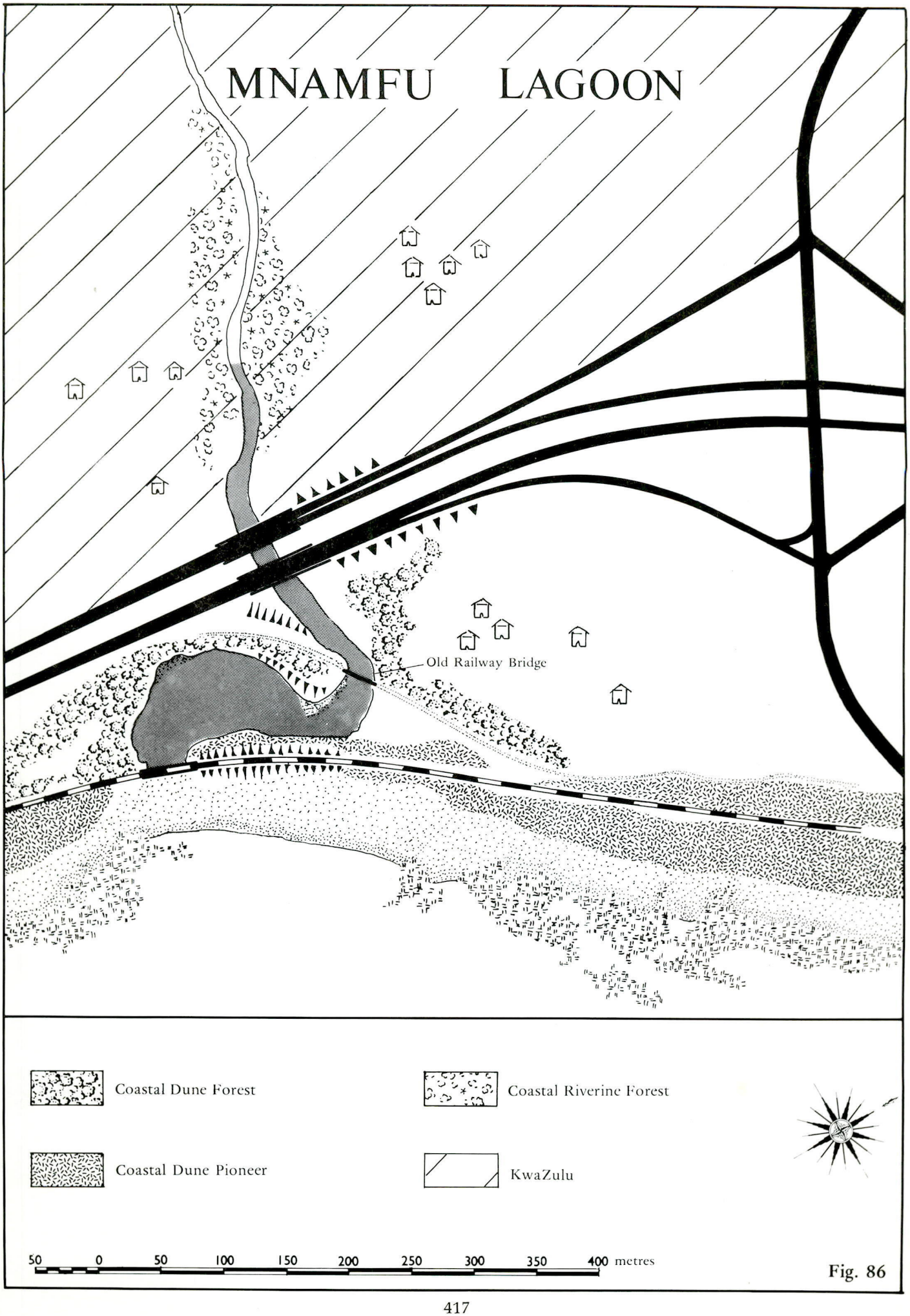

MNAMFU LAGOON
Old Railway Bridge
Coastal Dune Forest
Coastal Riverine Forest
Coastal Dune Pioneer
KwaZulu
50 0 50 100 150 200 250 300 350 400 metres

Fig. 86

Geomorphology

Geology. Table Mountain Sandstone formations surround the lagoon ([236]). Bedrock is at a relatively shallow depth ([257]).

Nature of bottom materials. The bottom materials comprise lagoonal and fluvial debris with lenses of marine washover sands near the mouth ([257]).

Sandbar characteristics. The lagoon lies behind a south extending sandbar, on which the railway line is built. The mouth is protected to the south by a rocky headland which protrudes from the coast. Lagoon levels are presumably permitted to fluctuate naturally.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics. No record.

Public health aspects

Bacteriology. No record. The proximity of Bantu dwellings alongside the river could mean that the lagoon is faecally polluted periodically.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

There is a luxuriant fringe of *Hibiscus tiliaceus* on the edge of both banks of the lagoon. Otherwise it is poorly endowed from a botanical point of view. Impacts on the vegetation which surrounded the lagoon seem to be attributable to African cultivation and modifications associated with railway and freeway construction.

Fauna. No record.

SYNTHESIS

Very little is known about the Mnamfu lagoon. There also seems to be no reason why it should (at this stage) be given any attention. Although in a fair environmental condition, the actual resource value of the Mnamfu lagoon is probably negligible. Impacts associated with road and rail construction are apparent.

| | | |

2.1.11.5

KWA-MAKOSI AND MFAZAZANA

Introduction

Lying only 600 m apart, information on the Kwa-Makosi and Mfazazana lagoons can be conveniently reviewed simultaneously as both have very similar characteristics.

Synonyms

Kwa-Makosi. On occasions the Kwa-Makosi is referred to simply as the Makosi.

Mfazazana. Variations in spelling of the name Mfazazana are Mfazazaan, Umfazaan, Umfazazane and Umfazaazan ([132]).

Zulu meaning ([289])

uMakhosi is said to mean "the river of the chief". According to Stayt the meaning of Mfazazana is "the river of the contemptible woman". It is a derogatory name given to the river because of a woman who was washing in its waters on one occasion, when labour pains overcame her and, contrary to social customs, she gave birth to her child on the banks of the river.

Location

Kwa-Makosi — 30°31'30"S; 30°36'30"E.
Mfazazana — 30°31'45"S; 30°36'30"E.

Accessibility

Kwa-Makosi — 97 km south west of Durban.
Mfazazana — 98 km south west of Durban.
In each case there is no vehicular access down to the water's edge.

Bridges

In each case there is a railway bridge across the mouth, the remains of the old railway bridge in the lagoon, and at the head of the lagoon the bridges of the recently constructed freeway. In the case of the Kwa-Makosi, embankments of both the freeway and the old railway line have encroached upon surrounding wetlands. The existing railway line has been built upon the sandbar itself.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area.
Kwa-Makosi. 10 km^2 ([245]) to 16 km^2
Mfazazana. 15 km^2

River length.
Kwa-Makosi. 7 km ([245]) to 9 km.
Mfazazana. 10,5 km

Mean annual run-off.
Kwa-Makosi. 1,5 x 10^6 m^3 ([245]).
Mfazazana. No record.

Flow. No record for either lagoon.

Flood history. No record for either lagoon.

Dams. In both cases no dams exist, nor have any been proposed.

Siltation. No record for either lagoon.

Land ownership/use. In both cases the catchment and surrounds of the lagoons in question are entirely Bantu influenced (comprising Location No.3), and destined to become incorporated into KwaZulu in the near future. Sugar cane (in this case grown by Africans) has been planted on the hillsides surrounding both lagoons.

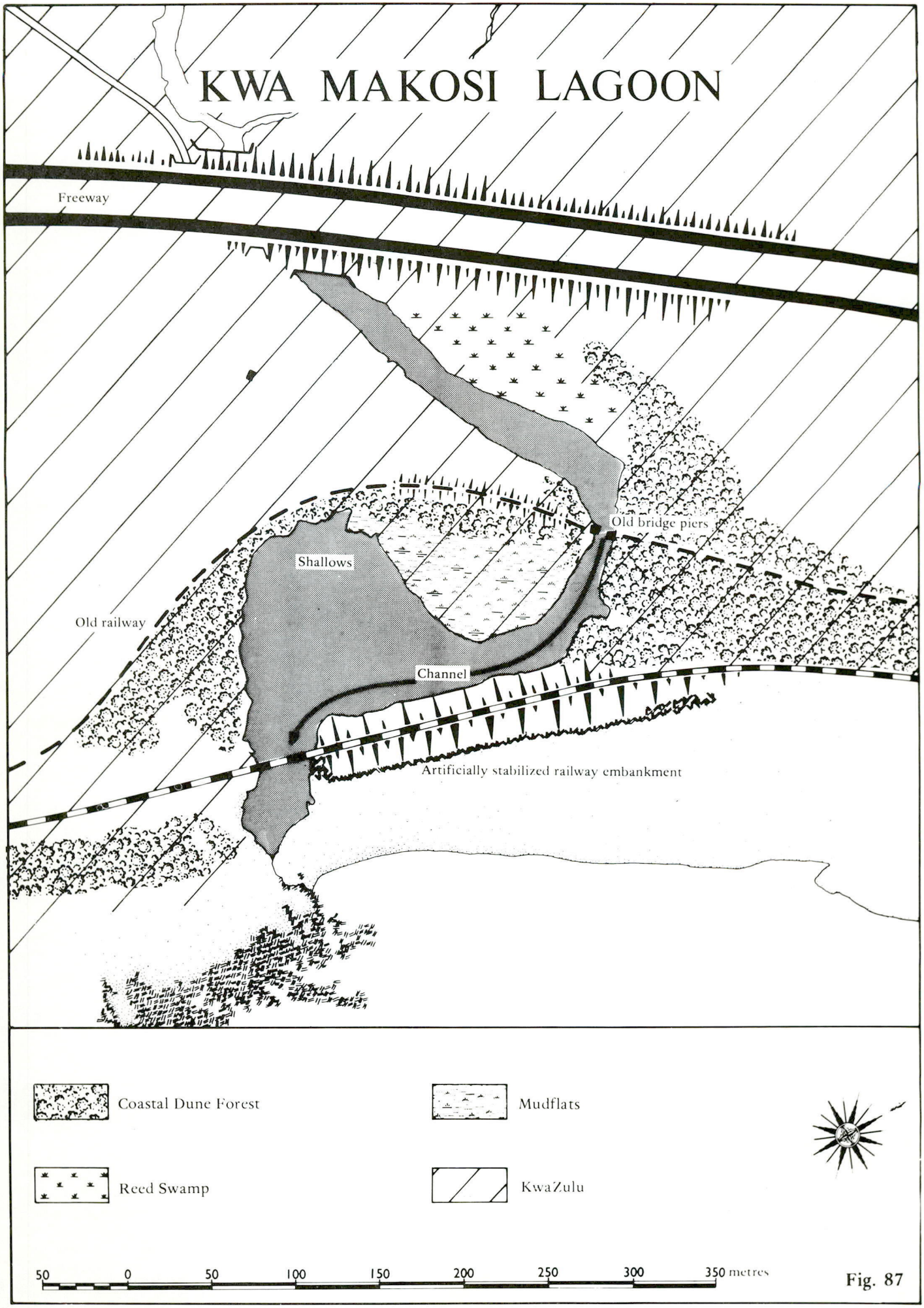

KWA MAKOSI LAGOON
Freeway
Old bridge piers
Shallows
Old railway
Channel
Artificially stabilized railway embankment
Coastal Dune Forest
Mudflats
Reed Swamp
KwaZulu
50 0 50 100 150 200 250 300 350 metres

Fig. 87

Local authority. In both cases under the temporary control of the Department of Bantu Administration.

Estuary uses. No record for either lagoon.

Morphometry of lagoon (see Fig. **87 & 88**).

Area.
Kwa-Makosi. 2,45 ha
Mfazazana 2,10 ha

Axial length.
Kwa-Makosi. 500 m
Mfazazana. 525 m

Shoreline length.
Kwa-Makosi 1,2 km
Mfazazana 1,3 km

Width.

Maximum:	**Kwa-Makosi** 110 m
	Mfazazana 100 m
Mouth:	**Kwa-Makosi** No record.
	Mfazazana ± 5 m during low flow periods.
Floodplain:	**Kwa-Makosi** 200 m
	Mfazazana 120 m

Bathymetry. No record for either lagoon.

Geomorphology

Geology. The catchment and surrounds of both lagoons are made up of Table Mountain Sandstone ([236, 245]). According to Orme bedrock below the Mfazazana lay buried by 4,6 m of sediment ([257]).

Nature of bottom materials.
Kwa-Makosi. No record.
Mfazazana. Bottom deposits comprise fluvial and lagoonal debris, with lenses of marine washover sand near the mouth ([257]).

Sandbar characteristics. The sandbars of both lagoons are south extending, and the mouths open on the southern end behind the protection of a rocky headland. In the case of the Kwa-Makosi, the sandbar has been stabilized and used as an embankment to carry the railway line.
It is presumed that the level of neither lagoon is artificially controlled.

Configuration of adjacent shore. ([132])
Kwa-Makosi.
Beach type — sheltered, asymmetrical

Average beach slope — 8°
Average beach width — 64 m
Average sand grain size — 874 microns
} indicative of rough surf zone conditions.

Mfazazana. No record.

Surf zone currents. Rip currents are present in the near vicinity of the Kwa-Makosi lagoon.

Physico-chemical characteristics.
No record for either lagoon.

Public health aspects
No record for either lagoon.

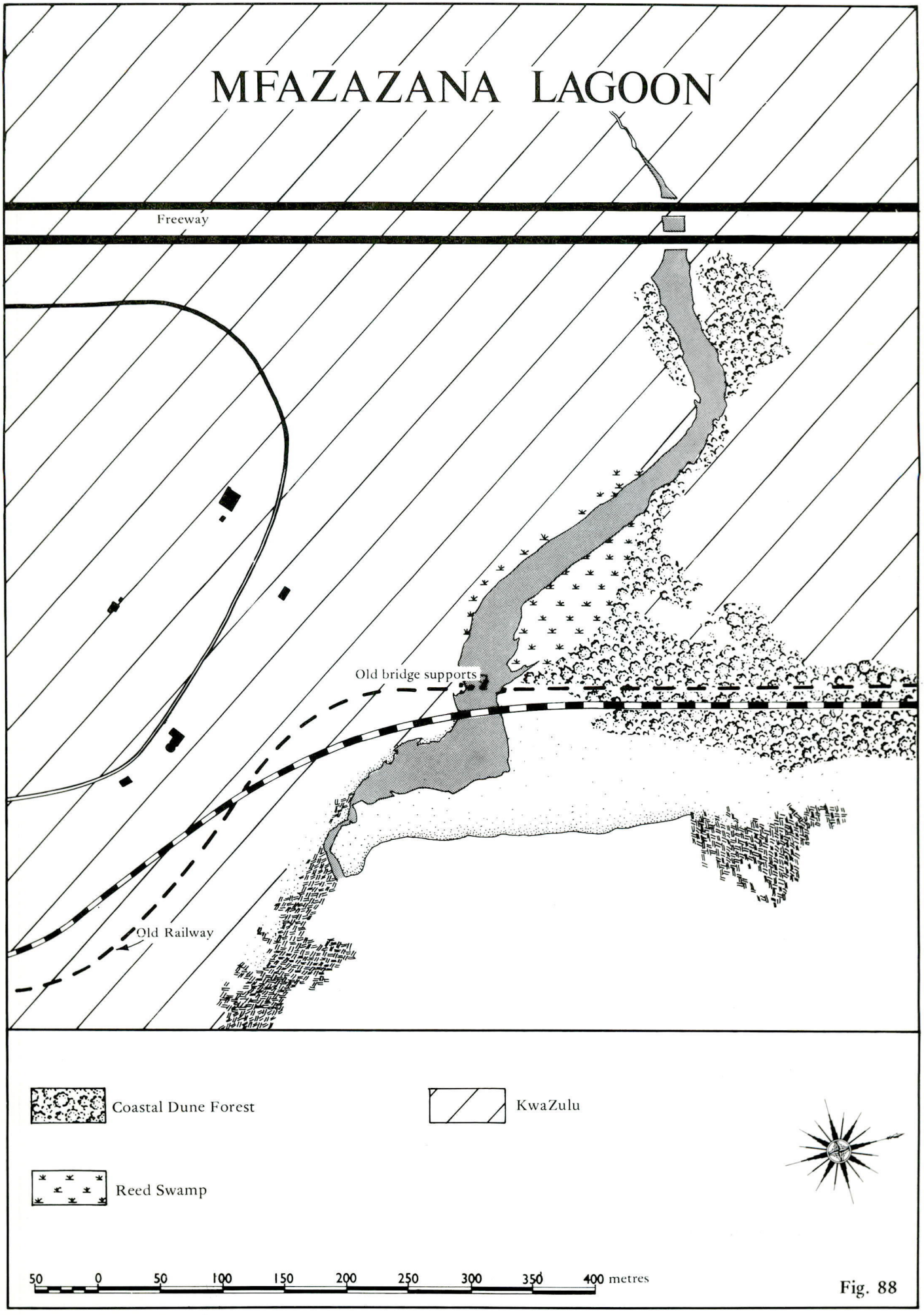

MFAZAZANA LAGOON
Freeway
Old bridge supports
Old Railway
Coastal Dune Forest
KwaZulu
Reed Swamp
50 0 50 100 150 200 250 300 350 400 metres

Fig. 88

BIOTIC CHARACTERISTICS

Flora

Neither lagoon supports plant communities which are of any real note. They are both fringed by *Hibiscus tiliaceus*, and on low lying areas have become colonized by various sedge and marsh communities. Most of the surrounding land has been cleared for sugar cane cultivation. A small patch of coastal dune forest has remained intact on the northern bank of the Kwa-Makosi lagoon.

Fauna

No record for either lagoon.

SYNTHESIS

Our state of knowledge of both the Kwa-Makosi and Mfazazana lagoons is exceptionally poor. However, in neither case is there any justification for further study. By present standards both are in fairly good environmental condition but neither are of any exceptional resource value. In the case of the Kwa-Makosi, impacts associated with the development of road and rail communications are particularly striking.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora			Fauna								Food Webs
KWA-MAKOSI AND MFAZAZANA			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																																	
Source of Information	Summary of available information																																
Fromme	1970 to 1975	132								●																							
Orme	1971	257						●		●																							
Ninham Shand & Partners	1971	245	●		●			●																									
NTRPC	1974	236						●																									
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	301		●						●													●										
1:25 000 Job No. 262	1976	473	●																														

2.1.11.6 MHLUNGWA

Synonyms
Umhlungwa.

Zulu meaning
No record.

Location
30°33'30"S; 30°35'E.

Accessibility
By road the Mhlungwa lagoon is 102 km south west of Durban. A track runs along part of the northern bank of the lagoon in its upper reaches, and another on the southern bank leads to the mouth.

Bridges
The railway line crosses the mouth of the lagoon. Although the freeway presently ends immediately north of the Mhlungwa lagoon, the national road crosses it 700 m from the mouth. The latter has been carried across the Mhlungwa floodplain on a 200 m long embankment, which judging from aerial photographs, appears to have brought about significant changes in the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 31 km^2

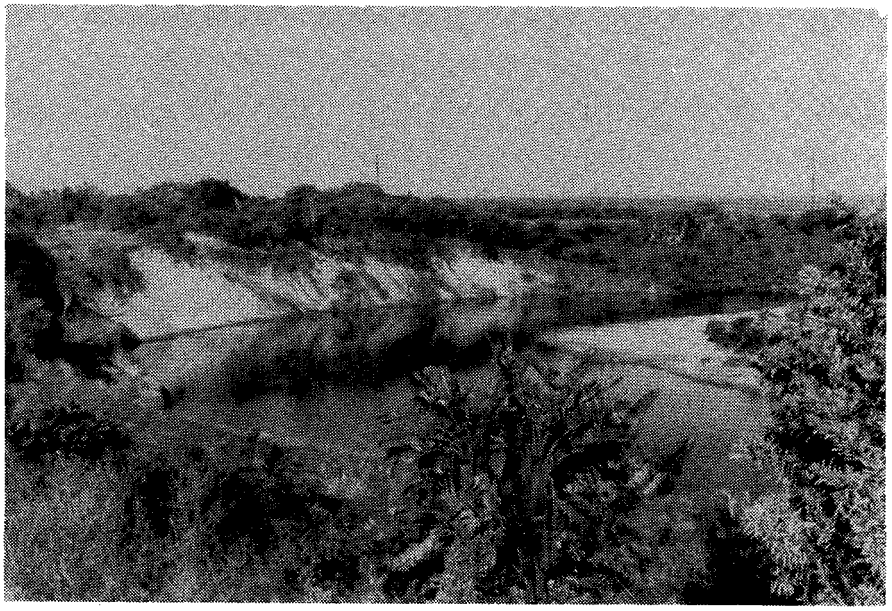
River length. 18 km

Mean annual run-off. No record.

Flow. A rough estimate of the average flow in 1971 was ,14 m^3/sec. ([206]).

Flood history. 1:50 year floods have been estimated to discharge 140 m^3/sec. (Strydom, Newmark and Antony, pers. comm.).

Dams.
Existing: None.
Proposed: None.



Slumping of the northern bank of the Mhlungwa lagoon.

Siltation: No record. Where the Mhlungwa lagoon deflects southwards, the northern bank has become subjected to erosion and undercutting. Sand slip from this bank must contribute significantly to the amount of deposition occurring in the lagoon.

Land ownership/use. For much of its length the Mhlungwa river acts as a boundary between a Bantu reserve (Location No. 3) and a European owned farming district. 24,5% of the catchment is Bantu influenced and destined to become incorporated into KwaZulu.

On the northern bank of the lagoon is a Bantu reserve, whilst on the southern bank is the sparsely developed residential area of Catalina, (a northern extension of Hibberdene).

Local authority. Hibberdene.

Estuary uses. No record.

Morphometry of lagoon (see Fig. **89**).

Area. 3,09 ha

Axial length. 800 m

Shoreline length. 1,7 km

Width.
Maximum: 60 m
Mouth: 10 m wide during low flow periods.
Floodplain: 200 m wide above the lagoon.

Bathymetry. No record. Judging from aerial photographs (dated 12 June 1976) the lagoon virtually empties itself completely when open to the sea. Its storage capacity has been lost due to siltation.

Geomorphology

Geology. Both catchment and lagoon are made up of Archaean granite ([236]).

Nature of bottom materials. No record. At low water, extensive sand banks become exposed.

Sandbar characteristics. The Mhlungwa lagoon lies behind a massive, stable, south extending barrier, upon which the railway line now runs. The mouth of the lagoon opens into the sea across a rocky shelf against the southern end of the bar. The latter is protected from the prevailing swell by rocks which protrude from the coast into the sea. No information could be obtained regarding how long the lagoon remains open. However, because of the elevated bed levels, exchange with the sea is presumed to be limited.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

There is no information on the physico-chemical characteristics of the Mhlungwa lagoon. Nevertheless of some relevance is the data on the chemical nature of the river water 3 km above lagoon in 1971 ([206]). This information is presented as Table **78**.

Public health aspects

Bacteriology. There is no information of this sort from the Mhlungwa lagoon. Only data on the bacteriological condition of the river water 3 km above the lagoon is available ([206]). These results (see Table **79**) indicated that the water could occasionally be organically enriched in the early 1970's.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

The upper reaches of the lagoon are fringed by *Barringtonia racemosa*, whilst in the lower reaches *Hibiscus tiliaceus* occupies this niche. Interspersed amongst these communities, but on higher ground, are *Phoenix* palms, *Strelitzia* and aloes. On the water's edge it is interesting to note that sedge communities occur as opposed to reeds.

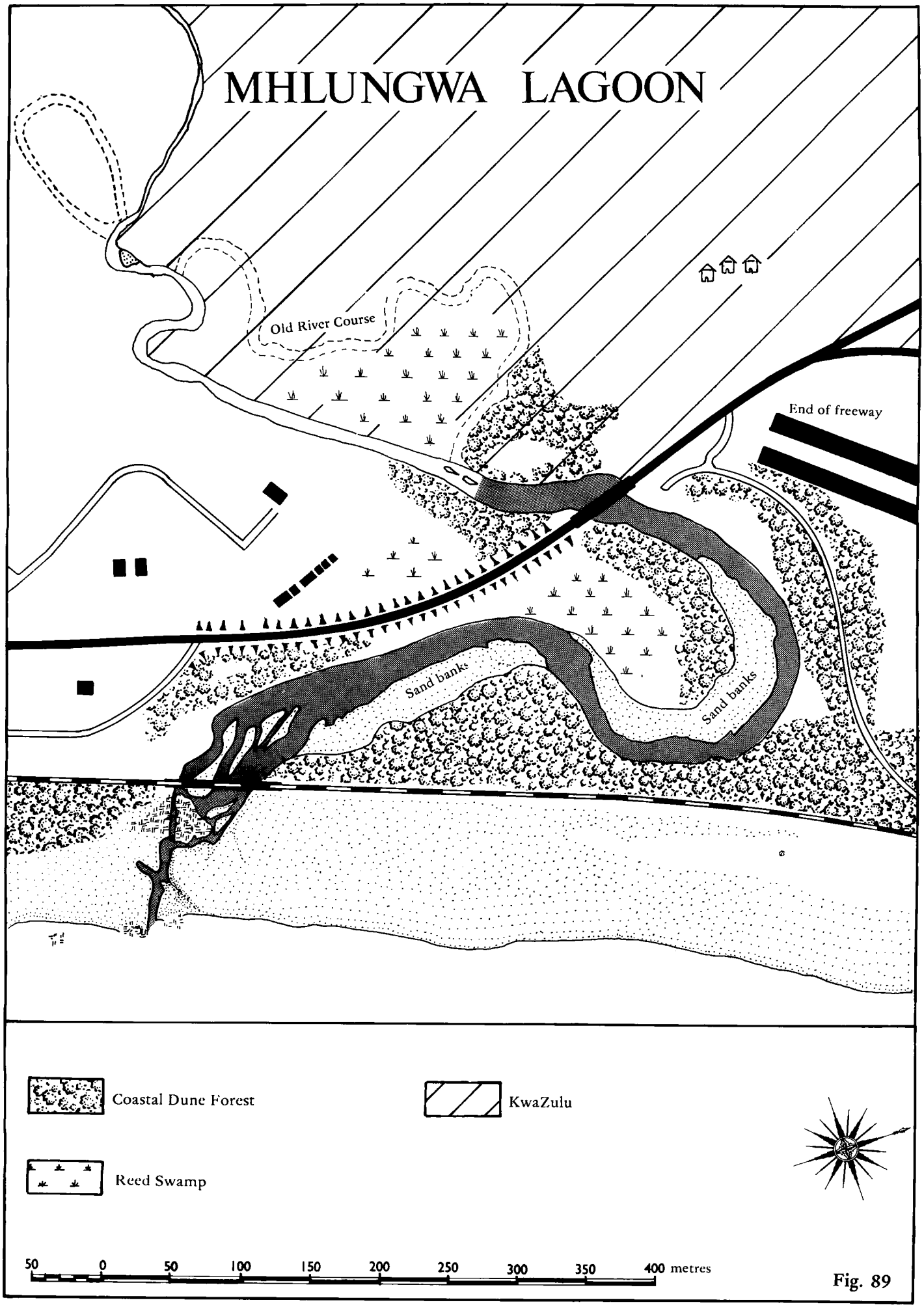

MHLUNGWA LAGOON
Old River Course
End of freeway
Sand banks
Sand banks
Coastal Dune Forest
KwaZulu
Reed Swamp
50 0 50 100 150 200 250 300 350 400 metres

Fig. 89

Table 78. Physico-chemical characteristics.

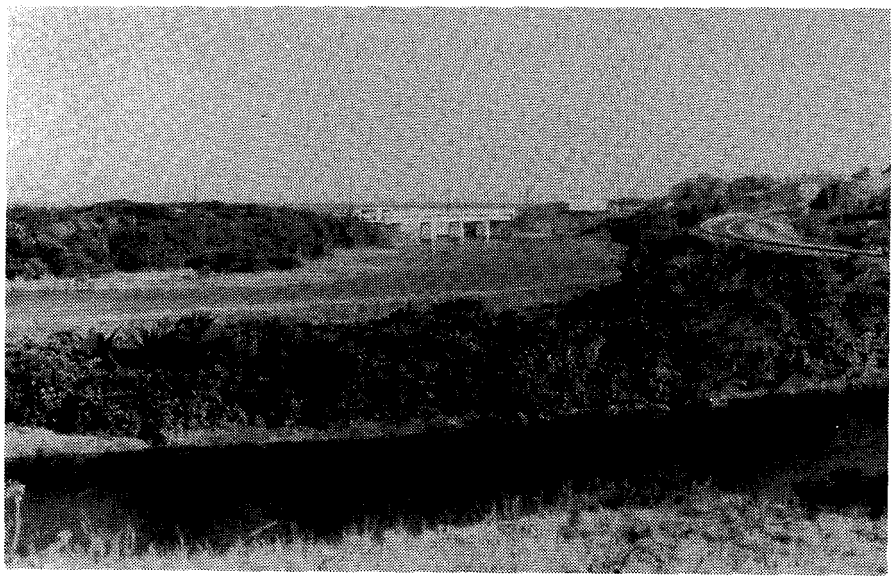
Locality: Mhlungwa river Distance above lagoon : 3km	SUMMER Feb 1971	WINTER July 1971
Hydrogen ion concentration (pH)	8.0	7.9
Saturated pH value	8.3	8.1
Conductivity micromhos/cm	370	462
Total dissolved solids ppm (calcd.)	228	285
Dissolved oxygen mg/litre	8.7	10.2
% Saturation	105	103
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	2.3	0.9
Kjedahl nitrogen mg/litre	0.7	0.4
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.65	0.35
Phosphates "	0.44	0.21
Total alkalinity "	86.0	124.2
Total hardness "	90.6	98.6
Calcium "	13.7	15.6
Magnesium "	13.7	14.5
Sodium "	50.5	60.0
Potassium "	1.9	1.9
Sulphates "	21.5	17.0
Chlorides "	71.5	83.4
Silica "	-	-
Iron "	-	-
Fluorides "	0.3	0.4
Free carbonic acid (as ppm carbon dioxide)	1.6	2.6
Temperature °C	25.0	16.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	poor	fair
Odour	-	-

Values underlined significant of disturbance.

Table 79. Bacteriology of the Mhlungwa river (3 km above the lagoon)

Date	Total Plate Count per ml x 10^3		*E. coli* I per 100 ml	Total Coliforms per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient	Confirmed	
March 1971			162	3 900
July 1971			123	733
23 March 1972	280	240	1 600	
4 July 1972	80	**2 500**	560	
1 Aug 1972	310	176		
23 Aug 1972	70	100		
9 Jan 1973	850	**1 600**		

Values in bold are significant of disturbance.



A general view of the Mhlungwa lagoon to illustrate the plant communities along the water's edge. (13 July 1977).

Fauna

Data from the lagoon itself is non-existent. Some information on the aquatic fauna of the river 3 km above the lagoon is available ([206]). From the species diversity and the number of animals present, conditions for aquatic life in 1972 appeared extremely favourable.

In January 1977 a survey of the estuarine associated birdlife on the Mhlungwa lagoon produced completely negative results (Nicholls, pers. comm.).

SYNTHESIS

Our general state of the Mhlungwa lagoon is poor. There appears to be no justification to motivate studies that may improve our knowledge of the system. In its present environmental condition, the Mhlungwa lagoon is not regarded as an important estuarine resource. It has fallen into a degraded state, through impacts associated with road construction and siltation.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other						Flora			Fauna							Food Webs
MHLUNGWA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																																	
Source of Information	Summary of available information																																
Kemp *et al*	1971 to 1973	206	●		●						○				○										○	○							
NTRPC	1974	236						●																									
Strydom, Newmark & Antony.	1977	pers. comm.			●																												
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	306		●						●													●										
1:25 000 Job No. 262	1976	471	●																														

Synonyms

Whilst referred to as the Mzimayi on the 1:50 000 map (3030 DA), the name Mhlabatshane as shown on the 1:500 000 series, and as used by Kemp *et al* ([206]) has been adopted. This is necessary to avoid confusion between this system and the Mzimayi which lies 30 km further north (see Section 2.1.10.4).

Zulu meaning

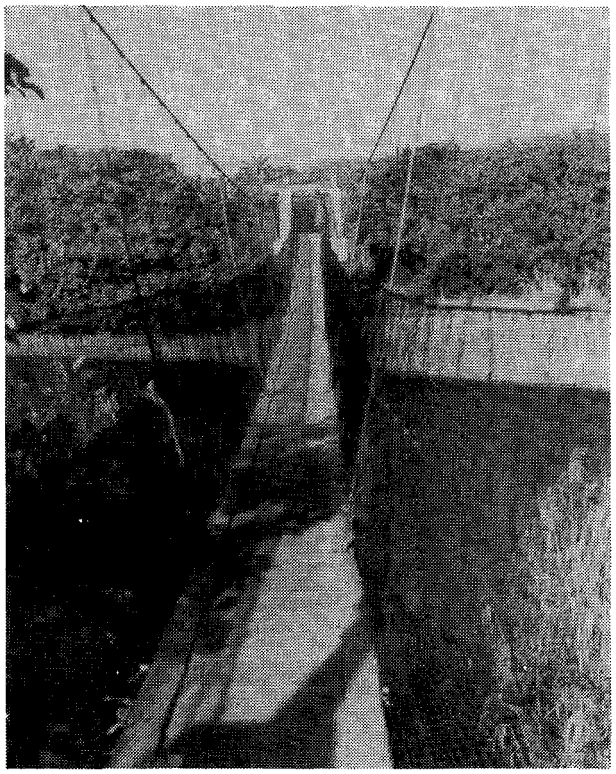
'uMzimayo' is a word used to signify a strong thick-set man referring in this instance to Chief Dumisa once an elephant hunter in the Umzinto district ([289]).

Location

30°35'S; 30°34'15"E.

Accessibility

The Mhlabatshane lagoon is 106 km south west of Durban, and by virtue of the various tracks and paths on either side of the lagoon, easily accessible. There is a landing strip for light aircraft, just south of the lagoon.



A footbridge has been suspended over the middle reaches of the Mhlabatshane lagoon.

Bridges

Both the south coast railway line and national road cross the lagoon, 30 m and 100 m from the mouth respectively. In addition there is a footbridge suspended over the middle reaches of the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 34 km^2 to 49 km^2 ([206]).

River length. 16 km ([206]).

Mean annual run-off. No record.

Flow. A rough estimate of the average flow in 1971 was ,11 m^3/sec. ([206]).

Flood history. No record.

Dams.
Existing: None.
Proposed: None.

Siltation. No record.

Land ownership/use. 44% of the catchment (comprising Location No.4) is Bantu influenced and destined to become incorporated into KwaZulu. The lower catchment is influenced principally by sugar cane farming. On the 1:50 000 sheet 3030DA, a sisal mill is indicated 6 km above the lagoon. Whether such a mill would generate an effluent disposal problem if operative, could not be ascertained.

Around the lagoon are the settlements of Hibberdene (to the north) and Wood Grange (to the south). Both cater almost entirely for holiday makers, by the provision of various caravan parks, holiday chalets and camps. Proposals for additional facilities of this nature are pending (NTRPC, pers. comm.).

For 45 m on either side of the lagoon the land is zoned as either Admiralty or Government reserve (NTRPC, pers. comm.).

Local authority. Hibberdene.

Estuary uses. The lagoon is used for a variety of purposes such as canoeing, fishing and paddling. It is the focal point of what is known as Pleasant Valley.

Morphometry of lagoon (see Fig. **90**)

Area. 2,27 ha

Axial length. 550 m

Shoreline length. 1,2 km

Width.
Maximum: 60 m
Mouth: 10 m during normal, low flow periods.
Floodplain: 100 m

Bathymetry. No record.

Geomorphology

Geology. Most of the catchment area is made up of granite, although Table Mountain Sandstone occurs nearer the coast, and around the lagoon ([238]). On the southern bank of the lagoon, rocks frequently outcrop at the water's edge (pers. obs.).

Nature of bottom materials. Although no actual records are available, the bottom materials probably comprise coarse fluvial deposits, which are periodically scoured out by floods. Lenses of washover marine sand presumably occur near the mouth.

Sandbar characteristics. The Mhlabatshane lagoon lies behind a short (40 m long) south extending bar. Being rock protected, the mouth of the lagoon (when it is open) forms against the southern end of the bar. Whether the sandbar is breached artificially or permitted to open naturally, could not be ascertained.

Configuration of adjacent shore ([132]).

Beach type — sheltered bight.

Average beach slope — 7°
Average beach width — 56m
Average sand grain size — 630 microns
} indicative of rough surf zone conditions

Surf zone currents. Rip currents in the near vicinity of the lagoon are absent.

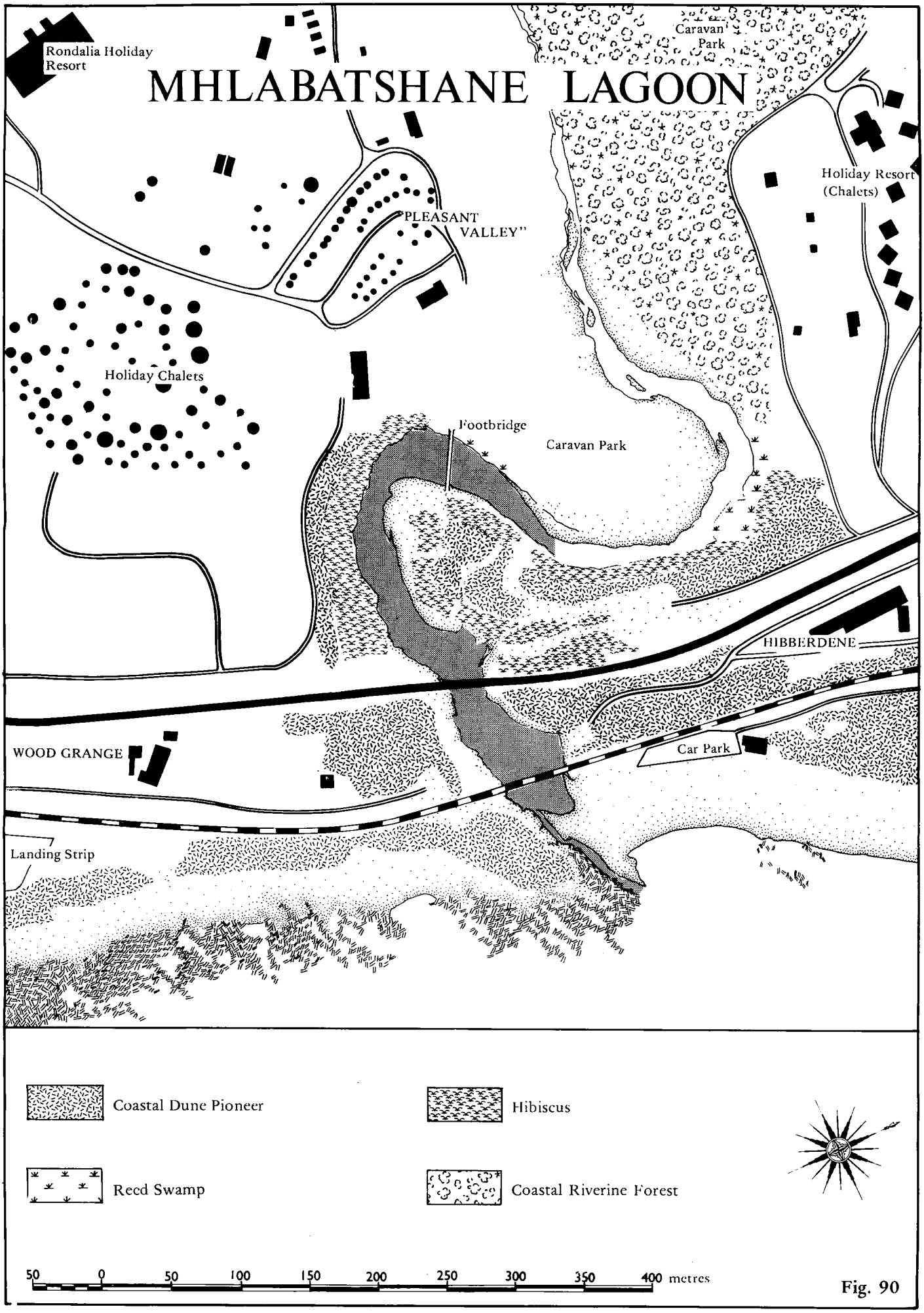

MHLABATSHANE LAGOON
Rondalia Holiday Resort
Caravan Park
Holiday Resort (Chalets)
"PLEASANT VALLEY"
Holiday Chalets
Footbridge
Caravan Park
HIBBERDENE
WOOD GRANGE
Car Park
Landing Strip
Coastal Dune Pioneer
Hibiscus
Reed Swamp
Coastal Riverine Forest
50 0 50 100 150 200 250 300 350 400 metres

Fig. 90

Physico-chemical characteristics

Information of this sort from the lagoon itself is non-existent. Only data on the physico-chemical characteristics of the river water 3,5 km above the lagoon is available ([206]). From these results (see Table **80**) no signs significant of disturbance were evident in 1971.

Public health aspects

Bacteriology. There is no information available on the bacteriological characteristics of the Mhlabatshane lagoon. Only data on characteristics of the river water 3,5 km above the lagoon is available ([206]) from a survey in the early 1970's (see Table **81**). Organic pollution was evident during the dry season, and there were isolated indications of faecal pollution.

Table 81. Bacteriology of the Mhlabatshane river (3,5 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* I per 100 ml	Total Coliforms per 100 ml	*Salmonella* per 250 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient	Confirmed		
March 1971			167	5 000	
July 1971			353	1 500	+
23 Feb 1972	800	520	3 600		
4 July 1972	**2 240**	700	60		
1 Aug 1972	210	**320**			
16 Aug 1972	220	**1 800**			
9 Jan 1973	230	**670**	960		

+ and values in bold are significant of disturbance.

Bilharzia. In view of the use made of the lagoon by people, the lack of knowledge regarding bilharzia, is a serious ommission.



An impression of the Hibiscus and *Phragmites* communities alongside the Mhlabatshane lagoon (13 July 1977).

Table 80. Physico-chemical characteristics

Locality: Mhlabatshane river Distance above lagoon : 3.5km	SUMMER Feb 1971	WINTER June 1971
Hydrogen ion concentration (pH)	8.0	7.6
Saturated pH value	8.4	8.4
Conductivity micromhos/cm	305	370
Total dissolved solids ppm (calcd.)	196	226
Dissolved oxygen mg/litre	7.9	9.6
% Saturation	93	94
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	3.6	0.7
Kjedahl nitrogen mg/litre	0.7	0.3
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.28	0.34
Phosphates "	0.31	0.23
Total alkalinity "	81.0	91.4
Total hardness "	73.7	79.7
Calcium "	11.1	12.1
Magnesium "	11.2	12.0
Sodium "	50.0	47.5
Potassium "	1.5	1.7
Sulphates "	15.4	15.3
Chlorides "	55.5	64.5
Silica "	-	-
Iron "	-	-
Fluorides "	0.3	0.3
Free carbonic acid (as ppm carbon dioxide)	1.6	4.5
Temperature ^{o}C	24.0	15.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

BIOTIC CHARACTERISTICS

Flora

Around the lagoon there is a very well established fringe of *Hibiscus tiliaceus* above which *Phoenix* palms and *Strelitzia* are conspicuous. The reed (*Phragmites*) occurs at the water's edge in certain places.

A thin strip of riverine forest runs along the northern bank of the Mhlabatshane river above the lagoon.

Fauna

There is no information available on the fauna of the Mhlabatshane lagoon. However, the sand prawn (*Callianassa*) is obviously common in the bed of the lagoon (pers. obs. 13 July 1977). Data on some of the animal communities in the river 3,5 km above the lagoon, indicated that at the time of sampling, favourable conditions for aquatic life prevailed ([206]).

SYNTHESIS

Virtually nothing is known about the Mhlabatshane lagoon. In view of its recreational value, the most urgent surveys required are those relating to bilharzia and the bacteriological quality of the lagoon.

Although silted, the lagoon is in a fair environmental condition. However, other than certain botanical features, the system has no outstanding value as an estuarine resource.

The planting of sugar cane onto the river banks is evident above the lagoon. Care must be taken to ensure that through over-popularity people do not eventually destroy the character of the Mhlabatshane lagoon and simultaneously that of Pleasant Valley.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other							Flora		Fauna							Food Webs
MHLABATSHANE ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids															★																
Source of Information	Summary of available information																														
Fromme	1970 to 1975	132								●																					
Kemp *et al*	1971 to 1973	206	●		●						○				○										○	○					
NTRPC	1974	236						●																							
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 261	1976	309		●						●														●							
1:25 000 Job No. 262	1976	469	●																												

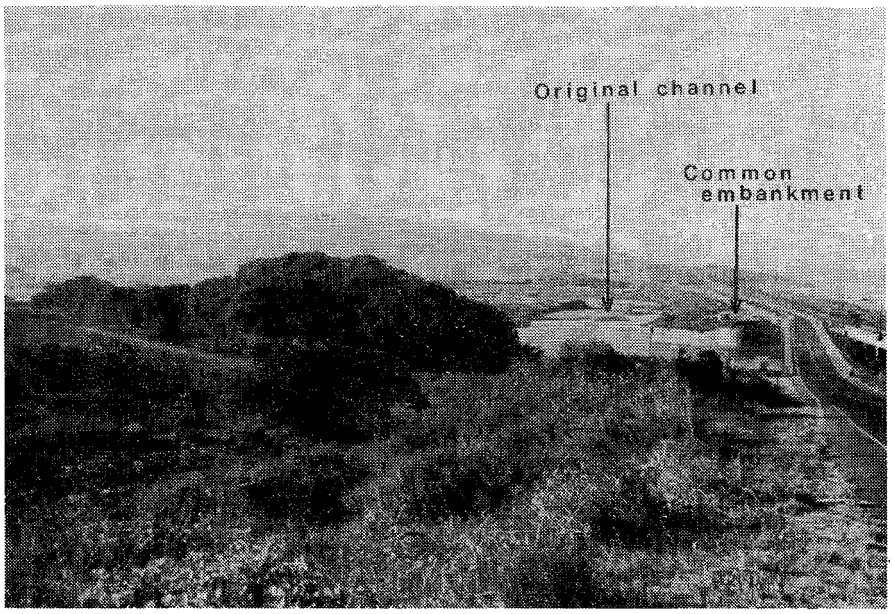
Synonyms
Mzumbu ([213]); Umzumbi ([239]); Umzumbe ([245]).

Zulu meaning
Two meanings have been proposed ([289]).

(1) 'the bad kraal' where the Hlongwa people established themselves as brigands.
(2) 'the river of loops and twists'.

Location
30°36'30"S; 30°33'E.

Accessibility
By road the Mzumbe lagoon is 110 km south west of Durban and 18 km north of Port Shepstone. Other than a rough track alongside the edge of the floodplain towards the upper reaches of the lagoon, there is no vehicular access to the water's edge.



The Mzumbe lagoon viewed from the south — in order to show the road/railway embankment and the original channel position (10 June 1977).

Bridges
Both the railway line and the national road approach the lagoon from the northern bank on a 700 m long common embankment, but cross the lagoon on separate bridges ±150 m from the mouth. The causeway upon which these lines of communication are carried, was built by infilling the old channel of the Mzumbe, because this was the easiest and cheapest way to bridge the system (Maud, pers. comm.). The causeway has led to gross alteration of the lagoon. Former water areas have been lost through siltation, the channel position has altered, and a new sandbar has been laid down. An embankment built across the floodplain to carry the old railway line, had similar effects many years ago.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 534 km² ([213]); 541 km² ([206, 245, 257]); 777 km² ([223]).

River length. 84 km ([206, 245]).

Mean annual run-off. 73,6 x 10^6 m³ ([223]) to 76 x 10^6 m³ ([213]).

Flow. A rough estimate of the average flow in 1970 was ,95 m³/sec. ([206]).

Flood history. Floods from the Mzumbe catchment can be severe. In May 1959 both the railway bridge ([257]) and the road bridge ([220]) were washed away and the flood reached girder bed level of the road bridge. 1:50 year floods have been estimated to discharge 800 m^3/sec. (Strydom, Newmark and Antony, pers. comm.). The effects of a river break out in November 1972 are provided by NRIO ([238]). Although described as catastrophic, this term is normally used to express floods that exceed the probable maximum, or 1:100 year frequency ([220]).

Dams.
Existing: None.

Proposed: The Udege dam site has been located 36 km above the lagoon. If built the dam would have a total capacity of 58,6 x 10^6 m^3 ([245]).

Siltation. Annual siltation at the proposed Udege dam site has been estimated at 0,22 x 10^6 m^3/annum ([245]). This represents a high rate of siltation ([189]). Aerial photographs provide confirmation thereof by revealing extensive deposits of sand in both the river and lagoon.

Land ownership/use. With 84% of the catchment area made up of Locations No. 4, 6 and 8, virtually all of the drainage basin is Bantu influenced and destined to become incorporated into KwaZulu.

The northern bank of the Mzumbe lagoon is totally undeveloped, whilst overlooking the southern bank is the township of Umzumbe.

Local authority. Umzumbe.

Estuary uses. No record. In its present condition it is highly unlikely that the Mzumbe lagoon is used for any purpose.

Morphometry of lagoon (see Fig. **91**)
Area. 15,8 ha

Axial length. 950 m

Shoreline length. 3,9 km

Width.
Maximum: 400 m
Mouth: 10 m during low periods ([239]).
Floodplain: 900 m

Bathymetry. No record. The mouth is 0,5 m deep ([239]).

Geomorphology
Geology. The river is said to traverse rocks of the Basement complex throughout its catchment area ([245]). These comprise granite throughout most of the area, but Tugela series at the coast ([238]). Bedrock lies at a depth of 5,1 m below normal bed level at the bridge site ([220]).

Nature of bottom materials. According to Orme ([257]), the bottom materials of the Mzumbe lagoon reflect appreciable Holocene sedimentation.

Sandbar characteristics. The Mzumbe sandbar has been described as a massive coastal barrier ([257]), and is composed of two parts:

(1) the stable 750 m long bar carrying the road and railway line, and
(2) a more recent unstable bar extending 600 m beyond the end of the former. The crest may be 4 m to 5 m above chart datum ([239]).

Both are south extending. According to NRIO the mouth position is relatively stable ([238, 239]) because between June 1971 and July 1974 no significant changes occurred. During a flood in November 1972 however, the entire sandspit was removed, between the northern bridge head and the river mouth in its southerly position ([238]). The mouth is open for most of the year ([239]).

Van Heerden ([316]) considered spit growth at the Mzumbe to be similar to that at the Mkomazi, in that large amounts of fluvially supplied offshore sediments were necessary. Sand movement in the surf zone is said to be strong ([239]).

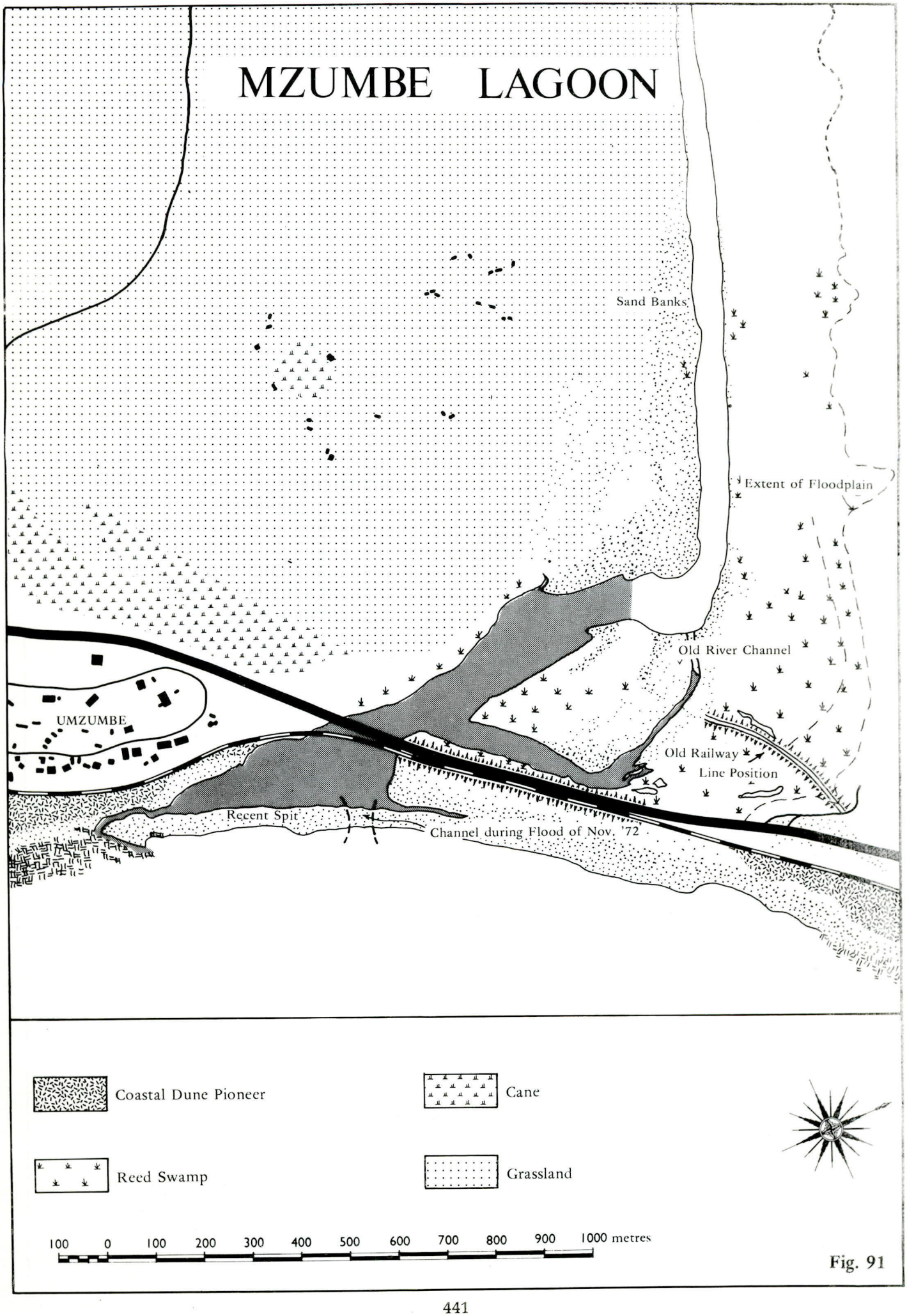

MZUMBE LAGOON
Sand Banks
Extent of Floodplain
Old River Channel
UMZUMBE
Old Railway
Line Position
Recent Spit
Channel during Flood of Nov. '72
Coastal Dune Pioneer
Cane
Reed Swamp
Grassland
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 91

The channel through the bar can be 2 m to 3 m deep. At such times the bed level of the estuary at the mouth is 1,5 to 2 m above chart datum (i.e. just above the average tidal range). A rock sill in the river mouth prevents the channel scouring any deeper.

Configuration of adjacent shore ([132]).
Beach type — well sheltered asymmetrical beach.

Average beach slope — 8°
Average beach width — 88 m
Average sand grain size — 633 microns
} indicative of rough surf zone conditions.

Surf zone conditions. Rip currents in the near vicinity of the lagoon are reported to be present.

Physico-chemical characteristics

There is no information available on the physico-chemical characteristics of the Mzumbe lagoon. However, although representative of conditions eight years ago, data on the chemical nature of the river water, from a point 2 km above the lagoon is available ([206]). This information has been presented in Table **82**.

Public health aspects

Bacteriology. Information on the bacteriological characteristics of the lagoon is non-existent. From the very limited amount of information available (see Table **83**) on conditions in the river, 2 km above the lagoon ([206]) *Salmonella* (as an indication of faecal pollution) has been isolated on only one occasion.

Table 83. Bacteriology of the Mzumbe river (2 km above the lagoon)

Date	Total Plate Count per ml x 10^3		*E. coli* I per 100 ml	Total Coliforms per 100 ml	*Salmonella* per 250 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed		
March 1971			69	4 700	
July 1971			136	789	+
4 Feb 1972	256	112			
23 Feb 1972	800	264	1 300		

+ is significant of disturbance.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

The only plant community of any significance is that on the floodplain where a variety of sedges (such as *Mariscus*) and hygrophilous grasses occur. *Voacanga thouarsii* (wild frangipani) represent the remnants of a swamp forest. ([189])

A machine digging trenches on the floodplain (pers. obsv. 10 June 1977) is suggestive of these communities becoming disturbed in the near future.

Fauna

There is no information available on the fauna of the Mzumbe lagoon although Grindley (pers. comm.) has not yet examined zooplankton samples he took from the lagoon in 1968. However,

Table 82. Physico-chemical characteristics. ([206])

Locality: Mzumbe river Distance above lagoon : 2km	SUMMER Feb 1970	WINTER June 1970
Hydrogen ion concentration (pH)	7.95	8.23
Saturated pH value	8.6	8.5
Conductivity micromhos/cm	229	273
Total dissolved solids ppm (calcd.)	134	166
Dissolved oxygen mg/litre	9.1	9.6
% Saturation	109	114
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.4	2.4
Kjedahl nitrogen mg/litre	0.3	0.2
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.33	0.62
Phosphates "	0.14	0.15
Total alkalinity "	61.5	72.7
Total hardness "	53.8	62.2
Calcium "	9.4	12.0
Magnesium "	7.4	7.8
Sodium "	28.1	32.5
Potassium "	1.5	2.2
Sulphates "	2.7	8.9
Chlorides "	29.9	34.3
Silica "	-	-
Iron "	-	-
Fluorides "	0.3	0.3
Free carbonic acid (as ppm carbon dioxide)	1.4	0.8
Temperature °C	25.0	24.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

surveys in the river 2 km above the lagoon were undertaken in June 1972 ([206]). The results were indicative of favourable environmental conditions for aquatic life upstream of the lagoon.

Birds. A survey (on 23 January 1977) revealed only four estuarine dependent species (Nicholls, pers. comm.). However, birds such as the African sedge warbler, apparently find the Mzumbe floodplain particularly suitable as a habitat ([189]), (Cooper, pers. comm.).

SYNTHESIS

Other than a fair geomorphological/hydrological understanding of the system, our general state of knowledge of the Mzumbe lagoon is poor. In its present environmental condition the lagoon has become degraded to the extent that it is regarded as having little resource value. However, Ward's study of the botanical characteristics of Natal's estuaries should clarify the value of the plant communities on the Mzumbe floodplain.

The Mzumbe lagoon is similar to the Mpambanyoni (see Section 2.1.10.3) in that it is the severe erosion occurring in Bantu reserves that has caused its decline.

The Mzumbe illustrates that when road and rail construction are imposed upon the mouth of a system which is already subjected to heavy siltation, the combination leads to very rapid deterioration.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry					Other								Flora		Fauna								Food Webs
MZUMBE ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																																		
Source of Information	Summary of available information																																	
Meinecke	1959	220			●			●																										
Midgley & Pitman	1969	223	●		●																													
Kemp *et al*	1970 to 1972	206	●		●						○				○										○	○								
Fromme	1970 to 1975	132								●																								
Orme	1971	257	●							●																								
Ninham Shand & Partners	1971	245	●					●		●																								
Loxton. Hunting & Assoc.	1971	213	●		●																													
NRIO	1972 to 1975	238 and 239		●			●			●																								
NTRPC	1974	236						●																										
van Heerden	1976	316								●																								
Strydom, Newmark & Antony	1977	pers. comm.			●																													
Cooper	1977	pers. comm.																						●				●						
Hopwood	1978	189						●		●														●				●						
Aerial photos (Scogings)		No.																																
1:10 000 Job No. 261	1976	313		●						●														●										
1:25 000 Job No. 262	1976	468	●	●																														

Synonyms
Injambili [206].

Zulu meaning
iNtshambili means "the two dogs" [289], because the river system comprises two streams running towards the sea like two dogs coursing parallel with one another after an antelope.

Location.
30°38'15"S; 30°32'30"E.

Accessibility
By road the iNtshambili lagoon is 113 km south west of Durban. A track on the southern bank of the lagoon makes the lower reaches accessible, although this is used primarily as an access for skiboat owners to the beach.

Bridges
The south coast railway line and the national road cross the lagoon on bridges 40 m and 75 m from the mouth respectively.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 34 km^2 [206].

River length. 12 km to 13 km [206].

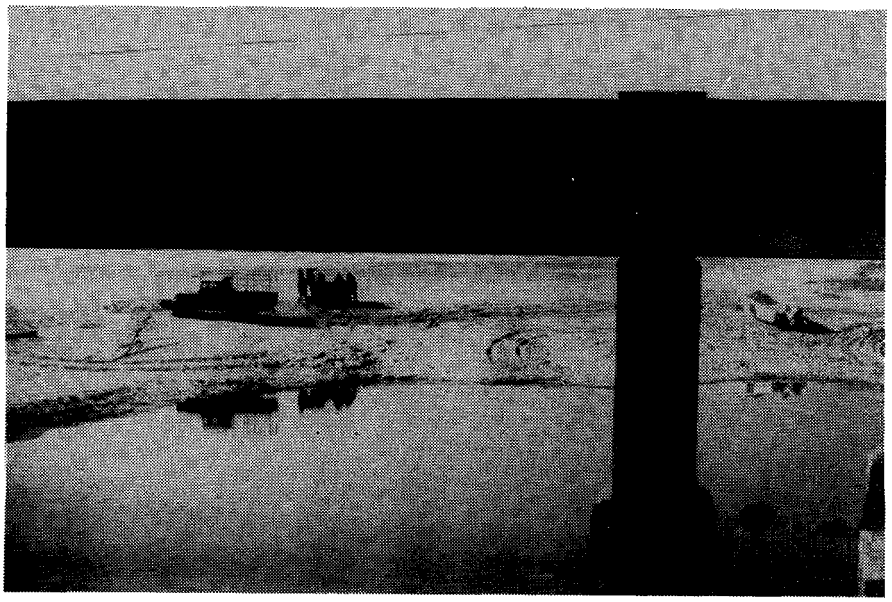
Mean annual run-off. No record.

Flow. A rough estimate of the average flow in 1971 was ,085 m^3/sec. [206].

Flood history. No record.

Dams.
Existing: None.
Proposed: None.

Siltation. No record.



The iNtshambili sandbar is a popular ski-boat launching site.

Land ownership/use. Most of the catchment is made up of a European farming community. 26% of the catchment, (comprising Location No. 5) is Bantu influenced and destined to become incorporated into KwaZulu.

Overlooking the lagoon on the southern bank is the township of Pumula. Being zoned as road and Admiralty reserves, the northern bank is undeveloped. However, the development of holiday chalets in this vicinity has been proposed and approved (NTRPC, pers. comm.).

Local authority. Melville.

Estuary uses. Although no use appears to be made of the lagoon the iNtshambili mouth is a popular skiboat launching site ([132]).

Morphometry of lagoon (see Fig. **92**).

Area. 1,7 ha

Axial length. 550 m

Shoreline length. 1,5 km

Width.
Maximum: 60 m
Mouth: During floods in April 1978 the mouth was ± 40 m wide (pers. obsv.)
Floodplain: 150 m

Bathymetry. No record.

Geomorphology

Geology. The entire system (both catchment and lagoon) are made up of granite ([189, 236]).

Nature of bottom materials. No record.

Sandbar characteristics. The iNtshambili sandbar is a short (75 m long) south extending barrier. The mouth is rock protected and consequently forms at the southern end of the bar.

Configuration of adjacent shore ([132]).
Beach type — asymmetrical, well sheltered beach.

Average beach slope — 8°
Average beach width — 75 m
Average sand grain size — 773 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are reported to be present in the near vicinity of the lagoon.

Physico chemical characteristics

No data from the lagoon exists. However, the physico-chemical characteristics of the river 3,5 km above the lagoon were studied in 1971 ([206]). The results (see Table **84**) provide at least some indication as to what characteristics can be expected in the lagoon.

Public health aspects

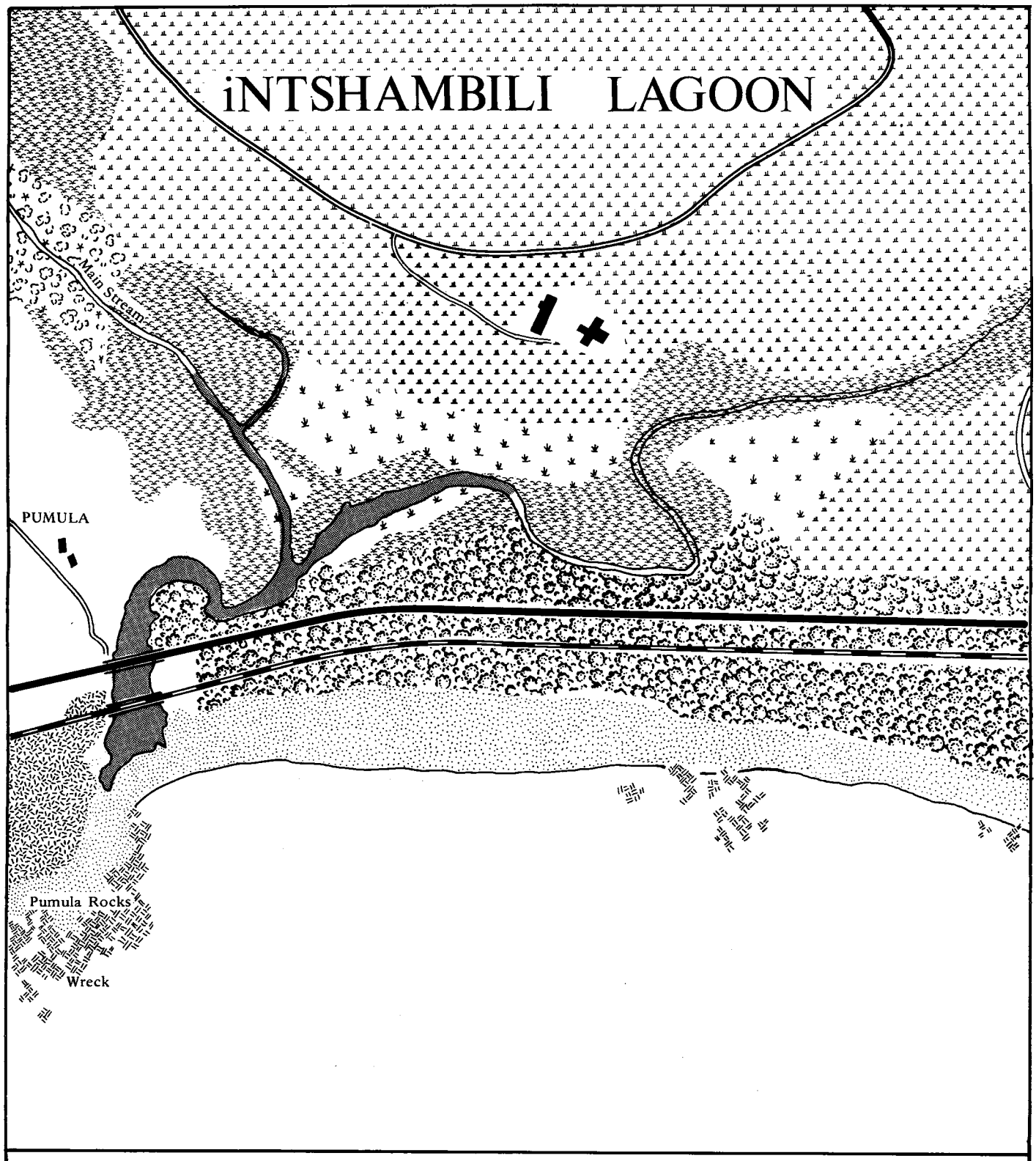
Bacteriology. Only bacteriological data from the river 3,5 km above the lagoon is available ([206]). The results (see Table **85**) suggest that occasional organic enrichment and faecal pollution can occur, but at relatively low levels which are not consistently maintained.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

An outstanding characteristic of the lagoon and the river above it, is the particularly well established margin of swamp forest comprising *Barringtonia racemosa* (the freshwater mangrove) ([189]). The suggestion that *Barringtonia* does not occur south of Sezela ([30]) is therefore incorrect.



Coastal Dune Forest

Coastal Dune Pioneer

Coastal Riverine Forest

Barringtonia

Cane

Reed Swamp

100 0 100 200 300 400 500 metres

Fig. 92

Table 84. Physico-chemical characteristics. ([206])

Locality: iNtshambili river Distance above lagoon : 3.5km	SUMMER Feb 1971	WINTER June 1971
Hydrogen ion concentration (pH)	8.0	7.5
Saturated pH value	8.5	8.5
Conductivity micromhos/cm	355	403
Total dissolved solids ppm (calcd.)	217	263
Dissolved oxygen mg/litre	7.7	9.5
% Saturation	95	93
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.2	0.8
Kjedahl nitrogen mg/litre	0.2	0.1
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.14	0.28
Phosphates "	<u>0.40</u>	0.16
Total alkalinity "	77.1	71.8
Total hardness "	76.1	75.7
Calcium "	11.1	10.9
Magnesium "	11.7	11.8
Sodium "	53.5	70.8
Potassium "	2.0	2.0
Sulphates "	10.2	20.0
Chlorides "	<u>80.3</u>	<u>86.1</u>
Silica "	-	-
Iron "	-	-
Fluorides "	0.3	0.3
Free carbonic acid (as ppm carbon dioxide)	1.5	4.4
Temperature °C	27.0	15.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values <u>underlined</u> significant of disturbance.

Table 85. Bacteriology of the iNtshambili river (3,5 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* I per 100 ml	*Salmonella* per 250 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed	
March 1971			294	
July 1971			222	+
4 Feb 1972	200	140		
23 Feb 1972	288	**488**	1 250	
4 July 1972	120	**320**	20	
1 Aug 1972	**1 130**	620		
23 Aug 1972	690	50	20	
9 Jan 1973	410	390	2 133	

+ and values in bold are significant of disturbance.

Fauna

There is no information available on the fauna of the iNtshambili lagoon. However, from a survey conducted by Kemp *et al* 3,5 km above the lagoon ([206]), very favourable environmental conditions for aquatic life appeared to exist at this point in the river in June 1972.

SYNTHESIS

Our overall state of knowledge of the iNtshambili lagoon is poor. However, it is a lagoon which, albeit small, is in a very satisfactory environmental condition. Its principal value (on the basis of our limited information) can be attributed to the well established swamp forest/mangrove associate *Barringtonia racemosa*. It is also an unusual lagoon in that its catchment area is well conserved, and the two streams which enter it are undisturbed. An effort should be made to study the iNtshambili lagoon in greater detail.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other						Flora			Fauna							Food Webs
iNTSHAMBILI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																						←★→		←★→								
Source of Information	Summary of available information																															
Fromme	1970 to 1975	132								●										●												
Kemp *et al*	1971 to 1973	206	●		●						○				○										○	○						
NTRPC	1976	236						●																								
Hopwood	1978	189						●															●									
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	316		●																			●									
1:25 000 Job No. 262	1976	466	●																													

2.1.11.10 **KOSHWANA**

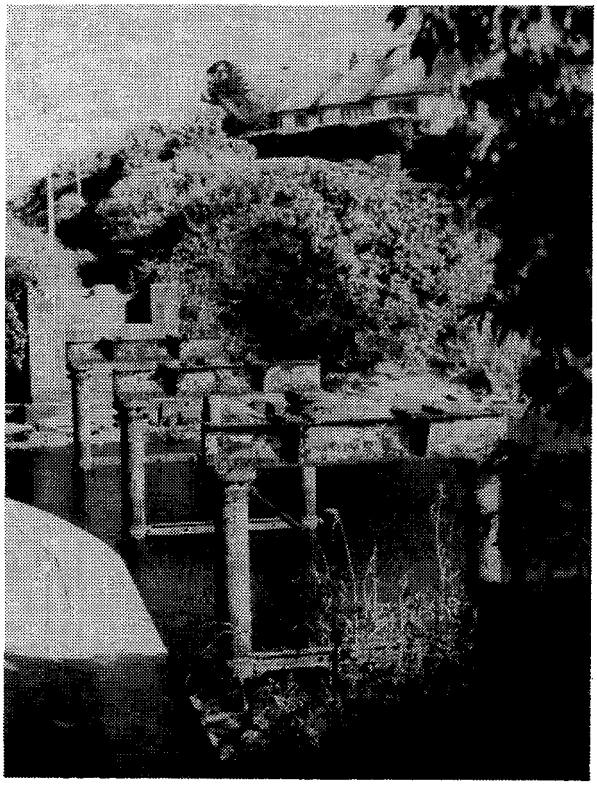
Synonyms
Ikotshwana ([189]); Banana Beach Lagoon.

Zulu meaning
Ikotshwana means "a small stream dried up and covered over in long grass" ([289]).

Location
30°39'30"S; 30°31'E.

Accessibility
By road, the Koshwana lagoon is 110 km south west of Durban. Secondary roads on both sides of the lagoon make it easily accessible, although the use of a boat is necessary in order to inspect the lagoon thoroughly.

Bridges
The railway line crosses the lagoon on a bridge 25 m from the mouth. Immediately above it, the remains of the old railway bridge are still *in situ*.



The remains of the old railway bridge across the Koshwana lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 12 km^2

River length. 6,25 km

Mean annual run-off. No record.

Flow. No record.

Flood history. 1:25 year floods have been estimated to discharge 75 m^3/sec. (Strydom, Newmark & Antony, pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. No record.

Land ownership/use. All but 4% of the catchment is made up of European owned cane farms. The land around the lagoon is developed as a residential area, comprising Bendigo Beach (to the South) and Melville (to the North).

Local authority. Melville.

Estuary uses. Although the lagoon is not used for any particular purpose, the sandbar at the mouth forms part of a popular bathing beach.

Morphometry of lagoon (see Fig. **93**).
Area. 1,16 ha

Axial length. 475 m

Shoreline length. 1,25 km

Width.
Maximum: 45 m
Mouth: No record.
Floodplain: 150 m

Bathymetry. No record.

Geomorphology
Geology. Geologically the system is made up of rocks of the basement complex, with granite in the catchment and Tugela series at the coast ([238]).

Nature of bottom materials. No record.

Sandbar characteristics. There is a very short, south extending sandbar between the Koshwana lagoon and the sea. The mouth of the lagoon is rock protected and consequently opens at the extreme southern end of the bar. Its position is probably stable, although no information on how long it remains open or closed could be found. Unless the lagoon backs up into the vicinity of the sewage works, the artificial control of water levels is probably not necessary.

Configuration to adjacent shore ([132]).
Beach type — well sheltered asymmetrical beach.

Average beach slope — 6°
Average beach width — 62 m
Average sand grain size — 512 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents in the vicinity of the lagoon are apparently absent.

Physico-chemical characteristics
There is no information available on the physico-chemical characteristics of the Koshwana lagoon or the river above it. With a sewage works located immediately above the lagoon, nutrient enrichment is probable.

Public health aspects
Bacteriology. There is no information available on the bacteriological characteristics of the Koshwana lagoon or the river above it. The presence of a sewage works above the lagoon, probably means that the water is faecally polluted.

Bilharzia. No record.

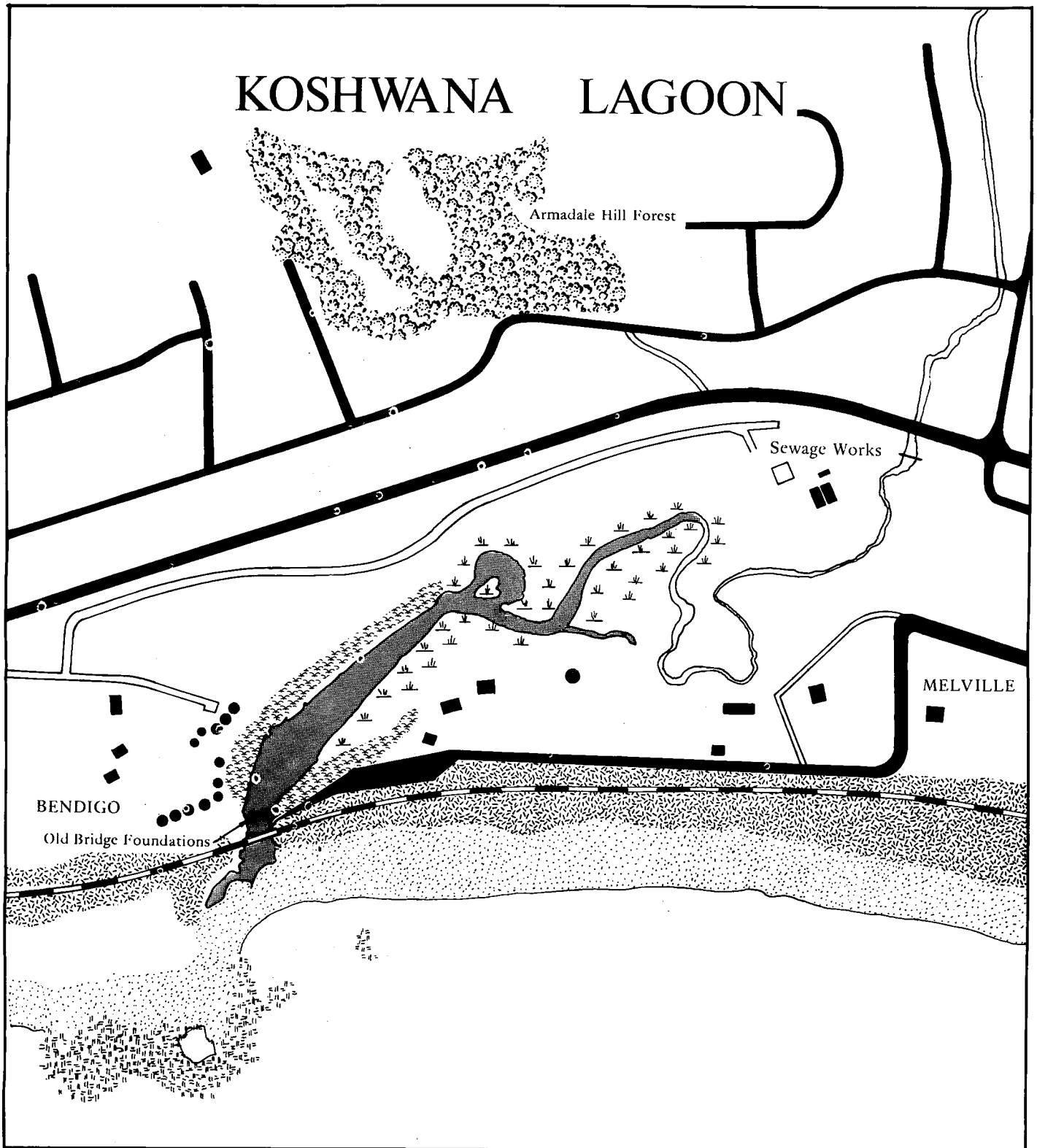
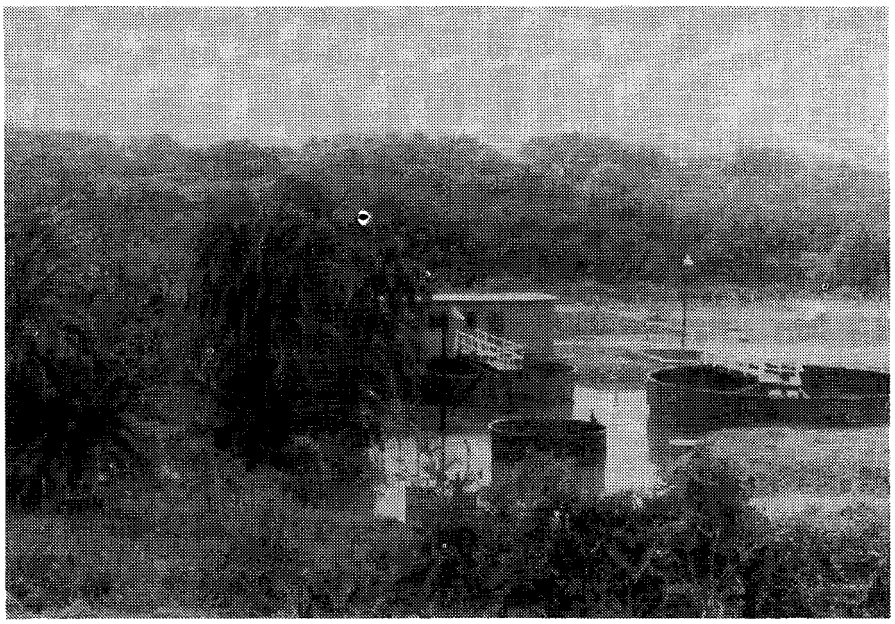

KOSHWANA LAGOON
Armadale Hill Forest
Sewage Works
MELVILLE
BENDIGO
Old Bridge Foundations
Coastal Dune Forest
Reed Swamp
Coastal Dune Pioneer
Hibiscus
100 0 100 200 300 400 500 metres

Fig. 93



Flooding of the sewage works above the Koshwana lagoon (on 24 April 1978) increases the potential of polluting the system.

BIOTIC CHARACTERISTICS

Flora

The most conspicuous lagoon associated plant community surrounding the system is a *Phragmites* reed swamp. The sides of the lagoon are steep and support a typical lagoonal *Hibiscus/Strelitzia* dominated flora.

Overall the Koshwana lagoon appears to have no great botanical importance. However, 1 km west of the lagoon, are the coastal forests of Henderson's Estate ([189], [244]) which have considerable conservation value.

Fauna

No record.

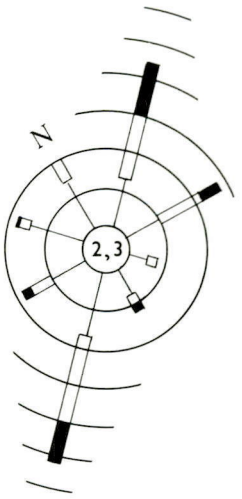
SYNTHESIS

Our state of knowledge of the Koshwana lagoon is very poor. However, being of dubious resource value, no detailed study of the lagoon seems warranted at this stage. As the Koshwana lagoon is the focal point of a resort development, there is, in the interests of public health, the need to establish whether the lagoon is faecally contaminated or infected by bilharzia. The siting of a sewage works immediately above the lagoon makes both conditions extremely likely.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other							Flora			Fauna								
KOSHWANA			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	Food Webs
Data Voids															★																		
Source of Information	Summary of available information																																
Fromme	1970 to 1975	132								●																							
NTRPC	1974	236						●																									
Strydom, Newmark & Antony	1977	pers. comm.			●																												
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	320		●																				●									
1:25 000 Job No. 262	1976	465	●																														

Sunwich Port
Damba
Anerley
Mhlangamkulu
Southport
Sea Park
Mtentweni
Umtentweni
Surfzone Current
Mzimkulu
PORT SHEPSTONE
Mbango
Boboyi
Zotsha
Mhlangeni
Uvongo
Vungu
Kongweni
Surfzone Current
MARGATE
Uvuzana
32°
44°
36°
35°
43°
43°
37°
35°
41°
39°
39°
36°
37°
27°
52°
18°
47°
24°
48°
44°
45°
20°
Pearce and Schumann (261)
Prevailing Nearshore Current
SCALE 1:100 000

GENERALISED WIND ROSE



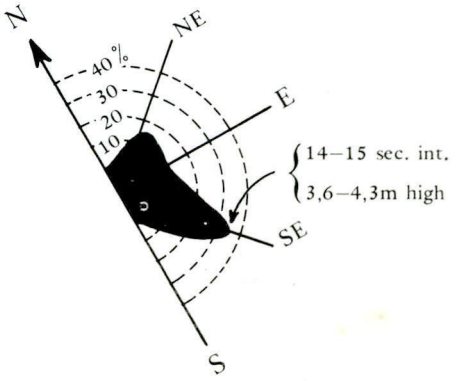
2–11 12–29 30–61 61+ km/h

Arcs represent 5% intervals
Percentage calm within circle



SWELL OBSERVATIONS

(Distribution by direction, height and period)



2.1.12.1 **DAMBA**

Synonyms
Idombi ([244]); Idombe ([206]); Indombe; Domba.

Zulu meaning
No record.

Location
30°40'15"S; 30°30'45"E.

Accessibility
By road the Damba lagoon is 118 km south west of Durban. The northern bank of the lagoon is more accessible than the southern, the latter being low lying and covered in swamp forest.

Bridges
The railway line crosses the mouth of the lagoon, and the sandbar has been artificially stabilized to carry it. The national road approaches the lagoon from the south on a 120 m long embankment that has been built across the floodplain. The bridge is 120 m from the mouth. The old railway bridge foundations have been left in the bed of the lagoon, immediately downstream of the road bridge.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 26 km^2 ([206]).

River length. 11 km ([206]).

Mean annual run-off. No record.

Flow. A rough estimate of the average flow in 1971 was ,11 m^3/sec. ([206]).

Flood history. No record.

Dams.
Existing: None.
Proposed: None.

Siltation: No record.

Land ownership/use. 64% of the catchment (comprising Location No. 5) is Bantu influenced, and destined to become incorporated into KwaZulu.
The lagoon is surrounded by residential and holiday resort development. On the southern bank is Anerley, and on the northern bank is Sunwich Port.

Local authority. Bendigo.

Estuary uses. No record.

Morphometry of lagoon (see Fig. **94**).
Area. 1,7 ha

Axial length. 500 m

Shoreline length. 1,18 km

Width.
Maximum: 65 m
Mouth: No record
Floodplain: 200 m

Bathymetry. 2 m (in the lower reaches) but shallowing gradually to 0,8 m at the head of the lagoon (pers. obsv. (5 September 1978)).

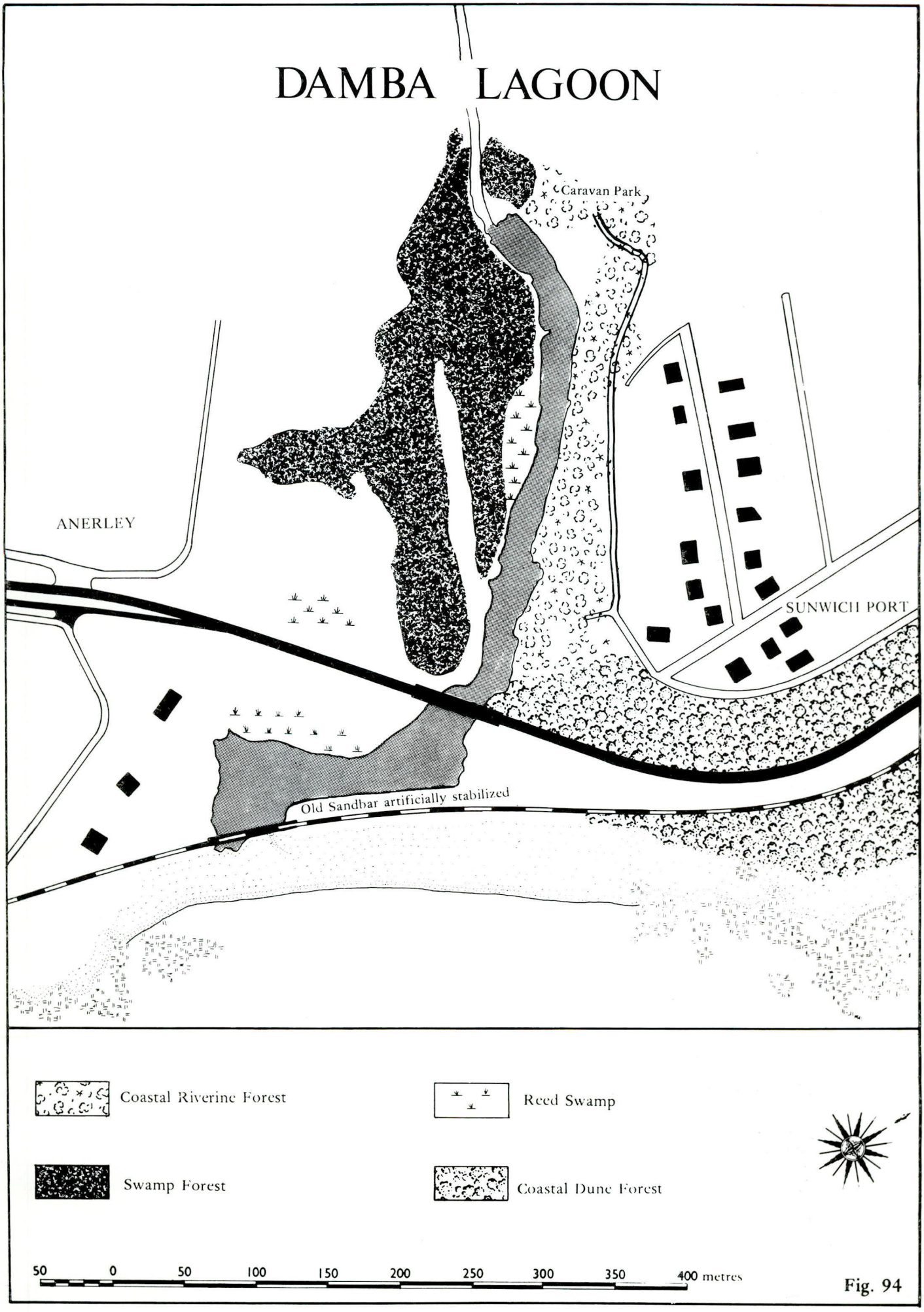

DAMBA LAGOON
Caravan Park
ANERLEY
SUNWICH PORT
Old Sandbar artificially stabilized
Coastal Riverine Forest
Reed Swamp
Swamp Forest
Coastal Dune Forest
50 0 50 100 150 200 250 300 350 400 metres

Fig. 94

Geomorphology

Geology. The geology of the catchment area consists of granites of the Basement complex ([236]). The lagoon is surrounded by Ecca shale, this being most conspicuous where exposed at the coast on either side of the lagoon.

Nature of bottom materials. No record.

Sandbar characteristics. The sandbar at the mouth of the Damba lagoon is south extending, and until artificially stabilized by the railway line, was ± 250 m long. Whether the lagoon level is artificially controlled could not be established, but there appears to be no reason why breaching should be undertaken.

Configuration of adjacent shore ([132]).
Beach type — sheltered bight.

Average beach slope — 7°
Average beach width — 61 m
Average sand grain size — 1 081 microns.
Despite being regarded as sheltered, the nature of the beach is indicative of very rough surf zone conditions.

Surf zone currents. Rip currents are reported to be present in the near vicinity of the lagoon.

Physico-chemical characteristics

There is no information of this sort relating to the Damba lagoon. Some details on the physico-chemical characteristics of the river water 5 km above the lagoon is available ([206]), (see Table **86**). At this point in the river, no signs significant of disturbance were apparent in 1971.

Public health aspects

Bacteriology. There is no information on the bacteriological characteristics of the lagoon, although contamination through seepage from septic tanks is suspected (NTRPC, pers. comm.). Data from the river 5 km above the lagoon in the early 1970's (see Table **87**) indicated that organic enrichment and faecal pollution were of a relatively low order ([206]).

Table 87. Bacteriology of the Damba river (5 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* 1 /100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed
March 1971			206
July 1971			168
4 Feb 1972	224	112	
23 Feb 1972	600	440	3 267
4 July 1972	26	60	
1 Aug 1972	240	140	60*
23 Aug 1972	60	10	49
9 Jan 1973	740	240	200*

* Presumptive counts of *E. coli* 1/100 ml

Table 86. Physico-chemical characteristics.

Locality: Damba river Distance above lagoon: 5km	SUMMER Feb 1971	WINTER July 1971
Hydrogen ion concentration (pH)	8.0	7.4
Saturated pH value	8.4	8.4
Conductivity micromhos/cm	335	390
Total dissolved solids ppm (calcd.)	203	236
Dissolved oxygen mg/litre	7.7	9.2
% Saturation	94	95
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.5	0.5
Kjedahl nitrogen mg/litre	0.4	0.4
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.18	0.25
Phosphates "	0.38	0.16
Total alkalinity "	93.9	83.3
Total hardness "	82.7	83.7
Calcium "	12	12
Magnesium "	12.8	13.1
Sodium "	46	50
Potassium "	1.3	1.8
Sulphates "	10.0	16.9
Chlorides "	62.7	74.4
Silica "	-	-
Iron "	-	-
Fluorides "	0.03	0.03
Free carbonic acid (as ppm carbon dioxide)	1.8	6.2
Temperature °C	26.2	17.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

Bilharzia. To date there is no evidence to suggest that bilharzia snails occur either in the lagoon or in the river above it.

BIOTIC CHARACTERISTICS

Flora

The Damba lagoon is recognised as an important botanical area on the south coast ([189, 244]) because of the swamp forest which fringes the lagoon. It is best developed on the southern bank. The vegetation is described in more detail by Nicholson ([244]), but comprises a particularly fine stand of *Barringtonia racemosa* (fresh water mangrove) *Voacanga thouarsii* (wild frangipani) and *Syzygium cordatum* (Umdoni). *Phragmites* and *Hibiscus tiliaceus* (lagoon hibiscus) occur as a fringe alongside the lower reaches of the lagoon. The seldom seen Toad tree (*Tabernaemontana ventricosa*) is also present.

Above the lagoon is the well preserved vegetation of the Damba river valley, and adjacent to it the Armadale Hill forest ([189]).

Fauna

Although no information on the fauna of the Damba lagoon is available, it is reasonable to assume that due to the well preserved flora, the lagoon and its surrounds are equally well endowed with animal life associated with such vegetation. Some information on the birdlife in the area is provided by Nicholson ([244]).

Information on some of the aquatic communities 5 km above the lagoon is available ([206]). However, the results were disappointing in terms of diversity and numerical abundance.

SYNTHESIS

Our general state of knowledge of the Damba lagoon is poor. In view of its satisfactory environmental condition, more thorough surveys of the lagoon are warranted in order to evaluate its resource and conservation potential. A bacteriological survey is necessary to determine whether the lagoon is polluted by seepage from septic tanks.

Other than the effects of embankments and suspected faecal pollution, the Damba lagoon and its surrounds seems to be free of any serious problems. Care should be taken to ensure that urban encroachment onto vital areas such as the swamp forest, does not occur in the future. This is in fact occurring in the form of a caravan park development at the headwaters of the lagoon (see Fig. **94**).

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																							BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other									Flora			Fauna								Food Webs
DAMBA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids															★							←	★	→	←	———	★	———	★	———	→			
Source of Information	Summary of available information																																		
Nicholson	1969	244																				●		●				●						
Kemp *et al*	1970 to 1973	206	●		●						○				○											○	○							
Fromme	1970 to 1975	132								●																								
NTRPC	1974	236						●																										
Hopwood	1978	189						●																●										
Aerial photos (Scogings)		No.																																
1:10 000 Job No. 261	1976	322		●																				●										
1:25 000 Job No. 262	1976	464	●																															

Synonyms

Care must be taken to ensure that confusion does not arise between the Mhlangamkulu lagoon, and the uMhlangankulu lagoon ± 35 km further south. The qualification (north) and (south) could be adopted as a precaution.

Zulu meaning

The great reedy river ([289]).

Location

30°41'15"S; 30°29'50"E.

Accessibility

By road the Mhlangamkulu lagoon is 120 km south west of Durban. A track along the northern bank of the lagoon renders the upper reaches of the system more accessible than the remaining areas.

Bridges

Both the south coast railway line and national road cross the lagoon on bridges 20 m and 220 m from the mouth respectively. Neither have made any detectable impact upon the system.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 12 km^2

River length. 7 km

Mean annual run-off. No record.

Flow. No record.

Flood history. 1:25 year floods have been estimated to discharge 70 m^3/sec. (Strydom, Newmark & Antony, pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. No record.

Land ownership/use. The entire catchment area is under European owned farms many of which grow sugar cane. On the northern bank of the lagoon is Southport, whilst on the southern bank is Sea Park. Both are residential/resort areas.

Local authority. Bendigo.

Estuary uses. Jetty construction alongside the lagoon is indicative of it being used for boating purposes.

Morphometry of lagoon (see Fig. **95**)

Area. 3,94 ha

Axial length. 900 m

Shoreline length. 2 km

Width.
Maximum: 180 m
Mouth: No record. Aerial photography suggests the mouth may be 35 m wide during flood periods.

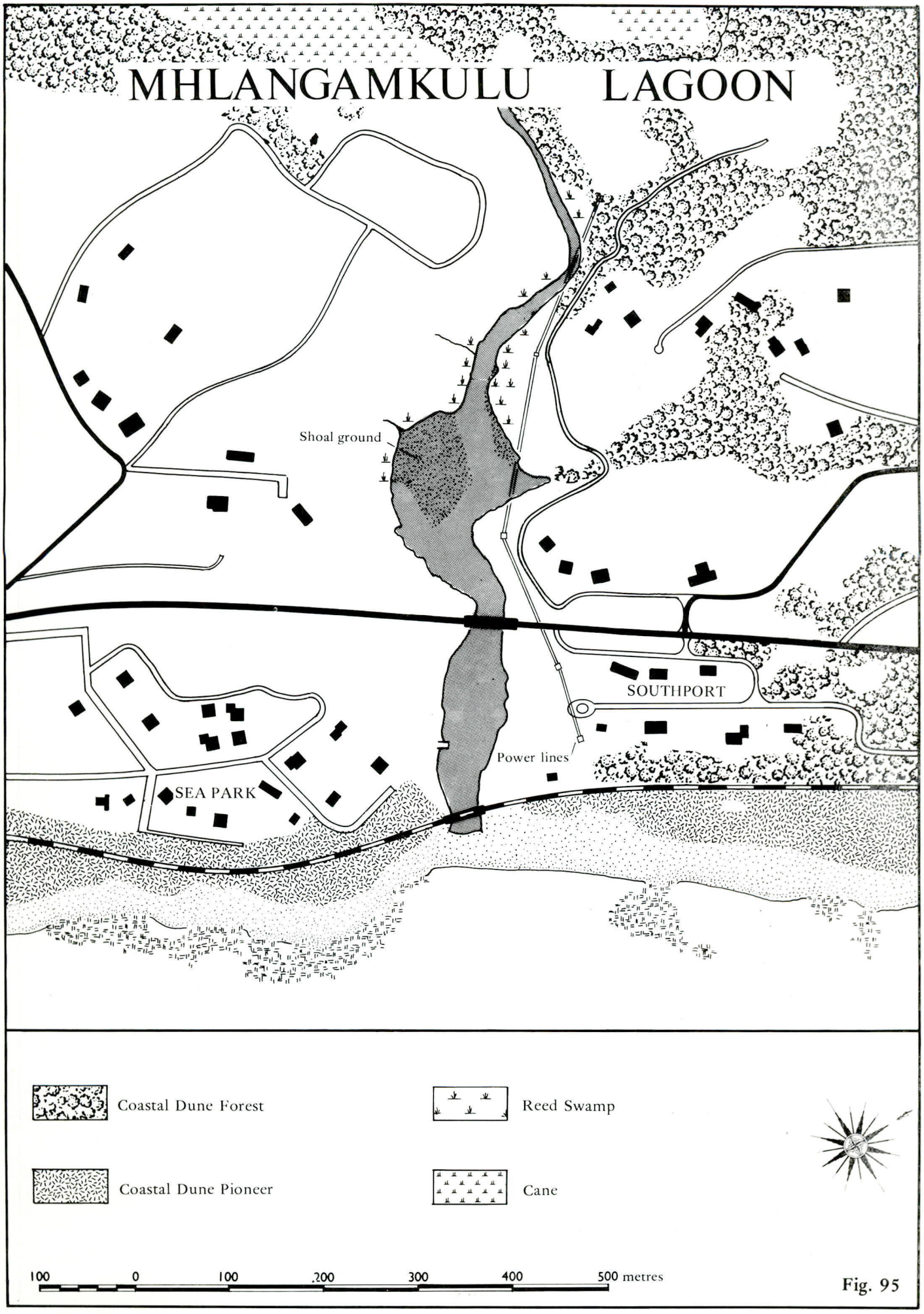

MHLANGAMKULU LAGOON
Shoal ground
SOUTHPORT
Power lines
SEA PARK
Coastal Dune Forest
Coastal Dune Pioneer
Reed Swamp
Cane
100 0 100 200 300 400 500 metres

Fig. 95

Floodplain: 200 m

Bathymetry. No record.

Geomorphology

Geology. Whilst the catchment area is made up of granite, Ecca shale outcrops near the coast and around the lagoon ([236]).

Nature of bottom materials. No record. Where the lagoon broadens in its middle reaches, a shallow area (extending for over 100 m) has developed against the southern bank.

Sandbar characteristics. The Mhlangamkulu sandbar, (behind which the lagoon is sealed) is short (40 m long) and of interest because it does not extend in any particular direction. Being protected by rocks immediately south of the system, probably means that when open, the channel leading to the sea is confined to the southern end of the bar during low flow periods. No information regarding how long the mouth remains open could be found.

Configuration of adjacent shore ([132]).
Beach type — sheltered bight.

Average beach slope — 7°
Average beach width — 75 m
Average sand grain size — 844 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are reported to be absent in the near vicinity of the lagoon.

Physico-chemical characteristics — No record.

Public health aspects

Bacteriology.
Bilharzia.
} No record.

BIOTIC CHARACTERISTICS

Flora

Other than a fringe of reeds (*Phragmites*) on the edge of the lagoon, the surrounding vegetation is disturbed and poorly developed. Consequently the system is of no particular botanical value. However, in the valley of the Mhlangamkulu river above the lagoon, the riparian vegetation is in an undisturbed condition ([189]).

Fauna

No record.

SYNTHESIS

Our general state of knowledge of the Mhlangamkulu lagoon is very poor. Consequently it is practically impossible to make any meaningful assessment of its present environmental condition or its resource potential. Riverine forest communities above the lagoon appear to be intact and worth conserving. In view of our ignorance, the system does warrant an elementary survey, before assigning it to any particular resource category. The lagoon does not appear to suffer from any obvious estuarine problems.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora		Fauna								Food Webs
MHLANGAMKULU ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																								←		★		→			
Source of Information	Summary of available information																														
Fromme	1970 to 1975	132								●																					
NTRPC	1974	236						●																							
Strydom, Newmark & Antony	1977	pers. comm.			●																										
Hopwood	1978	189						●															○								
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 261	1976	324		●						●													●								
1:25 000 Job No. 262	1976	463	●																												

2.1.12.3 **MTENTWENI**

Synonyms

Ententweni (P.W.D. road map in Natal Archives dated 1908).

Zulu meaning

The name comes from the word 'entwetweni' to which various meanings have been given by Stayt ([289]);

(a) the dithering river
(b) the river that glides smoothly
(c) a river of scummy water, and
(d) a river named after a fairly long grass with a sharp point called Umtente (possibly *Juncus*?) that used to grow there.

Location

30°42'30"S; 30°28'45"E.

Accessibility

By road, the Mtentweni lagoon is 123 km south west of Durban. Vehicular access to the edge of the lagoon is limited to the northern bank of its lower reaches. Without the use of a boat, the rest of the lagoon is not easily accessible.

Bridges.

The railway line crosses the lagoon on a bridge 60 m from the mouth. The Mtentweni sandbar has been raised and reinforced to carry the railway line. Between the railway bridge and the national road bridge (500 m inland) are supports of the old railway line. These now carry the main pipe-line of the Lower South Coast Regional Water Supply Corporation across the lagoon. The embankment upon which the old railway line was carried over the floodplain, still occurs on the southern bank.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 41 km^2 ([206]) to 65 km^2. Midgley & Pitman ([223]) estimate the Mtentweni catchment to be 256 km^2 in extent.

River length. 14 km ([206]) to 25,6 km (personal estimate). The Mbenga river is an important tributary.

Mean annual run-off. 3,89 x 10^6 m^3 ([223]).

Flow. A rough estimate of the average flow in 1971 was ,85 m^3/sec. ([206]).

Flood history. No record. However regular, and quite spectacular floods are characteristic (Mason, pers. comm.).

Dams

Existing: None.
Proposed: None.

Siltation. No record. Sand as distinct from silt, appears to be infilling the lagoon. This may relate to the geological nature of the catchment or be due to bank erosion as opposed to sheet erosion.

Land ownership/use. 35% of the catchment area, (comprising Location No. 5) is Bantu influenced, and destined to become incorporated into KwaZulu in the near future. The rest of the catchment area is made up of European owned sugar cane farms. The cane farm adjoining the lagoon is owned by Mr. Stott (Mason, pers. comm.).

On the northern bank of the lagoon (near the mouth) are the flats and holiday accommodation of Bendigo. Elsewhere the northern bank is zoned as Admiralty Reserve.

South of the lagoon is the township of Umtentweni with a population of ± 2 700 (Mason, pers. comm.). Although not holiday orientated or commercialized, noteworthy amongst the influx of visitors each year are a great number of school children (± 2 500 per annum) who come to

Umtentweni for coaching in various types of sports. The southern bank of the lagoon is zoned as public open space, but includes a caravan park and a municipal rubbish dump. Since March 1976, the latter has been used for no other purpose than the disposal of garden refuse.

A proposal has been made to develop/reclaim a low lying marshy area alongside the lagoon on its southern bank. This site may be used as a helicopter pad or for Municipal offices (Mason, pers. comm.).

Estuary uses. The lagoon is not used for any specific purpose although Indians fish and collect bait in the lagoon from the Bendigo side. In 1967 the construction of a weir was proposed, to raise water levels in the lagoon so as to facilitate boating (Jackson, pers. comm.). Several requests to exploit the Mtentweni lagoon for river sand have been made and refused by the Town Management Board (Mason, pers. comm.).

Morphometry of lagoon (see Fig. **96**)

Area. 7,95 ha

Axial length. 2,3 km

Shoreline length. 4,75 km

Width
Maximum: 75 m, although said to be 30 m according to Day ([113]).
Mouth: No record.
Floodplain: 150 m

Bathymetry. Day recorded maximum depths of 2,4 m in the lagoon in 1950 ([113]). More recent information is not available. However, the lagoon is reported by Mason (pers. comm.) to be shallowing steadily.

Geomorphology

Geology. Other than granite throughout the catchment area, there are only Ecca shales which outcrop at the coast ([236]). Bedrock is at 2,8 m below mean sea level ([257]).

Nature of bottom materials. In the 1950's Day ([113]) described the banks of the Mtentweni lagoon as steep, and the bottom materials to grade "from coarse sand on the seaward side to mud on the inshore bank".

Sandbar characteristics. What remains of the old Mtentweni sandbar is south extending and 150 m long. The old sandbar, on which the railway line now runs, was ± 400 m long. The latter has been stabilized on both the seaward side (with rubble) and on the landward side by a concrete retaining wall. The main sea bathing area is just south of the sandbar.

Day mentions that the lagoon was breached artificially when levels were too high and closed artificially if levels were too low ([113]). Mason (pers. comm.) confirms that this was the case until eight years ago, because of a farmer on the banks of the lagoon who used to insist that the lagoon be opened to prevent the flooding of his vegetables.

The lagoon is very seldom open (Maurice, pers. comm.) and was reported to be closed for seven months of the year by Day ([113]). When open, tidal effects are apparent as far as the road bridge (Mason, pers. comm.).

Configuration of adjacent shore ([132]).
Beach type — well sheltered asymmetrical beach.

Average beach slope — 6°
Average beach width — 63 m
Average sand grain size — 419 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents in the near vicinity of the lagoon are recorded as absent.

Physico-chemical characteristics

Data on the physico-chemical characteristics of the lagoon is virtually non-existent, although Day ([113]) recorded in January 1950 that the water of the lagoon was "clear (bottom visible at 0,6 m) warm, and only slightly brackish". He also found evidence of salinity stratification.

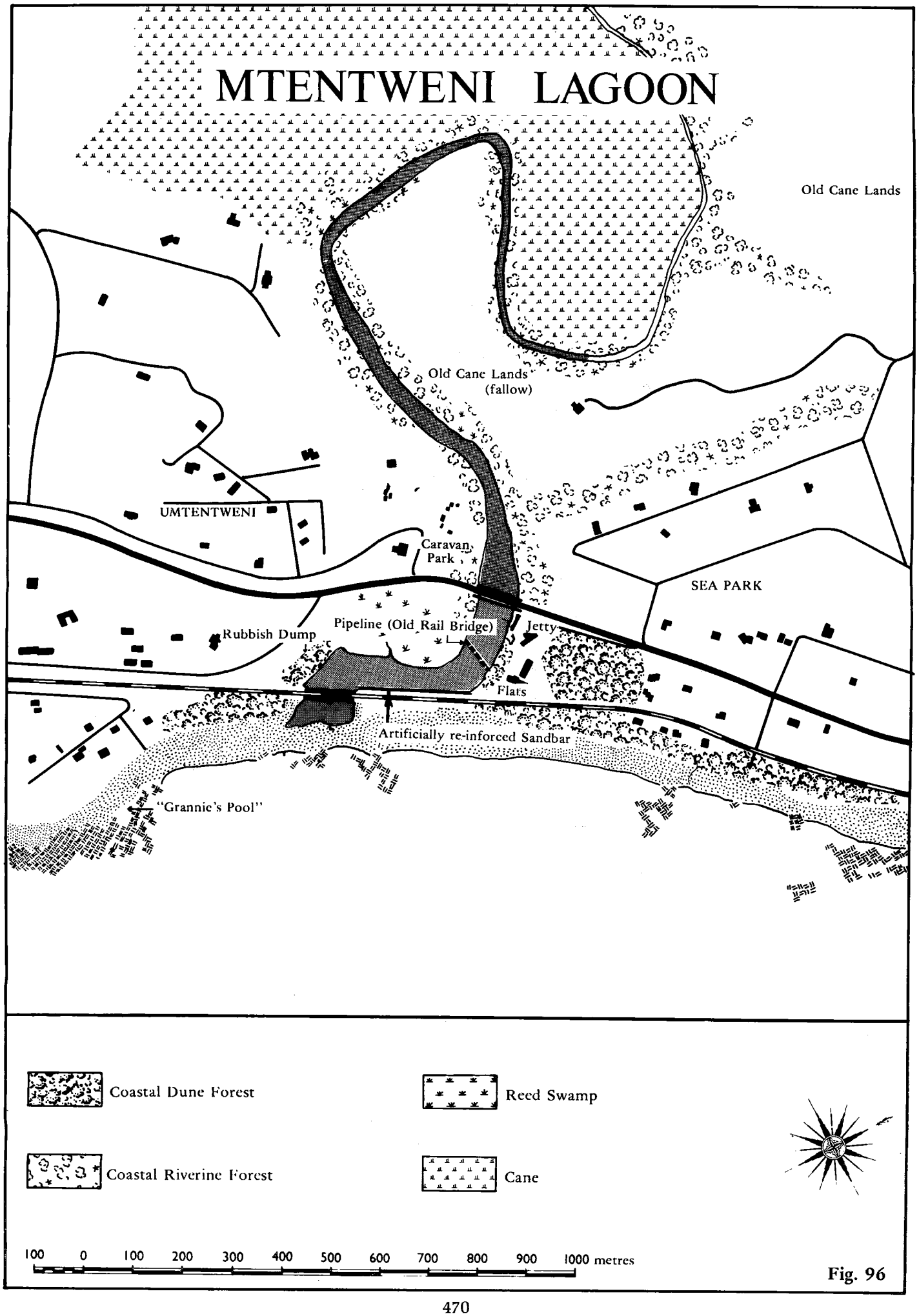

MTENTWENI LAGOON
Old Cane Lands
Old Cane Lands
(fallow)
UMTENTWENI
Caravan
Park
SEA PARK
Rubbish Dump
Pipeline (Old Rail Bridge)
Jetty
Flats
Artificially re-inforced Sandbar
"Grannie's Pool"
Coastal Dune Forest
Reed Swamp
Coastal Riverine Forest
Cane
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 96

Jackson (pers. comm.), recorded surface salinities of 5‰ in the lagoon on 30 October 1972 and 1 November 1973.

From the single rainy season sample from the Mtentweni river in 1971 (see Table **88**) several signs of pollution 4 km above the lagoon were evident ([206]). These resulted in the lower Mtentweni river being assigned to Class V (i.e. of a quality verging on public nuisance levels).

Public health aspects

Bacteriology. There is no information available on the bacteriological characteristics of the Mtentweni lagoon. However, some data on the bacteriology of the river water 4 km above the lagoon is available. ([206]) The results (see Table **89**) indicated that no serious faecal pollution or organic enrichment occurred.

Table 89. Bacteriology of the Mtentweni river (4 kms above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* 1 per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed
March 1971			93
July 1971			226
4 Feb 1972	54	50	
23 Feb 1972	460	240	1 700
4 July 1972	84	**340**	
1 Aug 1972	150	101	
23 Aug 1972	940	350	
9 Jan 1973	340	200	200

Values in bold are significant of disturbance.

Bilharzia. No bilharzia snails were found in the lagoon or the river above it by Jackson (pers. comm.) after inspections made on 30 October 1972 and 1 November 1973. However, only that section of the lagoon below the road bridge is regarded as bilharzia free, because the local authority feel that there is no guarantee that the upper reaches of the lagoon are completely safe (Mason, pers. comm.).

BIOTIC CHARACTERISTICS

Flora

Botanically speaking the Mtentweni lagoon does not appear to be particularly important. Sugar cane encroachment onto the upper reaches and urban encroachment on the lower reaches of the lagoon are largely responsible. Near the mouth, a low lying wetland area covered in *Phragmites* is conspicuous on the southern bank, but may well be reclaimed and developed in the near future (see under Land ownership/use.). Referring to the plant communities around the lagoon in 1950, Day ([113]) recollects "muddy flats covered in rank grass and fringed with *Phragmites* and *Juncus*, and dunes sparsely covered with creepers and grass". Hopwood has drawn attention to potentially valuable sections of riverine forest on the Mtentweni river ([189]).

Table 88. Physico-chemical characteristics.

Locality: Mtentweni river Distance above lagoon: 4km	SUMMER Feb 1971	WINTER
Hydrogen ion concentration (pH)	7.7	
Saturated pH value	8.4	
Conductivity micromhos/cm	279	
Total dissolved solids ppm (calcd.)	171	
Dissolved oxygen mg/litre	9.7	
% Saturation	129	
Oxygen absorbed mg/litre	-	
Biological oxygen demand mg/litre	5.9	
Kjedahl nitrogen mg/litre	0.3	
Ammonia mg/litre	-	
Nitrites mg/litre	-	
Nitrates "	0.11	NO RECORD
Phosphates "	0.40	
Total alkalinity "	83.3	
Total hardness "	75.3	
Calcium "	11.2	
Magnesium "	11.5	
Sodium "	37.5	
Potassium "	1.5	
Sulphates "	14.0	
Chlorides "	44.5	
Silica "	-	
Iron "	-	
Fluorides "	0.4	
Free carbonic acid (as ppm carbon dioxide)	3.2	
Temperature °C	31.0	
Turbidity (ppm silica scale)	-	
Colour (APHA units)	-	
Appearance	-	
Odour	-	

Values underlined significant of disturbance.

Fauna

Only Day's survey (on 22 January 1950) of the fauna of the Mtentweni lagoon is available ([113]). His survey revealed the following:

Lower trophic levels.

(a) Cracker shrimps (*Callianassa kraussi*) were abundant.
(c) Amphipods (*Orchestia*) and isopods (*Alloniscus*) were common.
(c) Gastropods (*Assiminea*), juvenile crabs (*Ocypode*) and shrimps were few.

Assiminea were collected again in the lagoon by Jackson (pers. comm.) in 1972 and 1973.

The sand prawn (or cracker shrimp) population used to be heavily exploited, but is now protected by the local authority. Prawn pumping is permitted under licence at the rate of 20 prawns per permit holder per day (Mason, pers. comm.).

Data on the aquatic fauna of the Mtentweni river 4 km above the lagoon is available ([206]). These results indicated that in 1972 favourable environmental conditions for aquatic life occurred above the lagoon.

Higher trophic levels.

Fish. 11 species were obtained by netting in 1950 ([113]). Those listed as common included — *Sarotherodon mossambicus* (mud bream), *Rhabdosargus holubi* (stumpnose), *Trachystoma euronotus* (mullet), *Gilchristella aesturius* (estuarine round herring), *Ambassis commersoni* (banded glassy) and *Glossogobius giurus* (tank toby).

Anglers reported catches of: *Otolithes ruber* (snapper salmon), *Argyrosomus hololepidotus* (kob or kabeljou), *Lutjanus argentimaculatus* (rock salmon), *Epinephelus* sp. (rock cod) and *Acanthopagrus berda* (perch) ([113]).

Birds. Due to conservation of indigenous bush in the township of Mtentweni, the birdlife is reported to be extremely rich (Tutton, pers. comm.). However the lagoon itself is not important in this regard. In the past fish eagles were once resident (Mason, pers. comm.).

SYNTHESIS

Although a fair amount of information about the Mtentweni lagoon is available, it is unfortunately outdated and can no longer be relied upon to assess the present resource value of the system. It does however provide a background against which any information gathered in the future can be compared. Although degraded, and disturbed in its present environmental condition, biological surveys of the lagoon are warranted. The *Callianassa* population of the Mtentweni is probably one of the richest on the south coast of Natal.

Apart from sanding up, other problems apparent in the lagoon relate to urban and sugar cane encroachment.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other						Flora		Fauna								Food Webs
MTENTWENI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																								←	★	→						
Source of Information	Summary of available information																																
Day	1950	113		●		●	●			●														●		●	●					
Midgley & Pitman	1969	223	●		●																											
Kemp *et al*	1970 to 1973	206	●					●			○				○										○	○						
Fromme	1970 to 1975	132								●																						
Orme	1971	257	●					●		●																						
Jackson	1972 to 1973	pers. comm.				●														●						●						
NTRPC	1974	236						●																								
Mason	1977	pers. comm.		●	●		●			●										●												
Hopwood	1978	189						●															○									
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	327		●																			●									
1:25 000 Job No. 262	1976	462	●																													

Synonyms

Umzimkulu is the most commonly used synonym ([132, 220, 238]).

Zulu meaning

Emzimkhulu is said to mean "the great river" or "great waters" ([289]).

Location

30°44'30"S; 30°27'30"E.

Accessibility

By road, the Mzimkulu estuary is 128 km south west of Durban. It is surrounded by Port Shepstone which is the south coast regional centre. A road and railway line run alongside the southern bank. Port Shepstone is also the terminal railhead, south of which, the railway becomes a narrow gauge line.

Bridges

Both the road and railway line approach the Mzimkulu from the north on a massive common embankment across the floodplain. They cross the estuary on a bridge 150 m from the mouth. There are 14 bridge supports some of which are incorporated into the sandbar itself. The bridge became operational in 1959.

From upstream the bridge piers resemble a semi-closed venetian blind and realign the natural flow of the river. Consequently, bridge pier scour causes strong erosion on the upstream side of the piers ([238]). The old bridge (swept away in May 1959) was on pillar-like supports, which offered less restriction to flow. Many people are convinced that siltation only developed into an acute problem in the Mzimkulu estuary once the new bridge was constructed, because the structure stabilized the spit and interfered with the flow. Orme ([257]) mentions the same thing.

Towards the head of the estuary, at a point known as Batstone's Drift, is the low level Archibald bridge. Immediately below it, the bridge of the south coast freeway is destined to be built. It is significant to note that the design of the new bridge is complicated by the instability of the northern bank above it, because of sugar cane encroachment. It is fortunate however, that the scour channel is on the opposite bank (Dykes, pers. comm.).

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. In terms of its catchment area, the Mzimkulu is the third largest river system in Natal ([242]). Estimates of the catchment size are:-

6 617 km^2 ([213])
6 643 km^2 ([206, 245])
6 700 km^2 ([242, 257])
6 750 km^2 ([85] , and Dykes pers. comm.).
6 760 km^2 ([223])

River length. 319 km ([213, 242, 257]) to 340 km (Dykes, pers. comm.).

Mean annual run-off. In terms of run-off, the Mzimkulu is the second largest river in Natal. For the period 1931 to 1968, the mean annual run-off was estimated to be 1 610 x 10^6 m^3 ([213, 242, 257]). Estimates by Midgley and Pitman are slightly less, i.e. 1 300 x 10^6 m^3 ([223]).

Flow. A rough estimate of the average flow in 1970, was 51 m^3/sec. ([206]).

Flood history. The most destructive, largest flood from the Mzimkulu was in May 1959. On this occasion the old combined rail/road bridge was swept away ([220, 242]). Maud (pers. comm.) claims that levels rose 13,4 m, at which stage the river was discharging 8 570 m^3/sec. Within the time span of a century, no flood has exceeded that experienced in 1959.

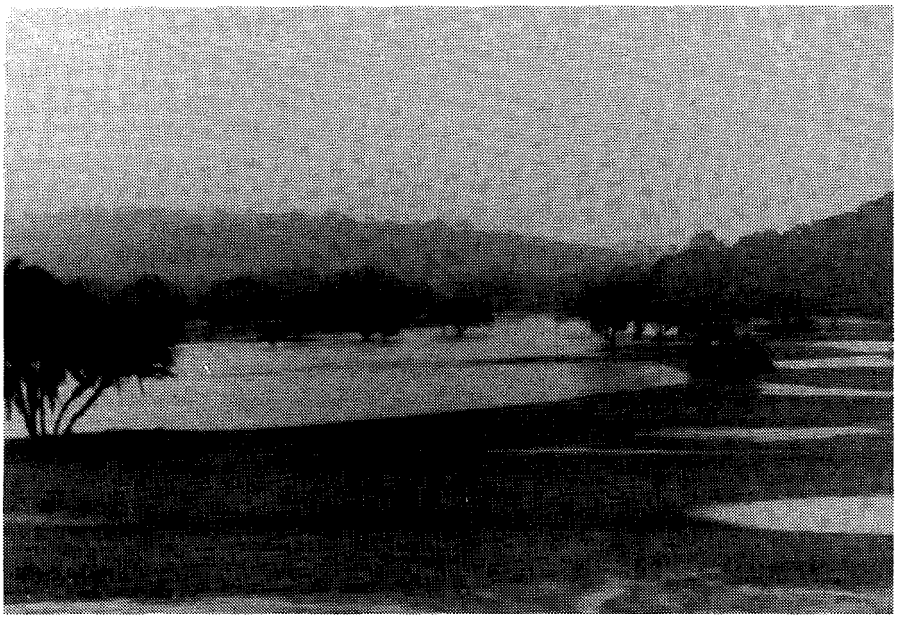
According to different opinions, the estuary became scoured to a depth of 9 m exposing the rock on which the bridge caissons were founded ([220]), and extensive damage was done to the Umzimkulu Sugar Mill.

Erosion and scour was so severe that the offshore bar which formed at the mouth of the Mzimkulu, extended 1,2 km and necessitated the issue of a warning notice to mariners ([220]).

In 1963 river levels rose 12,2 m (Maud, pers. comm.), and since then the bed level of the

estuary has been steadily rising, which means that the next really large flood is liable to have disastrous effects, because of the decreased capacity of the system.

The Archibald bridge is regularly overtopped during the rainy season, as is the golf course on the floodplain. According to which formula is used, the discharge of a 1:50 year flood is estimated to range from 2 350 m^3/sec. to 9 400 m^3/sec. (Dykes, pers. comm.). A realistic figure is probably 4 000 m^3/sec.



Flooding of the golf course on the Mzimkulu floodplain is not an unusual event (April 1978).

Level fluctuations. 800 m from the mouth, a tidal range of 1,5 m (varying according to rainfall and river level) was recorded by Day in January 1950 ([115]). On a high spring tide in 1974 tidal influences were detectable 3 km inland ([85, 89]).



Silt plumes emanating from the Mzimkulu estuary in December 1971 (photo by E. Moll). They are surface phenomena, but notice the tendency for them to be carried north before streaming south under the influence of the nearshore current.

Dams.
Existing: The Gilbert Eyles dam has been built on a tributary called the Mzimkulwana ([236]).

Proposed: ([245, 271])
(a) The Ili Forest dam site (with a total capacity of 503 x 10^6 m^3) is 240 km above the estuary.
(b) The Gibraltar dam site (with a total capacity of 1 615 x 10^6 m^3) is 39 km above the estuary.

Siltation. The Mzimkulu river carries a tremendous amount of silt down to the sea. At the proposed Gibraltar dam site, annual siltation is estimated to be 2,94 x 10^6 m^3 ([236]). Another indication of the quantity of silt borne by the Mzimkulu is that 41% of the Gilbert Eyles dam silted up in 6½ years, and 25% of its capacity was lost in one storm (May 1959) ([220]).

Day ([113]) recalls the deposition of 0,3 m of silt next to a jetty during the course of the few days that he was studying the estuary in January 1950. A pleasure launch which used to provide cruises up and down the estuary, eventually had to resort to a towing chain behind it in order to create a channel for itself to move in. NRIO consider the estuary to be unsuitable for recreational purposes because of silt pollution ([238]). Since floods in 1976, the island shown as present amidstream of the estuary in the photograph on the previous page, and by Connell *et al* ([89]), no longer exists.

Land ownership/use. The Mzimkulu catchment extends beyond Natal into the Transkei. Despite the opinion expressed in ([85]) there are numerous Bantu locations within Natal (such as the Ingwanewane Locations No's 1, 6 and 8) and in the Transkei (such as Insikeni Location No. 3, the Dumakude Location No. 7, the Gugweni Location No. 2, the Umfulamuhle Location No. 9 and the Imvubukazi Location No. 10) from which the silt load of the Mzimkulu is said to emanate. Near Harding, forestry areas are conspicuous, and nearer the coast, sugar farming is practiced.

On the northern bank of the estuary is the residential area of Shepstone North or Umtentweni, a golf course, sports club and yacht club.

On the southern bank of the estuary is the town of Port Shepstone, economically dependent upon various light industries (in Marburg) and quarrying. The expansion of quarries and the development of a cement factory is anticipated. Although a paper mill is shown on the southern bank of the estuary (on the 1:50 000 series sheet No. 3030 CB), a sugar mill belonging to the Mzimkulu Sugar Company exists.

Local authority. The southern bank is controlled by the Borough of Port Shepstone, and the northern bank by the Umtentweni Town Board.

Estuary uses. The estuary and its surrounds is used for a variety of recreational purposes such as power boating, angling, golfing, yachting and walking. In the past, the construction of a harbour has been proposed on a number of occasions. 70 years ago the Mzimkulu was navigable by small ocean going coasters, and barges carrying marble, lime and sugar were used in the estuary.

Morphometry of estuary (see Fig. **97**).

Area. The actual estuary limits are difficult to demarcate, but on the basis of Day's survey ([115]) and the observations of Maurice (pers. comm.), the estuary has been assumed to incorporate an area 73,9 ha in size.

Axial length. 5,5 km

Shoreline length. 11,2 km

Width.
Maximum: The estuary is 200 m at its widest point, although the channel is generally little more than 100 m wide ([242, 257]).
Mouth: The mouth varies in width from 10 m ([85]) to 120 m ([242]).
Floodplain: 1,0 km to 1,3 km ([242, 257]) wide, most of which is occupied by a golf course.

Bathymetry. Colonial engineers found the estuary to maintain a depth of 6 m for 8 km inland ([257]). Maud (pers. comm.) claims that at the turn of the century, the Mzimkulu river used to be 24 m deep at Helen's rocks — 9 km above the mouth. Early maps in the Natal Archives (dated 1881) (see Fig. **98**) indicate depths of 2,7 m at the mouth. In the early 1950's, Day recorded depths of 3,9 m at high tide and of 2,4 m at low tide, 800 m from the mouth ([115]). Maurice (pers. comm.) estimates the estuary to be 4 m deep at high tide near the bridge, but within 500 m of the mouth it shallows rapidly. After a survey in 1974, Connell *et al* made very similar observations.

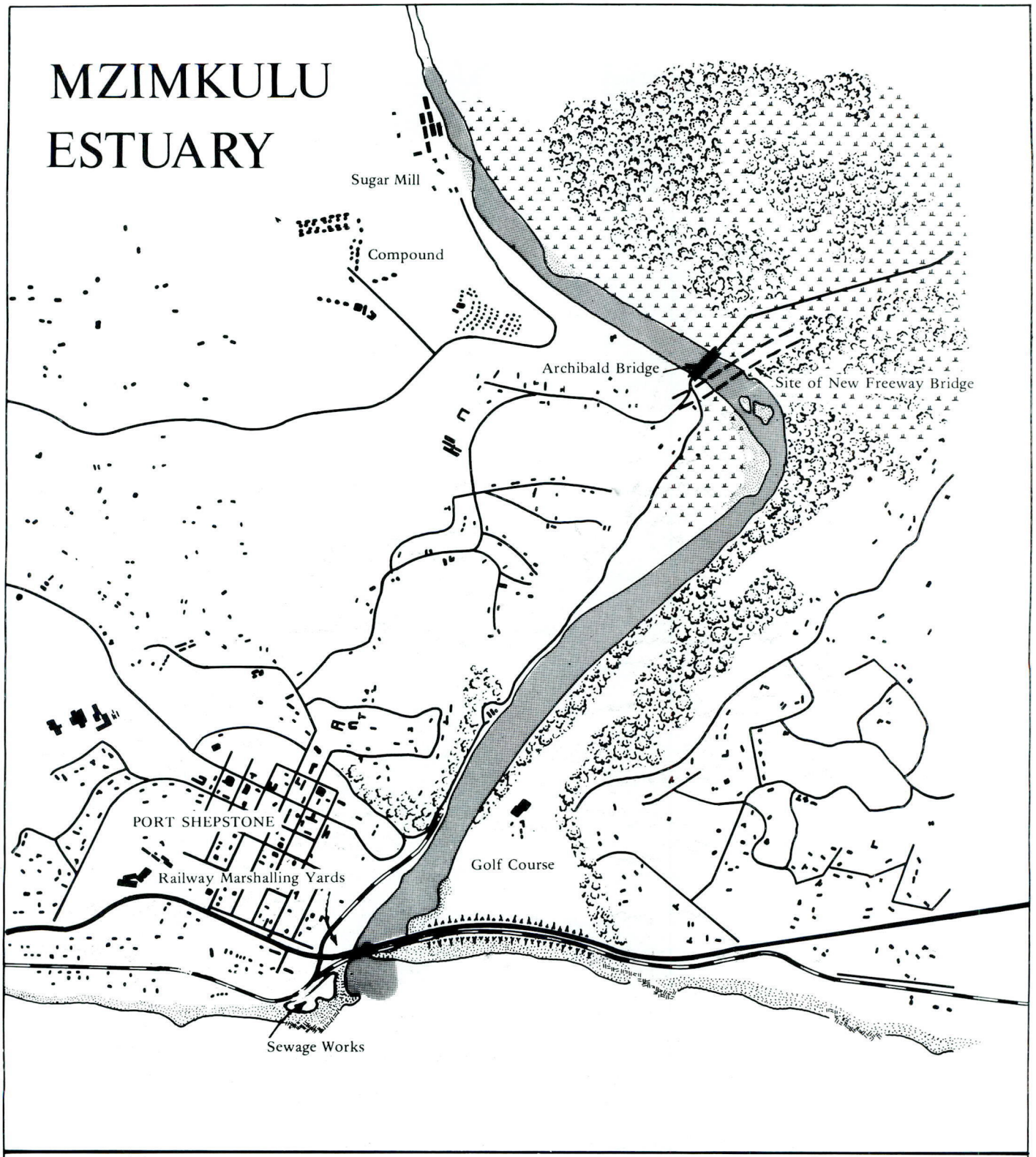

MZIMKULU
ESTUARY
Sugar Mill
Compound
Archibald Bridge
Site of New Freeway Bridge
PORT SHEPSTONE
Railway Marshalling Yards
Golf Course
Sewage Works
Coastal Dune Forest
Cane
500
0
500
1000
1500
2000 metres

Fig. 97

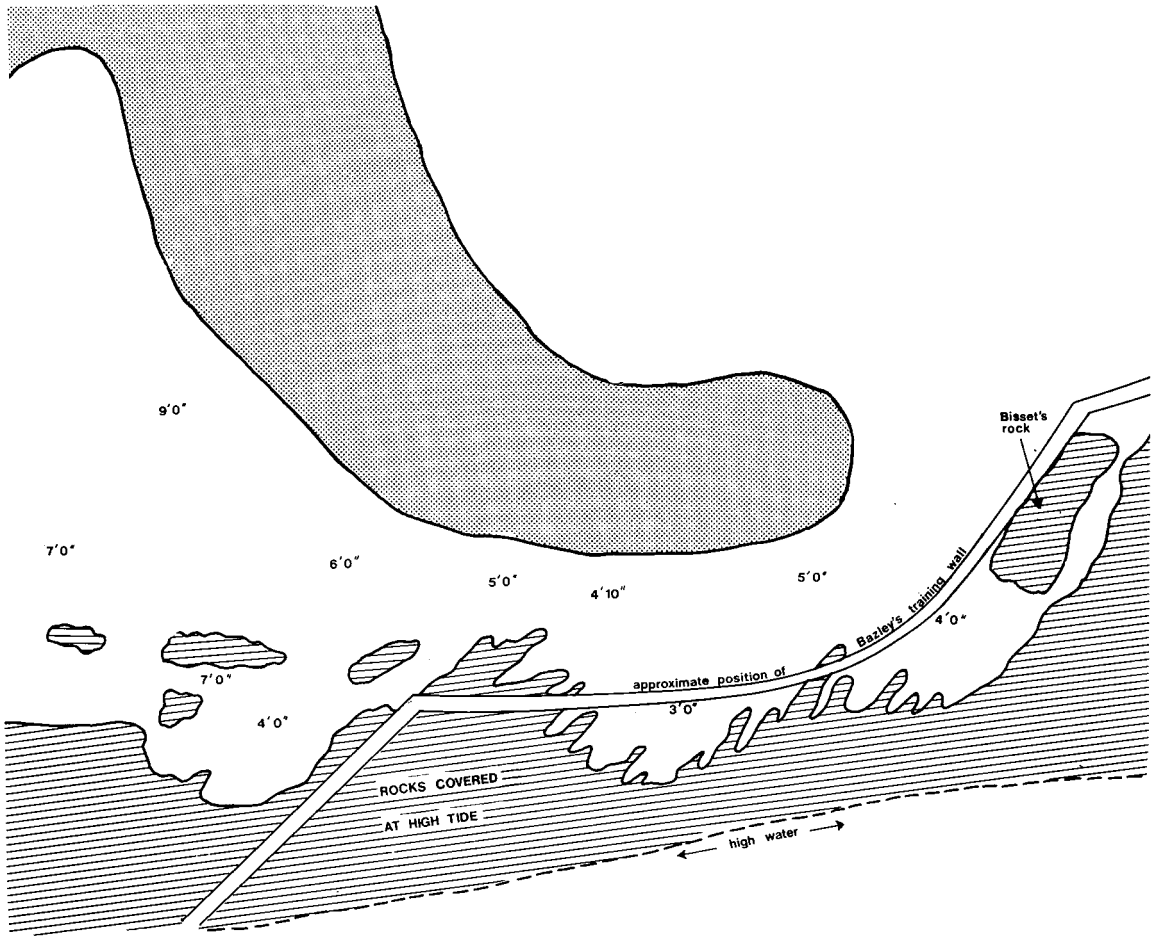


Fig. 98. Soundings made in the mouth of the Mzimkulu estuary on 5 October 1881. (Copied from a map in the Natal Archives).

Currents. Day ([115]) estimated outflowing currents to be swift and in the order of 1 m/sec. In the floods of May 1959, the mean current velocity was estimated at 50 km/hour (= 13,8 m/sec.) ([257]).

Geomorphology

Geology: From its source to the sea, the Mzimkulu river crosses Stormberg basalts (in the Drakensberg), rocks of the Beaufort, Ecca and Dwyka series, Table Mountain Sandstone and old granites ([245]). At the coast, the northern bank of the Mzimkulu is made up of Ecca shale and the southern bank of Dwyka conglomerates ([236]). At the mouth, bedrock is Dwyka tillite, 4 m to 15 m below mean sea level ([257]). Dykes (pers. comm.) has shown from seismic surveys that at the site of the proposed freeway bridge (3,6 m above the mouth), bedrock lies 60 m below the estuary floor. At this location, bedrock on the southern bank comprises fractured dolerite.

Nature of bottom materials. In 1950 both banks of the estuary were composed of very soft mud in the intertidal zone ([115]). These banks became more extensive higher up the estuary, especially on the southern side. At the mouth, only sand of marine origin occurs ([257]). Dykes (pers. comm.) has shown that 3,6 km inland a large clay lens exists ± 30 m below silty sand. This is indicative of lagoonal deposits laid down when the estuary was much deeper.

Sediment quality: After a survey in 1974, high concentrations of zinc were revealed in the sediments of the Mzimkulu estuary. Oxygen absorbed and Kjedahl nitrogen values indicated that in isolated patches, sediments high in organic content occurred. The sediments of the Mzimkulu were found to contain no chlorinated pesticides ([85, 89]).

Sandbar characteristics. The Mzimkulu spit is a massive south extending barrier, originally over 1 000 m long. Some 750 m of this spit has now been stabilized by road and rail construction. The

response of estuary and spit, prior to bridge construction, can be seen in Fig. **99**. This reveals how the geometry of the spit changed between 1891 and 1895. The response of the spit to the floods in March 1891 should be noted.

As early as 1881, protracted efforts were made by engineers to make the Mzimkulu navigable. Rocks on the southern bank (see Fig. **98**) had to be removed and a 150 m long concrete training wall (Bazley's wall) constructed ([189, 242]). Although it was hoped that natural scour would maintain a deep water anchorage, dredging was also contemplated.

Several groins were built in an attempt to stabilize the spit, and thus keep the mouth open. Sedimentation and problems associated with movement of the spit forced harbour plans to be abandoned early in the 20th century ([242]).

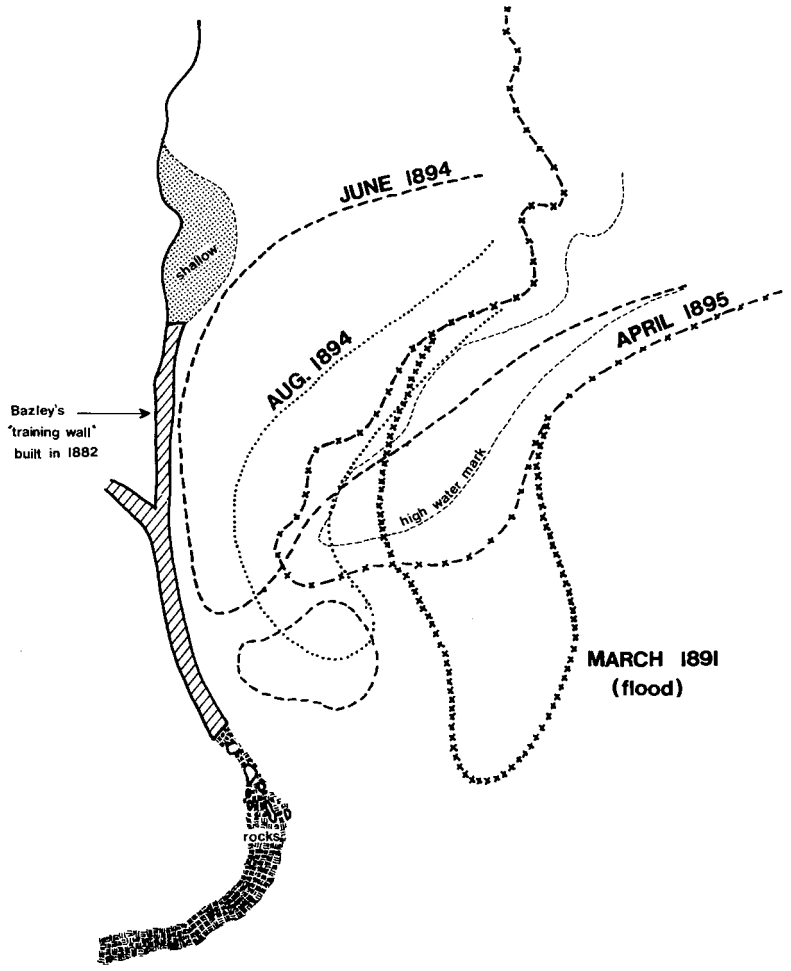
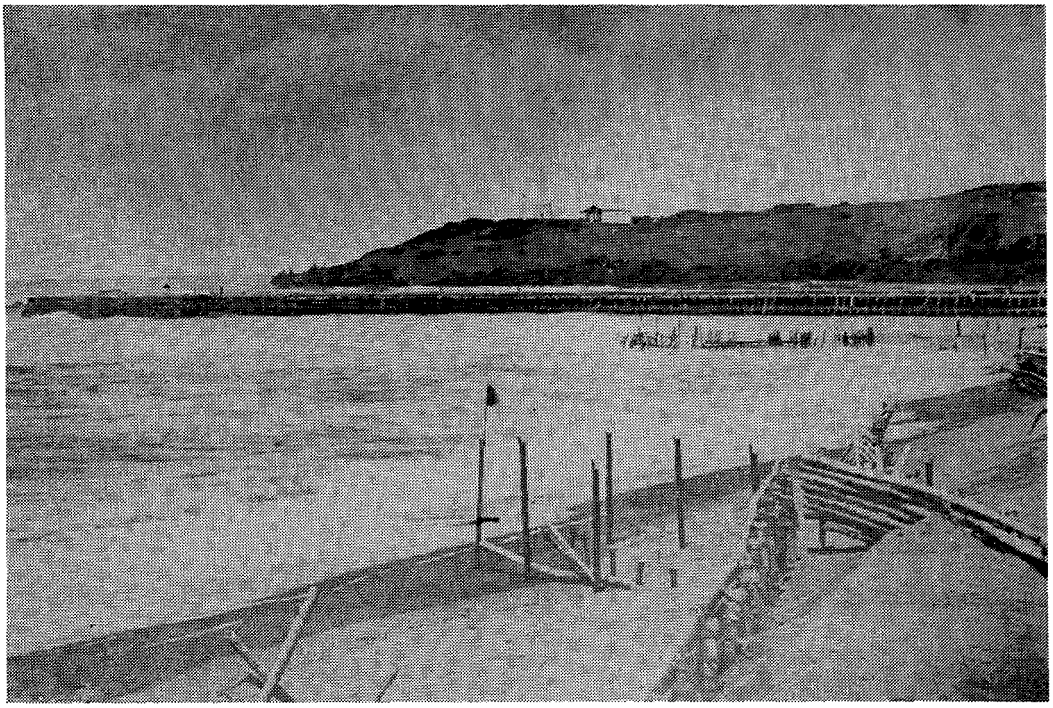


Fig. 99. Movement of the sandbar at the mouth of the Mzimkulu estuary in the 1890's (copied from a map in the Natal Archives).

Surprisingly enough, the mouth position can alter (Maurice, pers. comm.) and in dry years it can close in winter ([242]). North east gales, on a spring tide are generally responsible for closing the mouth of the Mzimkulu (Mason, pers. comm.). On such occasions breachng is necessary to prevent flooding of the golf course, and the Umtentweni Town Board is responsible for such action. The problem was considered to be sufficiently serious to involve NRIO in the feasibility of building another training structure at the mouth of the estuary to keep it open ([242]).

Configuration of adjacent shore ([132]).
Beach type — sheltered asymmetrical beach.

Average beach slope — 8°
Average beach width — 112 m
Average sand grain size — 1 053 microns
} indicative of very rough surf zone conditions.



A photograph (copied from a Mercury Pictorial dated 30 March 1911) showing the groynes which were built on the Mzimkulu sandbar in the 1890's.

Surf zone currents. The surfzone current is set strongly towards the north (Mason, pers. comm.). However, the preceding photograph by Moll (see under siltation) illustrates how sediment plumes from the Mzimkulu are taken northwards for a short distance before being carried south by the longshore current which, at this point in Natal, can be close inshore ([281]). The silt plumes described by Day ([115]) were said to stream south under the influence of the north east winds, but go northwards in the absence of wind, in response to the surfzone current direction.

Physico-chemical characteristics

Thermal properties. Surface temperatures of 24,5°C in the estuary, were recorded by Day in January 1950 ([115]). In August 1974 however, surface temperatures of 16,3°C to 16,°C were characteristic of the whole estuary ([89]). These were shown by Connell *et al* to be river temperatures, as the river water remained at the surface of the estuary.

Water transparency. During the rainy season, the water is normally very muddy. Day recorded Secchi disc values of less than 12,5 mm throughout the estuary, at all states of the tide in January 1950 ([115]), and commented on silt plumes which extended far out to sea, and chocolate brown breakers.

Salinity. Salinity stratification (i.e. fresh water of low salinity over-riding saline water) is generally evident in the Mzimkulu estuary ([89]). During floods, stratification breaks down, at which stage the estuary is transformed temporarily into a river mouth.

Nutrients. The levels of ammonia in the estuary in August 1974, were considered to be high, due to contaminated sea water entering the estuary from the Port Shepstone marine outfall/ sewage discharge near the estuary mouth ([85]). Nitrate and phosphate were within normal estuarine ranges.

Heavy metals. After examining the water in August 1974 for mercury, copper, lead, cadmium and zinc ([89]) metallic contamination of the estuary by lead and mercury was revealed. A specimen of *Acanthopagrus berda* (perch) taken from the estuary contained 0,207 mg Hg/kg ([85]). Heavy metal contamination may originate from the factories and industries of Marburg.

Pollution. Whilst the analyses of Kemp *et al* ([206]) (see Table **90**) showed no signs of pollution, no rainy season sample was taken **below** the sugar mill, which is an obvious pollution source. However, organic pollution of the estuary was established by Connell *et al* in 1974 ([89]).

Table 90. Physico-chemical characteristics. ([206])

Locality: UMZIMKULU Distance above estuary:	SUMMER 1970 1km (Station RR5)	WINTER 1970 Archibald Bridge (Stn RR6)
Hydrogen ion concentration (pH)	8.1	8.1
Saturated pH value	8.9	8.7
Conductivity micromhos/cm	94	151
Total dissolved solids ppm (calcd.)	72	102
Dissolved oxygen mg/litre	9.3	10.0
% Saturation	101	91
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.5	3.6
Kjedahl nitrogen mg/litre	0.3	nil
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.08	0.24
Phosphates "	0.09	0.05
Total alkalinity "	39.5	59.4
Total hardness "	31.9	54.9
Calcium "	7.7	9.1
Magnesium "	3.1	7.8
Sodium "	7.9	14.0
Potassium "	0.6	0.8
Sulphates "	3.3	2.7
Chlorides "	9.2	14.5
Silica "	-	-
Iron "	-	-
Fluorides "	0.1	0.2
Free carbonic acid (as ppm carbon dioxide)	0.6	1.0
Temperature °C	20.0	11.4
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	Turbid	Poor
Odour	-	-

Values underlined significant of disturbance.

Public health aspects

Bacteriology. From what bacteriological information is available, the estuary and river above it appear to be remarkably clear of faecal pollution ([85, 206]) (see Table **91**) and only sporadic organic enrichment was evident. However, if ammonia levels are high due to contaminated seawater entering the estuary from the sewage works at the mouth ([85]), then *E. coli* levels must presumably also be high on these occasions.

Table 91. Bacteriology of the Mzimkulu river (1 km above the estuary). ([206])

Date	Total Plate Count per ml x 10^3		*E. coli* 1/100 ml	
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Presumptive	Confirmed
4 Feb 1972	36	**384**	400	
25 Feb 1972	230	122	60	60
4 July 1972	160	270	200	—
2 Aug 1972	44	16	30	
23 Aug 1972	70	**130**	40	—
9 Jan 1972	160	**300**	800	640

Values in bold are significant of disturbance.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora.

In January 1950, Day ([115]) drew attention to a fringe of *Hibiscus tiliaceus* and *Phragmites* along the northern bank of the estuary, which varied in breadth depending on how flat the banks were. He described a small salt marsh near the old ferry site (comprising *Juncus* and *Salicornia*) and a carpet of green "*Vaucheria*-like" algae on inter-tidal mud flats. *Zostera* was absent.

Although golf course development on the northern bank of the estuary has eliminated much of the original vegetation, it is here that coastal forest on the steeply sloping sides of the Mzimkulu valley has been retained ([189]). Until persuaded to reposition it, proposals by the South African Railways to build a railway line along this bank to serve the proposed cement factory, threatened to interfere with these forest communities (([189]) and Mason, pers. comm.).

On the southern bank, vegetation alongside the estuary has been ruined by road construction and sugar cane encroachment. Sugar cane has also been planted above the estuary on its northern bank.

It may be of interest to readers that the Kaffirboom (*Erythrina caffra*) has a special significance in the Port Shepstone area, as it is believed to have been introduced to the region by the Portuguese in the 18th Century. Consequently the Kaffirboom features prominently on the Umtentweni flag (Mason, pers. comm.).

Fauna

Lower trophic levels.

Zooplankton: Grindley (pers. comm.) has samples of zooplankton from the Mzimkulu (taken in ± 1968) the examination of which has not yet been undertaken. In August 1974, the copepod *Pseudodiaptomus hessei* was found by Connell *et al* in the upper reaches of the Mzimkulu estuary, whilst *Paracalanus crassirostris* was common throughout ([89]). The presence of a new species of *Diaixis* was reported. Connell *et al* ([89]) considered the absence of mysids and of the copepod *Acartia natalensis* as indicative of a disturbed estuarine environment.

Benthos: The benthic fauna of the Mzimkulu estuary is regarded as being poorly developed, by most workers. It was described as extremely poor by Day in January 1950 ([115]). Excluding 13 species of rock dwelling molluscs on Bazley's wall, he reported the presence of four species of crabs (*Sesarma eulimene* as common) four species of prawns (*Metapenaeus monoceros* and *Palaemon pacificus* as common) a shrimp (*Caridina*), a tanaid (*Apseudes*), an isopod (*Philoscia*) and an amphipod (*Grandidierella*). *Penaeus indicus* was considered to be a noteworthy absentee in 1950.

In any event his survey was more productive than those of Connell *et al* ([89]) in August 1974. In the latter case, the low species diversity, and the frequent occurrence of high counts of single species, were indications of organically enriched conditions. The Umzimkulu sugar mill above the estuary, was considered to be responsible. High numbers of the oligochaete (*Paranais frici*) amongst clumps of detritus, was reported. Mason (pers. comm.) says that there is a small colony of cracker shrimps (*Callianassa kraussi*) on the northern bank, which is dwindling in size due to pollution by the sugar mill.

Samples of the bottom fauna of the Mzimkulu river, taken from just above the estuary ([208]), are of interest in that the low species diversity and the occurrence of high counts of single species, is similar to the situation in the estuary itself. For example, 66% of the animals in the bottom sediments were comprised of the annelid *Limnodrilus*, and amongst the marginal vegetation, 72% of the population was made up of the annelid *Chaetogaster*.

Higher trophic levels.

Fish: Twelve species of fish were recorded by Day as present in the estuary in January 1950 ([115]), the commonest being perch (*Acanthopagrus berda*) and mullet (*Mugil cephalus*). He considered stumpnose (*Rhabdosargus holubi*) to be notably absent, and made mention of large sharks that could be seen swimming around in the mouth of the estuary.

Maurice (pers. comm.) says that the Mzimkulu estuary is noted for its grunter (*Pomadasys commersoni*) during the period August to October. Only the odd perch (*Acanthopagrus berda*) and kob (or salmon, *Argyrosomus hololepidotus*) are taken by anglers within the estuary, despite the fact that seaward of the Mzimkulu sandbar, the area has a very fine reputation for catches of kob in summer. In season, good catches of garrick (*Lichia amia*) and shad (*Pomatomus saltatrix*) are also made, opposite the Mzimkulu sandbar.

Birds. Although Day ([115]) reported the presence of "very few wading birds" in January 1950, in December 1972 Sinclair (pers. comm.) reported 23 species of estuarine dependent birds on the Mzimkulu estuary, including 11 species of recognised waders. However, in January 1977, observations by Nicholls (pers. comm.) revealed only four species of terns to be present. He attributed the paucity of estuarine dependent birds to the lack of intertidal areas suitable as feeding grounds.

Reptiles: Until five years ago, a large turtle used to be seen regularly exploring the Mzimkulu estuary (Maurice, Mason, Berry, pers. comm.). According to Hughes (pers. comm.) this was probably a logger-head (in search of molluscs) or a green turtle (in search of *Zostera* or algae). However, in view of the known absence of such food ([89, 115]) the regular occurrence of a turtle in the Mzimkulu estuary is difficult to explain.

SYNTHESIS

Our state of knowledge of the Mzimkulu estuary is fairly good, but is nowhere like what it should be. Although in a degraded condition because of siltation (itself a result of erosion in the catchment and the stabilization of the sandbar through road and rail construction), the present resource potential of the estuary is difficult to assess. Its significance lies in its size, despite being polluted organically (from the sugar mill) by certain heavy metals, and by sewage ([85]). A determined effort should be made to eliminate such contaminants, particularly as industrial expansion in the vicinity of Port Shepstone is anticipated, and with it, the likelihood of increased pollution. This is also important because at present the estuary mouth very seldom closes, which means that effluents are adequately diluted by seawater. However, with the construction of the Gibraltar dam, the increased abstraction of water by industries, flood abatement and a reduction in flow, the estuary mouth may begin to close more often and for longer periods of time. If this is the case pollution levels and flushing of the estuary may become critical in the future. The benefits of the Gibraltar dam acting as a silt trap on the Mzimkulu must also be weighed up against disadvantages such as beach starvation due to the interception of sand. On the south coast of Natal, the latter could have important economic and ecological consequences.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other								Flora			Fauna								Food Webs
MZIMKULU ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles				
Data Voids							★				★															◄	★	►							
Source of Information	Summary of available information																																		
Hime	1881	Maps in Natal Archives		●						●												●													
Anon	1891 to 1896									●												●													
Kinsey				●																		●													
Day	1950	115		●	●	●				●													●		●	●	●	●							
Meinecke	1959	220			●					●																									
Midgley & Pitman	1969	223	●		●																														
Kemp *et al*	1970 to 1973	206	●		●						○					○										○	○								
Fromme	1970 to 1975	132								●																									
Loxton, Hunting & Assoc.	1971	213	●		●																														
Ninham, Shand & Partners	1971	245	●					●																											
Orme	1971	257	●		●		●	●		●																									
Sinclair	1972	pers. comm.																											●						
Connell *et al*	1974	89				●				●	●		●	●											●		●								
NTRPC	1974	236						●		●																									
NRIO	1974 to 1975	238								●																									
Cloete & Oliff	1976	85	Summary of Connell *et al* [89]																																
NRIO	1977	242								●																									
Dykes (Jeffares & Green)	1977	pers. comm.	●					●		●																									
Nicholls	1977	pers. comm.																											●						
Mason	1977	pers. comm.					●			●											●						●				●				
Maurice	1977	pers. comm.																									●	●			●				
Hopwood	1978	189						●														●		○											
Aerial photos (Scogings)		No.																																	
1:10 000 Job No. 261	1976	331		●																				●											
1:25 000 Job No. 262	1976	460		●						●														●											

Synonyms
Imbonga, (map dated 1908, in Natal Archives); Imbango (undated Geodetic map of Beacons in Natal Archives).

Zulu meaning
No record.

Locations
30°45'30"S; 30°27'E.

Accessibility
By road the Mbango lagoon is 2 km south west of Port Shepstone and 130 km south west of Durban. It is best approached from the south along a track leading to the mouth, on the seaward side of the railway line.

Bridges.
Both the railway line and the national road cross the lagoon on bridges 200 m and 650 m from the mouth respectively. Neither appear to have created any adverse effects on the lagoon.
Although well above the lagoon, the bridge for the proposed freeway is to involve the diversion and partial canalization of the Mbango river (Dykes, pers. comm.).

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 12 km^2

River length. 8 km

Mean annual run-off. No record. Much of the Mbango catchment is urbanized. Consequently there is likely to be more run-off than anticipated.

Flow. No record.

Flood history. Depending on which formula is used 1:50 year floods are estimated to discharge between 78 m^3/sec. and 145 m^3/sec. (Dykes, pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. No record. Although there is a minimum of agricultural sources in the catchment from which silt could be generated, and riparian vegetation appears intact, siltation rates may increase in the future with the construction of the south coast freeway above the lagoon.

Land ownership/use. The Mbango catchment is primarily influenced by extensions to Port Shepstone such as Marburg. The increased development of light industries in this area has been proposed. There is a large quarry upstream of the Mbango lagoon, which is owned by the local authority.
The edges of the lagoon have been zoned as either public open space or as a railway reserve. Alongside these reserves, residential development has taken place on both sides of the lagoon.

Local authority. Marburg.

Estuary uses. No record.

Morphometry of lagoon (see Fig. **100**)
Area. 0,9 ha

Axial length. 650 m

Shoreline length. 1,3 km

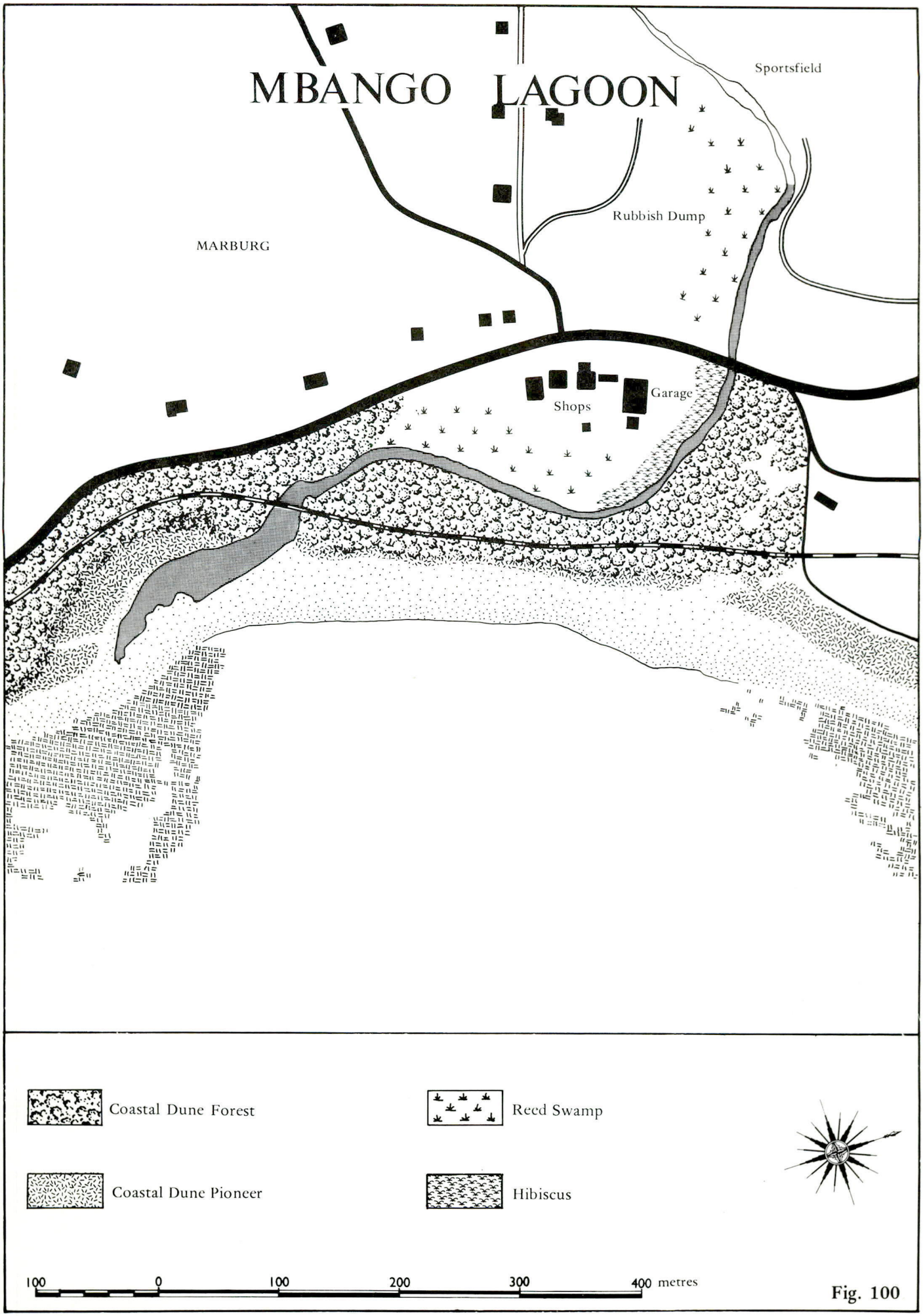

MBANGO LAGOON
Sportsfield
Rubbish Dump
MARBURG
Garage
Shops
Coastal Dune Forest
Reed Swamp
Coastal Dune Pioneer
Hibiscus
100 0 100 200 300 400 metres

Fig. 100

Width.
Maximum: 35 m
Mouth: No record.
Floodplain: 60 m

Bathymetry. No record.

Geomorphology

Geology. Both catchment and lagoon are made up of Dwyka tillite ([236]).

Nature of bottom materials. No record.

Sandbar characteristics. The lagoon lies impounded behind a 180 m long south extending bar. Whether artificial breaching occurs could not be ascertained, however, the mouth position is clearly stable and confined to the southern end of the bar. It is clearly protected by a headland which protrudes from the coast into the sea, immediately south of the lagoon.

Configuration of adjacent shore ([132]).
Beach type — sheltered asymmetrical beach.

Beach slope — 6°
Beach width — 74 m
Sand grain size — 569 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are said to be present in the near vicinity of the lagoon.

Physico-chemical characteristics

Although there is no information available in this respect, Ward (pers. comm.) has reported that the water in the lagoon is in a constantly turbid state. It is strongly suspected that the crushing of rocks at the quarry site above the lagoon is responsible.

Public health aspects

Bacteriology. No record.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

In terms of its botanical characteristics, the Mbango lagoon is not important, largely because of the urbanization of its surrounds. However, in the railway reserve, the coastal vegetation is in fairly good condition, and a small *Phragmites* reed swamp occurs on the southern bank in the middle reaches of the lagoon. In its lower reaches, there is a dense fringe of *Hibiscus tiliaceus.*

Fauna

No record.

SYNTHESIS

In terms of our present state of knowledge, virtually nothing is known about the Mbango lagoon. By virtue of its small size, and the more urgent need for research elsewhere, investigation of the Mbango lagoon cannot at this stage be justified. Although the lagoon appears to be in fair environmental condition, its potential resource value is considered to be negligible. Urbanization and quarrying appear to be problems from which the lagoon is probably adversely affected.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora		Fauna							Food Webs
MBANGO			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																															
Source of Information	Summary of available information																														
Fromme	1970 to 1975	132								●																					
NTRPC	1974	236						●																							
Dykes (Jeffares & Green)	1977	pers. comm.	●		●																										
Ward	1978	pers. comm.								●																					
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 261	1976	334		●																			●								
1:25 000 Job No. 262	1976	459	●																												

2.1.12.6 **BOBOYI**

Synonyms

Imboyboye — (PWD map dated 1908, in Natal Archives). Care should be taken to ensure that there is no confusion between the Boboyi and the Ku-Boboyi 35 km further south (see Section 2.1.13.8).

Zulu meaning

The Boboyi is named after a type of grass (called boyboyi) which is used for mat making and grew on its banks ([289]).

Location

30°46'15"S; 30°26'E.

Accessibility

By road, the Boboyi lagoon is 4 km south of Port Shepstone and 132 km south west of Durban. No provision has been made for vehicular access to the water's edge.

Bridges

Both the national road and the railway line cross the lagoon on a bridge 25 m from the mouth. Neither have created any detectable impact in the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 31 km^2 ([206]).

River length. 14 km ([206]); to 21 km (personal estimate).

Mean annual run-off. No record.

Flow. A rough estimate of the average flow in 1971 was ,085 m^3/sec. ([206]). This is very similar to that calculated by Bosch & Associates in December 1968 (i.e. 0,09 m^3/sec.).

Flood history. 1:50 year floods are estimated to discharge 170 m^3/sec. (Dykes, pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. No record.

Land ownership/use. 40% of the catchment is Bantu influenced comprising Location No. 5 and destined to become incorporated into KwaZulu. Nearer the coast, European owned sugar cane farms and the settlement of Marburg influence the area.

On the northern bank of the lagoon is Oslo Beach township, whilst the southern bank is undeveloped and set aside as the Marburg Commonage.

Local authority. Oslo Beach.

Estuary uses. The Boboyi lagoon is not used for any specific purpose. There was a proposal (in 1968) by the Marburg Immigration Settlement Board to dam the Boboyi, and develop a marina. This scheme has since been abandoned.

Morphometry of lagoon (see Fig. **101**)

Area. 1,3 ha

Axial length. 375 m

Shoreline length. 1,2 km

Width.
Maximum: 70 m
Mouth: 5 m during normal, low flow periods.
Floodplain: 240 m

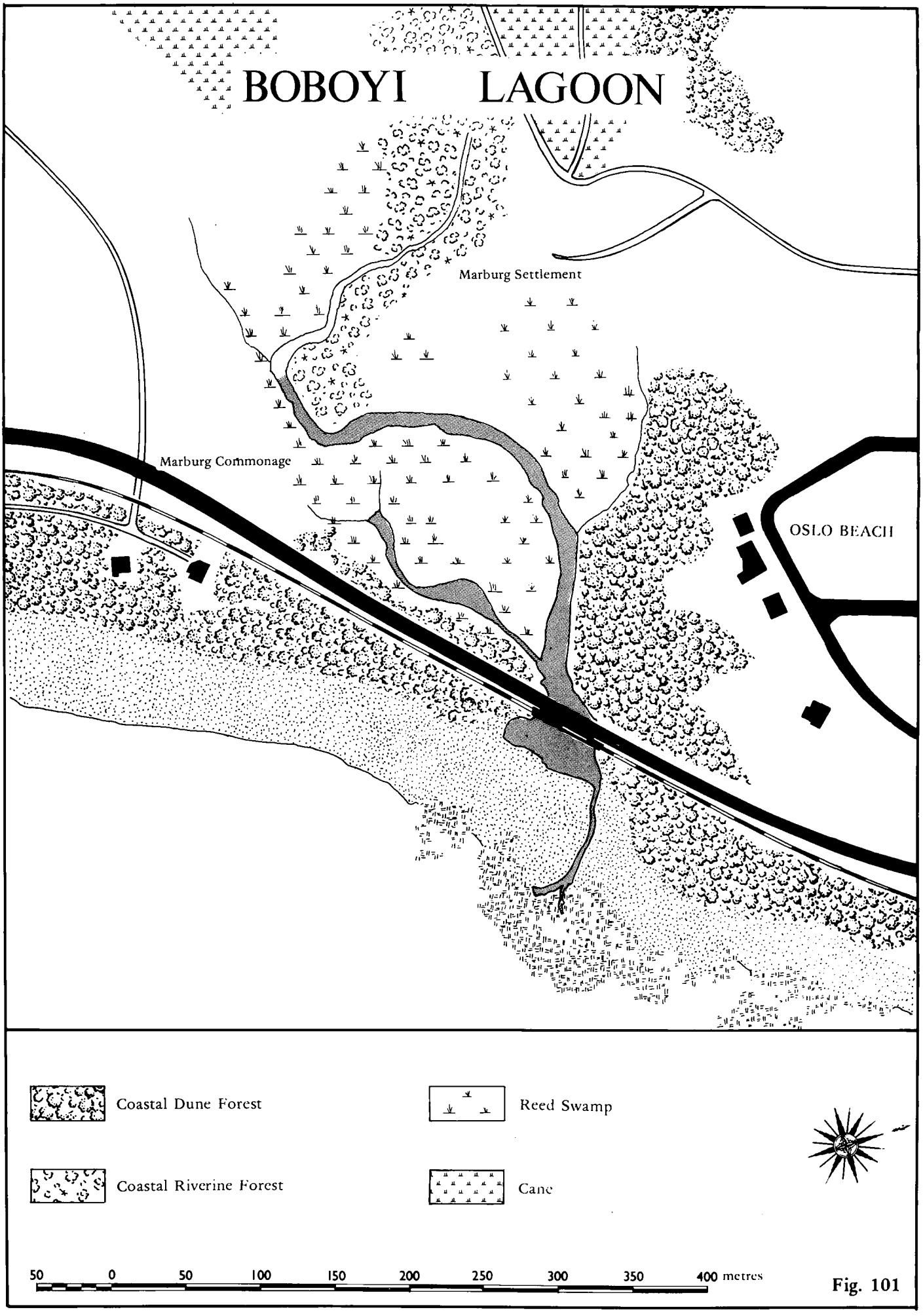

BOBOYI LAGOON
Marburg Settlement
Marburg Commonage
OSLO BEACH
Coastal Dune Forest
Reed Swamp
Coastal Riverine Forest
Cane
50 0 50 100 150 200 250 300 350 400 metres

Fig. 101

Bathymetry. No record.

Geomorphology

Geology. Both the catchment and the lagoon are made up of Dwyka tillite (([236]), Dykes pers. comm.). At the site of the proposed freeway, bedrock lies at a depth of 7,5 m.

Nature of bottom materials. Cores to a depth of 5 m in the vicinity of the Boboyi lagoon (in November 1968) showed undifferentiated fluvial sand underlying the lagoon (Bosch & Associates, pers. comm.).

Sandbar characteristics. The Boboyi lagoon is atypical in that it is a north deflected system. The mouth opens across rocks at the northern end of a 75 m long bar. This is almost certainly due to the fact that there is no rock protection south of the lagoon to defend it from the prevailing oceanic swells. Whether the lagoon is breached artificially could not be ascertained. Contact with the sea is probably very limited.

Configuration of adjacent shore ([132]).
Beach type — sheltered asymmetrical beach.

Average beach slope — 7°
Average beach width — 66 m
Average sand grain size — 686 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are absent in the near vicinity of the lagoon.

Physico-chemical characteristics

There is no data on the physico-chemical characteristics of the Boboyi lagoon. However, a study of the river was made in 1971 ([206]). The results (presented in Table **92**) are representative of conditions 6 km above the lagoon.

Although there were no indications of disturbance at the time, two samples are insufficient evidence on which to base such a conclusion.

Table 93. Bacteriology of the Boboyi river (6 km above the lagoon)

Date	Total Plate Count per ml x 10^3		*E. coli* 1 /100 ml	Total Coliforms per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed	
March 1971			187	6 400
July 1971			3 060	12 800
3 Feb 1972	37	28	650	
21 Feb 1972	550	350	1 900	
3 July 1972	43	**344**		
31 July 1972	150	**490**		
17 Aug 1972	240	170		
8 Jan 1973	**2 400**	250	333	

Values in bold are indicative of disturbance.

Table 92. Physico-chemical characteristics. ([206])

Locality: Boboyi river Distance above lagoon : 6km	SUMMER 1971	WINTER 1971
Hydrogen ion concentration (pH)	7.9	7.6
Saturated pH value	8.8	8.7
Conductivity micromhos/cm	220	292
Total dissolved solids ppm (calcd.)	135	184
Dissolved oxygen mg/litre	9.3	9.9
% Saturation	111	95
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	4.3	1.3
Kjedahl nitrogen mg/litre	0.4	0.4
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.24	0.52
Phosphates "	0.21	0.14
Total alkalinity "	54.0	60.8
Total hardness "	52.4	59.8
Calcium "	6.7	8.5
Magnesium "	8.7	9.3
Sodium "	30.0	39.0
Potassium "	1.2	1.8
Sulphates "	7.4	10.8
Chlorides "	46.7	59.8
Silica "	-	-
Iron "	-	-
Fluorides "	0.2	0.2
Free carbonic acid (as ppm carbon dioxide)	1.3	3.1
Temperature °C	25.0	14.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

Public health aspects

Bacteriology. Only data on the bacteriological quality of the river 6 km above the lagoon is available ([206]). From the results (presented as Table **93**) occasional periods of organic enrichment were evident.

Bilharzia. A letter from Dr. Jackson (dated 6 February 1968) to Bosch & Associates (pers. comm.) suggests that the Boboyi is free of bilharzia, because the presence of bilharzia snails in the Boboyi river had (after three years of sampling) never been revealed. Dr. Jackson warned however, that damming of the river would create conditions suitable for bilharzia snails.

BIOTIC CHARACTERISTICS

Flora

Although the general surrounds have been encroached upon to a certain extent by sugar cane and township development, conspicuous plant communities in the vicinity of the lagoon are:

(1) extensive reed swamp/marsh communities around the system in its middle reaches and
(2) 1,5 km of riparian vegetation alongside the Boboyi river immediately above the lagoon.

Fauna

There is no information available on the fauna of the Boboyi lagoon, however, data exists on some of the aquatic communities found 6 km above the lagoon in June 1972 ([206]). The results were indicative of an undisturbed riverine environment.

SYNTHESIS

Our general state of knowledge of the Boboyi lagoon is poor, and although the system is in a fairly undisturbed environmental condition, it is probably of limited resource value. At this stage, investigation of the Boboyi lagoon cannot be justified. Other than a proposal in 1968 to develop the lagoon as a marina, it has remained relatively undisturbed.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other							Flora			Fauna							Food Webs
BOBOYI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																																
Source of Information	Summary of available information																															
Bosch & Assoc.	1968	pers. comm.								●																						
Jackson	1968	pers. comm.																								○						
Fromme	1970 to 1975	132								●																						
Kemp *et al*	1971 to 1972	206	●		●						○				○											○	○					
NTRPC	1974	236						●																								
Dykes (Jeffares & Green)	1977	pers. comm.			●			●																								
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	337		●																				●								
1:25 000 Job No. 262	1976	458	●																													

2.1.12.7 **ZOTSHA**

Synonyms
Izotsha.

Zulu meaning
The Zotsha river derives its name from the Zotsha clan which lived on its banks ([289]).

Location
30°47'15"S; 30°25'30"E.

Accessibility
By road the Zotsha lagoon is 6 km south of Port Shepstone or 134 km southwest of Durban. There is no access to the lower reaches of the lagoon. The upper reaches of the lagoon are accessible via a dirt road on the southern bank, which leads to the Palm Kloof Pleasure Resort.

Bridges
Both the railway line and the national road cross the lagoon on bridges 600 m and 850 m from the mouth respectively. In both instances construction of embankments across the Zotsha floodplain on its southern bank, were necessary. The Zotsha lagoon is the last lagoon to be crossed by the south coast railway line. From here the railway runs inland to Paddock, en route to Harding.

In the near future, the bridge of the south coast freeway will be built immediately above Palm Kloof Pleasure Resort, over the upper reaches of the lagoon (Dykes, pers. comm.).

ABIOTIC CHARACTERISTICS
Catchment characteristics

Area. 56 km^2 ([213]); 65 km^2 ([206, 245]); 93 km^2 ([223]).

River length. 16 km ([206, 245]); 25 km (Dykes pers. comm.).

Mean annual run-off. 8 x 10^6 m^3 ([213]) to 16 x 10^6 m^3 ([223]).

Flow. A rough estimate of the average flow in 1971 was ,28 m^3/sec. ([206]).

Flood history. Depending on the formula used 1:50 year floods are estimated to discharge from 215 m^3/sec. to 416 m^3/sec. A realistic figure is probably 370 m^3/sec. (Dykes, pers. comm.).



A view of the lower reaches of the Zotsha lagoon during floods in April 1978.

Although floods of the Zotsha are seldom devastating, the level to which the flood waters can rise is rather alarming (Palmer, pers. comm.). Should heavy rains coincide with high spring tides, the floodwaters rise very rapidly and overtop the banks of the lagoon. On 20 March 1976, a combination of such events resulted in levels rising to within 2,5 m of the Palm Kloof Pleasure Resort tearoom verandah. Such floods subside as quickly as they rise.

Dams.
Existing: None.

Proposed: The Eureka dam site has been located 4 km above the lagoon ([245]). If built it would have a total capacity of 10,05 x 10^6 m^3 ([236]), however, it has been rated very low in terms of priority because of dubious economic viability.

Siltation. Annual siltation at the Eureka dam site has been estimated at 0,05 x 10^6 m^3 ([236]). Although stated to be a proportionately high rate of siltation ([236]), the consequences are not particularly striking in the lagoon.

Land ownership/use. 26% of the Zotsha catchment presently extends into a Bantu reserve (Location No. 5). However, this area is not to become incorporated into KwaZulu in the future. Land in the upper and lower catchment has been divided into a series of small privately owned farms. Sugar cane is grown near the coast, and just above the lagoon is the Goodside brickyard, and the Apostulides poultry farm.

North of the lagoon is the township of Oslo Beach, whilst to the south is Shelly Beach. At the head of the lagoon the Palm Kloof Pleasure Resort has been established.

Local authority. Shelly Beach.

Estuary uses. The Palm Kloof Pleasure Resort makes most use of the lagoon, for the purpose of boating. A minimum amount of angling occurs. The Zotsha mouth is a popular bathing area for non-whites ([239]).

Morphometry of lagoon (see Fig. **102**)

Area. Accepting the limits of the lagoon as described by Palmer (pers. comm.), the area of the lagoon is 7,3 ha.

Axial length. 2,25 km

Shoreline length. 4,7 km

Width.
Maximum: 70 m
Mouth: 10 m during normal low flow periods.
Floodplain: 220 m

Bathymetry. In its lower reaches, the lagoon is ± 1 m deep (Palmer, pers. comm.). In its upper reaches it is 2 m to 3 m deep.

Geomorphology

Geology. Whilst certain references suggest that both the catchment area and lagoon are made up of Dwyka conglomerates (([236]), Dykes, pers. comm.), Ninham Shand & Partners ([245]) mention that granite and Table Mountain Sandstone also occur in the catchment.

Nature of bottom materials. Drilling at the bridge site of the freeway has revealed 4 m of river sand overlying bedrock (Dykes, pers. comm.). The entire lagoon is characterized by a clean, sandy bottom according to Palmer (pers. comm.).

Sandbar characteristics. The Zotsha sandbar is 450 m long and south extending. The channel to the sea opens across rocks at the southern end which form a sill below which the water level cannot fall. There is a strong likelihood that during floods in the past, the lagoon may have broken out at a point 400 m north of its normal mouth position.

It is generally closed during winter, but during summer opens and closes naturally quite regularly. The longest period of uninterrupted contact with the sea is approximately six weeks (Palmer, pers. comm.). When open to the sea, the tidal range at the Palm Kloof Pleasure Resort is said to be in the region of 0,5 m. The lagoon is never breached artificially.

Configuration of adjacent shore ([132]).
Beach type — sheltered asymmetrical beach, suitable for recreational use.

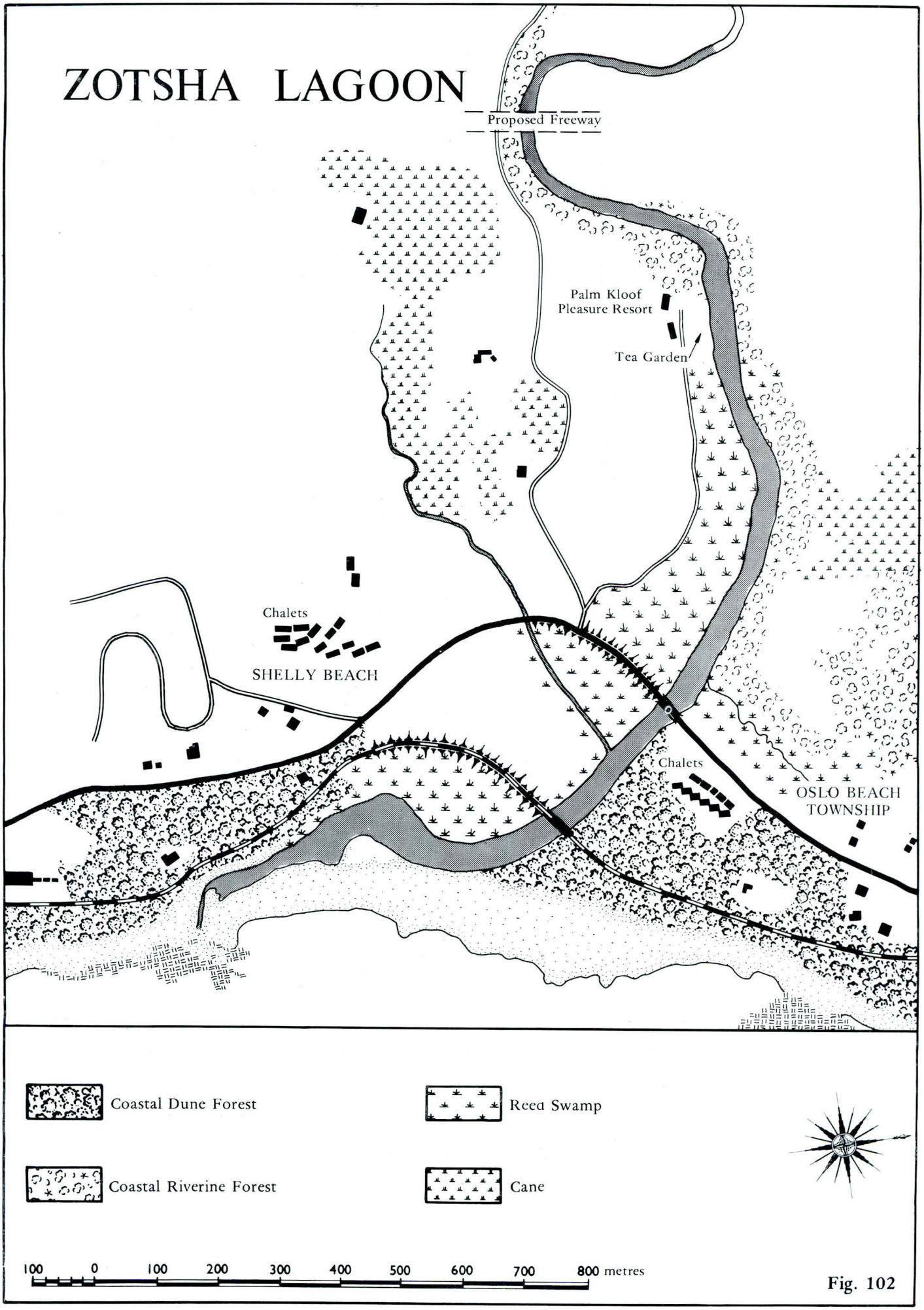

ZOTSHA LAGOON
Proposed Freeway
Palm Kloof
Pleasure Resort
Tea Garden
Chalets
SHELLY BEACH
Chalets
OSLO BEACH
TOWNSHIP
Coastal Dune Forest
Reed Swamp
Coastal Riverine Forest
Cane
100 0 100 200 300 400 500 600 700 800 metres

Fig. 102

Table 94. Physico-chemical characteristics. ([206])

Locality: Zotsha river Distance above lagoon : 3km	SUMMER Feb 1971	WINTER July 1971
Hydrogen ion concentration (pH)	7.45	7.15
Saturated pH value	9.0	7.7
Conductivity micromhos/cm	120	930
Total dissolved solids ppm (calcd.)	773	6 250
Dissolved oxygen mg/litre	8.6	8.1
% Saturation	105	86
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	3.9	1.6
Kjedahl nitrogen mg/litre	0.4	0.1
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.47	0.31
Phosphates "	.18	.11
Total alkalinity "	26.8	71.2
Total hardness "	143	2 099
Calcium "	11.3	79.9
Magnesium "	28	461
Sodium "	235	1 625
Potassium "	6.9	75
Sulphates "	50	750
Chlorides "	422	3 197
Silica "	-	-
Iron "	-	-
Fluorides "	0.2	0.6
Free carbonic acid (as ppm carbon dioxide)	1.8	-
Temperature °C	26.5	18.5
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

Average beach slope — 9°
Average beach width — 99 m
Average sand grain size — 693 microns
} indicative of rough surf zone conditions.

Surf zone currents. Rip currents in the near vicinity of the lagoon are reported to be absent.

Physico-chemical characteristics

Data from the Zotsha lagoon itself is non-existent. However, a few results from the Zotsha river 3 km above the lagoon are available ([206]), the characteristics of which (see Table **94**) are extraordinarily different to that of neighbouring streams. Thus it is not surprising that the water quality of the Zotsha river remained unclassified by Kemp *et al* ([206]). In both the wet and the dry season, (particularly the latter) the water of the Zotsha river is very conductive and particularly hard. Consequently total dissolved solids, calcium, magnesium, sodium, potassium, sulphate and chloride values are all high.

In the wet season such values are ± 5 times higher than normal; whilst in the dry season they are 30 times higher. Although such mineralization may be attributable to the geology of the Zotsha catchment, Kemp (pers. comm.) is convinced that these results were attributable to the influence of sea water. If this is the case, then the lagoon extends a lot further than generally believed. However, judging from the gradient of the river bed above the Palm Kloof Pleasure Resort, and the presence of rapids over rocky sections of the river, it is doubtful whether sea water ever reaches the bridge from which Kemp *et al* ([206]) conducted their sampling. Whilst seawater is said to render the water unsuitable for irrigation, it may also be due to geological mineralization of the water, as in the case of the Zinkwasi (see Section 2.1.5.2).

Salinities of 5‰ were recorded by Jackson in the Zotsha lagoon in September 1975 (pers. comm.), however salinities are said to approach that of sea water (35‰) when the system is open to the sea (Palmer, pers. comm.).

Public health aspects

Bacteriology. There is no information available on the bacteriological characteristics of the Zotsha lagoon. However, results from the Zotsha river, 3 km above the lagoon in the early 1970's (see Table **95**) revealed no faecal pollution and sporadic periods of organic enrichment.

Table 95. Bacteriology of the Zotsha river (3 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* 1 /100 ml	Total Coliforms per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours at ambient.	Confirmed	
March 1971			824	11 200
July 1971			86	3 100
3 Feb 1972	210	**240**		
21 Feb 1972	400	160	366	
3 Jul 1972	105	**336**		
31 Jul 1972	120	81	20	
17 Aug 1972	320	84		
8 Jan 1973	970	190		

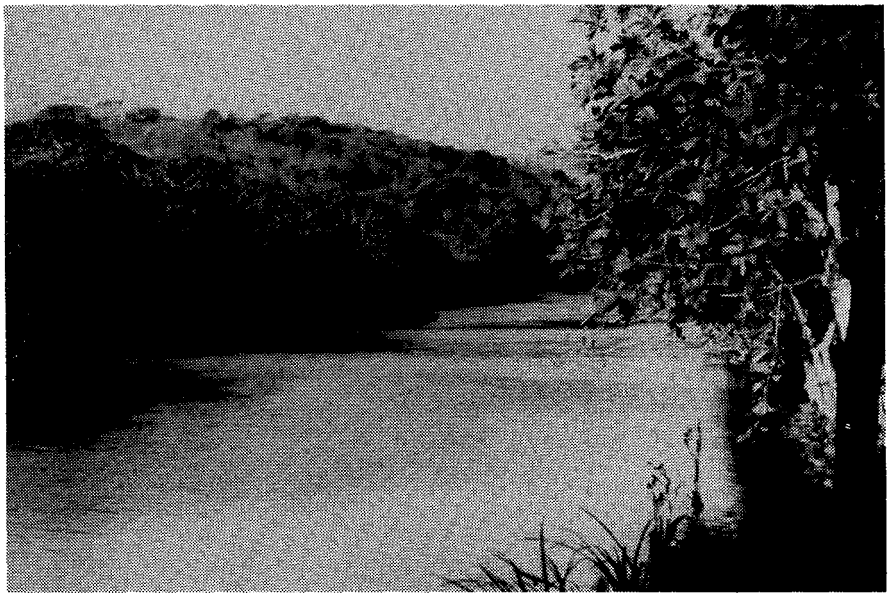
Values in bold are significant of disturbance.

Bilharzia. Amongst the various snail species found above the lagoon, Jackson (pers. comm.) reported the presence of *Physopsis* on 31 October 1973. A sign erected by the Town Board, immediately above the Palm Kloof Pleasure Resort, advises against contact with the water (van den Berg, pers. comm.). Bearing in mind what has been said about the salinity of the system, the occurrence of *Physopsis* presents an interesting anomaly.

BIOTIC CHARACTERISTICS

Flora

The principal plant communities surrounding the lagoon include an extensive, low lying wetland area (dominated by *Phragmites*) in the lower reaches, and a riverine forest community (with *Barringtonia* on the water's edge) in the upper reaches. On the northern bank some patches of coastal forest have remained undisturbed. The diversion and semi-canalization of a tributary stream in the lower reaches of the lagoon, has adversely affected the development of swamp communities on the southern bank.



Barringtonia racemosa alongside the upper reaches of the Zotsha lagoon (13 July 1977).

Fauna

Lower trophic levels.

Benthos: Jackson (pers. comm.) recorded the molluscs *Assiminea bifasciata* and *Trachycystis* sp. as present in the lagoon on 25 September 1975. The edible crab (*Scylla serrata*) is also present (Palmer, pers. comm.).

Data on various aquatic communities from the Zotsha river 3 km above the lagoon was acquired in June 1972 ([206]). The high species diversity (with the exception of the fauna of the sediments) was indicative of undisturbed environmental conditions above the lagoon at that particular time.

Higher trophic levels.

Fish. Palmer (pers. comm.) recalls the presence of four species of fish in the Zotsha lagoon; mud bream (*Sarotherodon mossambica*), garrick (*Lichia amia*), mullet (unspecified) and rock salmon (*Lutjanus argentimaculatus*). The largest rock salmon caught weighed 3,5 kg.

Birds: ± 10 species of estuarine associated birds have been recorded in the vicinity of the Palm Kloof Pleasure Resort (Palmer, pers. comm.). A bird park has been established there.

Others: Otters, vervet monkeys and leguaans have also been seen.

SYNTHESIS

Our state of knowledge of the Zotsha lagoon is fairly poor, and either outdated or based upon hearsay. It appears to be an important lagoon on the south coast, in regard to the manner in which

it is used and because of the fauna and flora which it supports. A thorough investigation of the Zotsha lagoon is warranted. It is unique on the south coast as far as the chemical characteristics of the river water are concerned.

In its present environmental condition, the lagoon has very few problems and has been well cared for. Some disturbance of swamp communities on the floodplain in the lower reaches is apparent, due to the construction of rail and road communications.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text.	ABIOTIC																				BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora			Fauna							Food Webs
ZOTSHA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids											★											←★→		←★→							
Source of Information	Summary of available information																														
Midgley & Pitman	1969	223	●		●																										
Fromme	1970 to 1975	132								●																					
Kemp *et al*	1971 to 1973	206	●		●						○				○										○	○					
Ninham Shand & Partners	1971	245	●					●																							
Loxton, Hunting & Assoc.	1971	213	●		●																										
NTRPC	1974	236						●		●																					
Jackson	1975	pers. comm.				●																				●					
NRIO	1975	239																		●											
Palmer	1977	pers. comm.		●	●	●	●			●										●						●	●	●	●	●	
Dykes (Jeffares & Green)	1977	pers. comm.	●		●			●																							
Aerial photos (Scogings)		No.																													
1:10 000 Job No. 261	1976	339,357		●																			●								
1:25 000 Job No. 262	1976	457	●	●																											

Synonyms

The name Mhlangeni is used on maps such as the 1:500 000 and 1:250 000 series of Natal. It is recommended that this name be adopted, rather than the name uMhlanga ([189]) (as on the 1:50 000 sheet 3030 CD) so as to avoid confusion between this lagoon on the south coast, and the well known Mhlanga lagoon on the north coast (see Section 2.1.7.3). The letter 'e' or 'u' can precede the name Mhlangeni.

Zulu meaning

uMhlangini means "the river of reeds" ([17, 289]).

Location

30°49'S; 30°23'45"E.

Accessibility

By road, the Mhlangeni lagoon lies 11 km south of Port Shepstone, or 139 km south west of Durban. Comprising the focal point of St. Michael's-on-Sea, the mouth of the Mhlangeni lagoon is easily accessible from either bank. The upper reaches of the lagoon are accessible only on foot.

Bridges

The national road crosses the lagoon on a bridge 75 m from the mouth, built in almost the same place as the old road bridge (dated 1932).

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 36 km^2 to 52 km^2 ([206]).

River length. 11 km ([206]) to 14 km (pers. est.).

Mean annual run-off. No record.

Flow. A rough estimate of the average flow in 1971 was ,085 m^3/sec. ([206]).

Flood history. Depending on the formula used, the discharge from a 1:50 year flood has been estimated to range from 216 m^3/sec. to 370 m^3/sec. (Dykes, pers. comm.). The latter figure is calculated from the observed flood level in 1959.

Dams.
Existing: None.
Proposed: None.

Siltation. No record — but from aerial photos the lagoon is obviously very shallow and badly silted up.

Land ownership/use. 47% of the upper catchment (comprising Location No. 5) is Bantu influenced, and destined to become incorporated into KwaZulu in the near future.

In the lower part of the catchment are sugar cane farms.

Around the lagoon are the residential and resort areas of Windsor-on-Sea (to the north) and St. Michael's-on-Sea (to the south).

On both banks the land has been zoned as public open space.

Local authority. Margate Town Board.

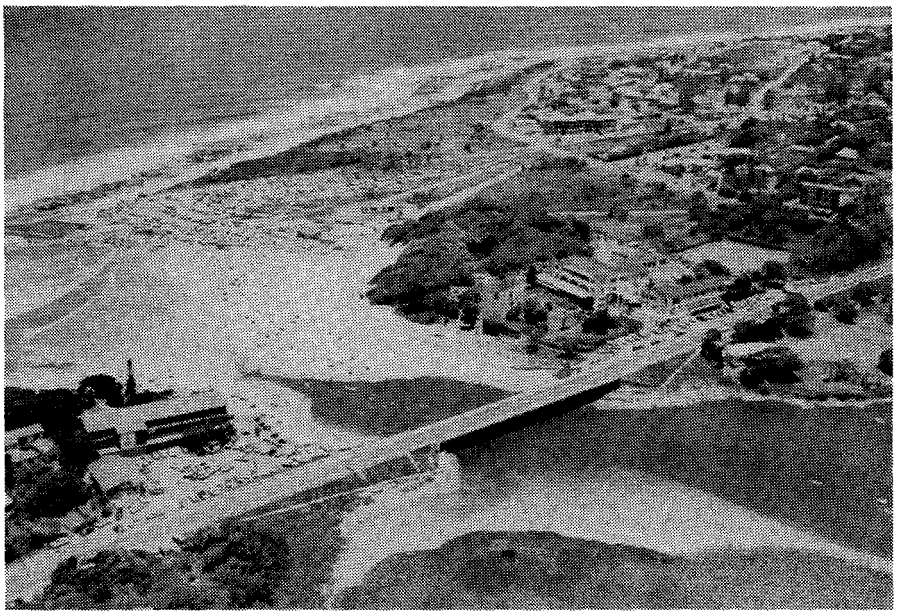
Estuary uses. The Mhlangeni lagoon is an extremely popular recreational centre on the south coast of Natal. It is used extensively for rowing boats, canoes, paddle boats and swimming. The sandbar itself comprises the Surf Bay bathing beach.

Morphometry of lagoon (see Fig. **103**).

Area. 3,6 ha

Axial length. 550 m

Shoreline length. 1,7 km



An aerial photo of the Mhlangeni lagoon showing its recreational potential. (A post card reproduction with permission of Art Publishers (Pty) Ltd).

Width.
Maximum: 115 m
Mouth: 10 m during low flow periods.
Floodplain: 250 m although estimated to be 500 m wide by Orme ([257]).

Bathymetry. No record.

Geomorphology

Geology. The catchment of the Mhlangeni is made up of both Table Mountain Sandstone and rocks of the Dwyka series ([236]). Table Mountain Sandstone lies beneath the Mhlangeni lagoon at 19 m below mean sea level ([257]).

Nature of bottom materials. (see Fig. **104**). Orme ([257]) has shown that the bottom materials of the Mhlangeni comprise up to ± 20 m of silty sand, amongst which is the occasional layer of Dwyka tillite boulders.

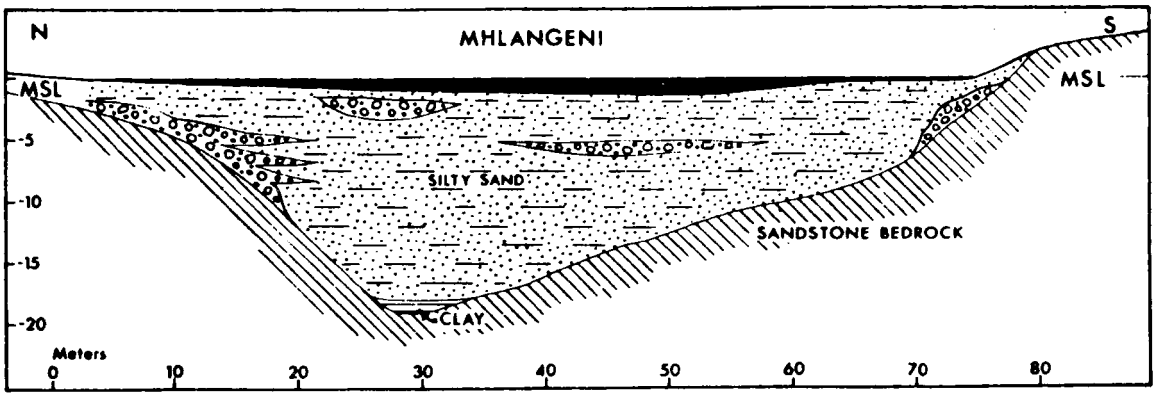


Fig. 104. Cross section through the Mhlangeni lagoon (after Orme ([257])).

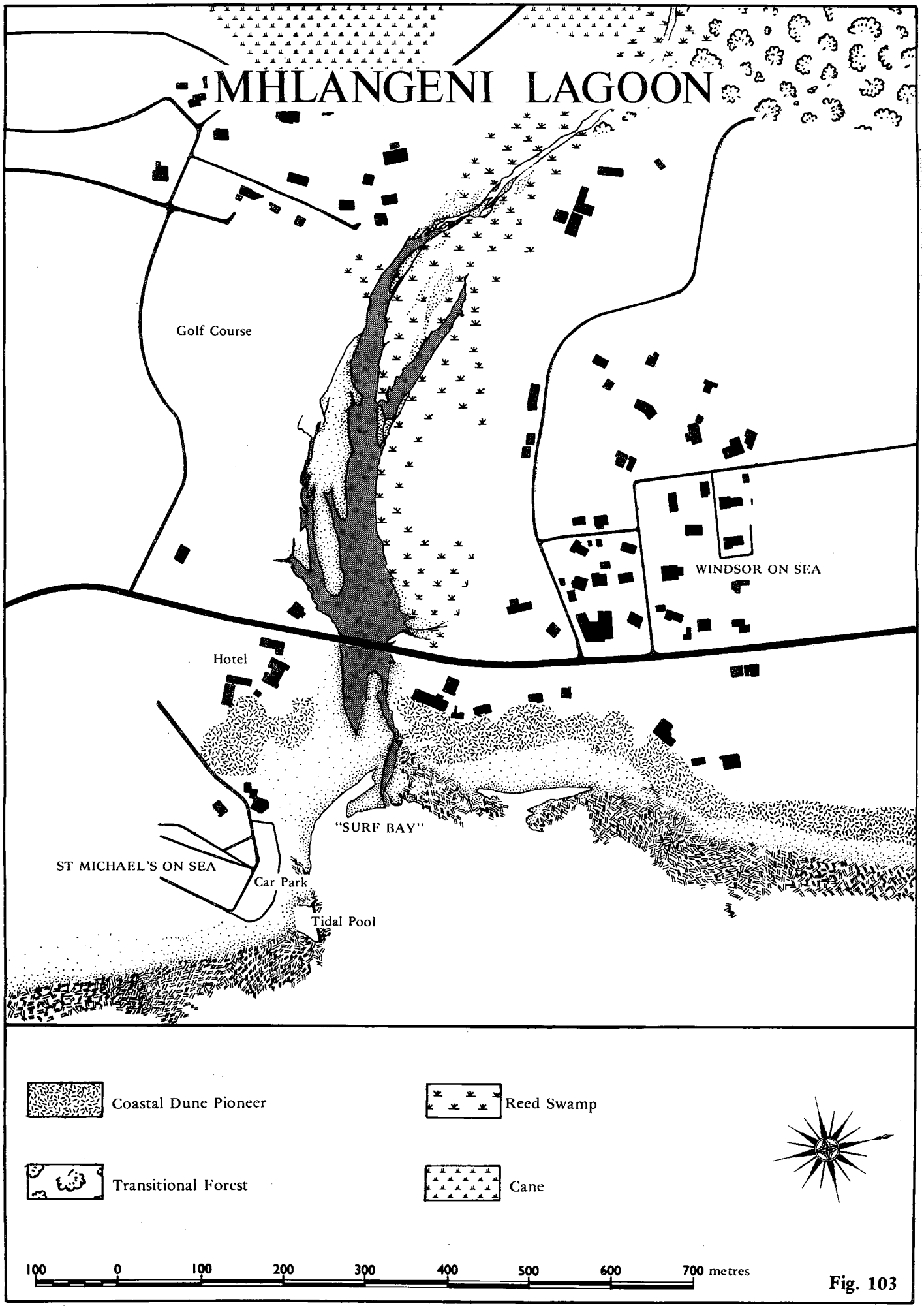

MHLANGENI LAGOON
Golf Course
WINDSOR ON SEA
Hotel
"SURF BAY"
ST MICHAEL'S ON SEA
Car Park
Tidal Pool
Coastal Dune Pioneer
Reed Swamp
Transitional Forest
Cane
100 0 100 200 300 400 500 600 700 metres

Fig. 103

Sandbar characteristics. The Mhlangeni sandbar is interesting in that it is almost as short (100 m) as it is broad, but also north extending, despite rock protection south of the system. Its atypical form appears to be due to the configuration of the coast, in that the lagoon lies within a cove. It comprises the principal bathing beach area.

Breaching has to be undertaken by the Town Board to prevent (a) portions of the golf course from becoming swampy, (b) inundation of septic tanks at the caravan park and (c) malfunctioning of storm water drains.

The sea overtops the bar at each high tide.

Configuration of adjacent shore ([132]).
Beach type — well sheltered cove.

Average beach slope — 2°
Average beach width — 165 m
Average sand grain size — 293 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents in the near vicinity of the lagoon are absent.

Physico-chemical characteristics

Salinities of 5‰ to 10‰ were recorded in the lagoon by Jackson (pers. comm.) in September 1975. However, information on any other physico-chemical characteristics of the Mhlangeni lagoon is completely lacking. There is some information on the chemical nature of the Mhlangeni river, 4,5 km above the lagoon in Kemp *et al* ([206]). Their results (presented as Table **96**) indicate that at this point in the system, no signs of significant disturbance were apparent in 1971. It is surprising however, that Kemp suggests the samples taken at this point were contaminated by sea water.

Table 97. Bacteriology of the Mhlangeni river (4,5 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* 1 /100 ml	Total Coliforms per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed	
March 1971			**9 420**	16 600
July 1971			285	1 400
3 Feb 1972	112	104		
21 Feb 1972	220	300	3 950	
3 July 1972	108	**390**	156	
31 July 1972	360	180		
17 Aug 1972	130	7		
8 Jan 1973	110	**580**		

Values in bold are significant of disturbance.

Public health aspects

Bacteriology. Van den Berg (Chief Health Inspector, Margate) and the State Department of Health, have accumulated information on *E. coli* from within the lagoon. Counts have shown that the lagoon is faecally polluted. The sources of pollution are considered to be septic tanks from a nearby caravan park, and the Gamalaka Bantu location in the catchment. Considering the degree of

Table 96. Physico-chemical characteristics. ([206])

Locality: Mhlangeni river	SUMMER	WINTER
Distance above lagoon : 4.5km	1971	1971
Hydrogen ion concentration (pH)	7.5	7.1
Saturated pH value	8.9	9.0
Conductivity micromhos/cm	31.0	34.8
Total dissolved solids ppm (calcd.)	181	217
Dissolved oxygen mg/litre	8.0	9.8
% Saturation	90	94
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	2.3	2.5
Kjedahl nitrogen mg/litre	0.7	0.2
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.33	0.26
Phosphates "	0.32	0.12
Total alkalinity "	45.9	37.2
Total hardness "	61.4	60.3
Calcium "	6.2	6.7
Magnesium "	11.2	10.6
Sodium "	44.0	57.5
Potassium "	2.0	2.1
Sulphates "	6.6	12.5
Chlorides "	81.0	87.6
Silica "	-	-
Iron "	-	-
Fluorides "	0.1	0.1
Free carbonic acid (as ppm carbon dioxide)	2.7	5.7
Temperature °C	22.0	14.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

human contact with the water in the lagoon, this situation is deplorable. It is a situation which is in the Town Board's own interests to rectify.

From bacteriological data of the Mhlangeni river 4,5 km above the lagoon ([206]), sporadic indications of faecal pollution and organic enrichment were evident in the early 1970's (see Table 97).

Bilharzia. Jackson (pers. comm.) collected *Physopsis* from the river above the lagoon in September 1975. A signboard at the head of the lagoon warns that contact with the water beyond that point is dangerous. It should be noted that bathers have been reported to develop a skin rash after swimming in the lagoon (van den Berg, pers. comm.).

BIOTIC CHARACTERISTICS

Flora

Although heavily reeded on the northern bank, the Mhlangeni lagoon is unimportant from a botanical point of view. Urban encroachment, golf course development, and sugar cane encroachment above the river are all responsible.

Fauna

Jackson (pers. comm.) reported the following types of molluscs as present in the lagoon in September 1975: *Assiminia bifasciata, Achatina* sp., *Bellamya* and *Edouardia* sp..

From the presence of burrows in the sand, the sand prawn (*Callianassa kraussi*) must occur. Other than this, there is no information on the fauna of the Mhlangeni lagoon.

After sampling in the river 4,5 km above the lagoon, information on a few of the animal communities is available ([206]). The benthic fauna in the sediments was poorly developed, but sampling amongst stones in the current revealed a very diverse animal community in June 1972.

SYNTHESIS

Our state of knowledge of the Mhlangeni lagoon is fairly poor. Although in a degraded environmental condition (being silted and highly disturbed), the lagoon has an important recreational function. By virtue of it being faecally polluted and extensively utilized by the public, attention should be focused on the ways and means of eliminating pollution sources and thus reducing the number of harmful bacteria. No value is attached to the Mhlangeni lagoon as an estuarine resource.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC											
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other							Flora		Fauna								Food Webs
MHLANGENI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids															★																	
Source of Information	Summary of available information																																
Fromme	1970 to 1975	132								●																							
Kemp *et al*	1971 to 1973	206	●		●						○				○											○							
Orme	1971	257						●		●																							
NTRPC	1974	236						●																									
Jackson	1975	pers. comm.				●																					●						
Dykes (Jeffares & Green)	1977	pers. comm.			●																												
van den Berg	1977	pers. comm.													●					●													
Hopwood	1978	189																					○										
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	345,362		●						●														●									
1:25 000 Job No. 262	1976	455	●																														

Synonyms

"Uvongo" is the most commonly used synonym, through distortion of the word Vungu by Europeans. Sometimes the prefix 'i' ([17]) or 'e' ([101]) precede the word.

Zulu meaning

Vungu is obviously an onomatopeic word used to describe the 25 m high waterfall which is the main feature of the lagoon. The name is said to mean "the reverberating roar of the falls", ([17]) as well as "making a low, murmuring sound" ([289]) similar to "bees buzzing in the distance" ([17]).

Location

30°50'S; 30°23'45"E.

Accessibility

By road, the Vungu lagoon lies 15 km south west of Port Shepstone, and 142 km south west of Durban. Provision has been made on both banks for vehicular access to the mouth of the lagoon.

Bridges

No bridges cross over the lagoon, although in the past various footbridges have been built across the outlet channel. These are regularly washed away at high spring tide, or when there is a storm at sea. The national road crosses over the crest of the falls immediately above the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 80 km^2 ([236]); 98 km^2 ([223]); 103 km^2 ([213]); 111 km^2 ([206, 245, 257]); 121 km^2 (Dykes, pers. comm.)

River length. 16 km ([206]) to 32 km ([245, 257]), Dykes, pers. comm.).

Mean annual run-off. 17 x 10^6 m^3 ([213]) to 18 x 10^6 m^3 ([223]).

Flow. A rough estimate of the average flow in 1970 was ,57 m^3/sec. ([206]).

Flood history. Depending on the formula used, 1:50 year floods from the Vungu river are estimated to discharge from 317 m^3/sec. to 385 m^3/sec. (Dykes, pers. comm.). The river floods regularly every year, and occasionally twice a year ([17]).

However the most devastating influence in the lagoon is the sea, which when high and followed by stormwaves, can wash right up to the foot of the falls.

Dams.

Existing: A number of weirs impound the Vungu river at certain places, one of which is on the crest of the falls. The river also forms several pools along its course.

Proposed: A potential dam site (with a total capacity of 16,6 x 10^6 m^3 ([236])) has been located at Stoneylands, 11 km above the lagoon ([245]).

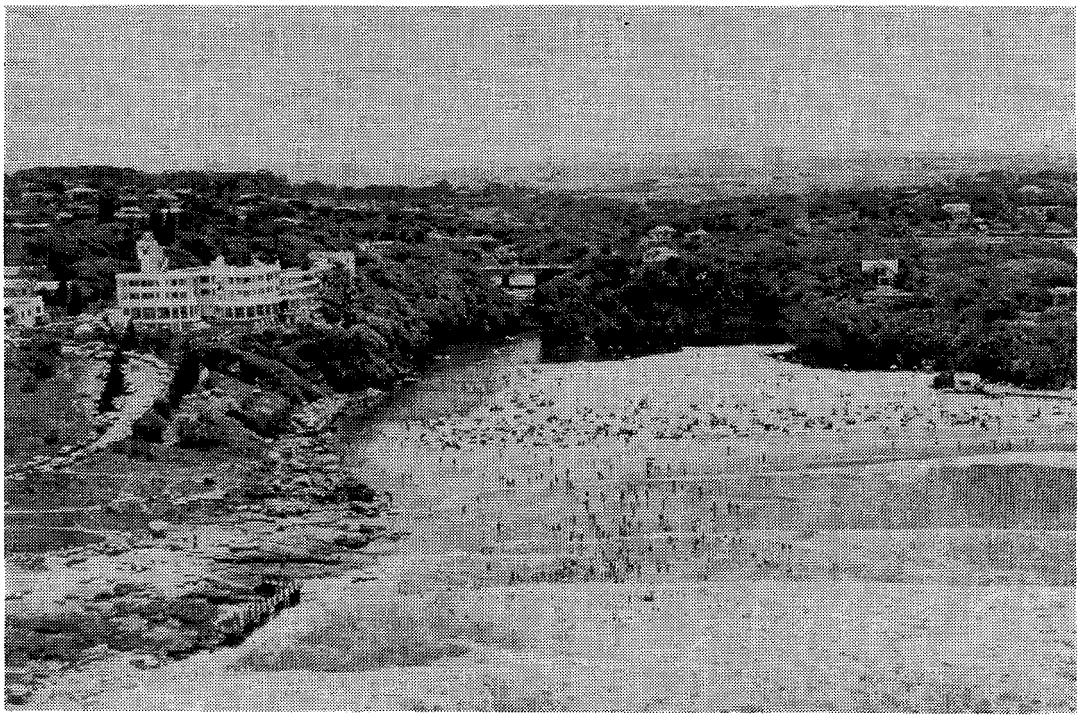
Siltation. Annual siltation at the Stoneylands dam site is estimated to be 0,07 x 10^6 m^3 ([236]).

Land ownership/use. 24% of the catchment area (comprising Location No. 5) is Bantu influenced and destined to become incorporated into KwaZulu. The rest of the catchment is made up of European owned farms most of which grow sugar cane. On both sides of the Vungu river the land is zoned as parkland and has been proclaimed a municipal nature reserve.

On the northern bank of the lagoon is a tearoom and shopping centre, whilst on the southern bank is a hotel. The construction of flats on the southern bank of the Vungu lagoon has been proposed. The population of Uvongo township (± 2 400) may increase to 4 000 over peak holiday periods (Collocott, pers. comm.).

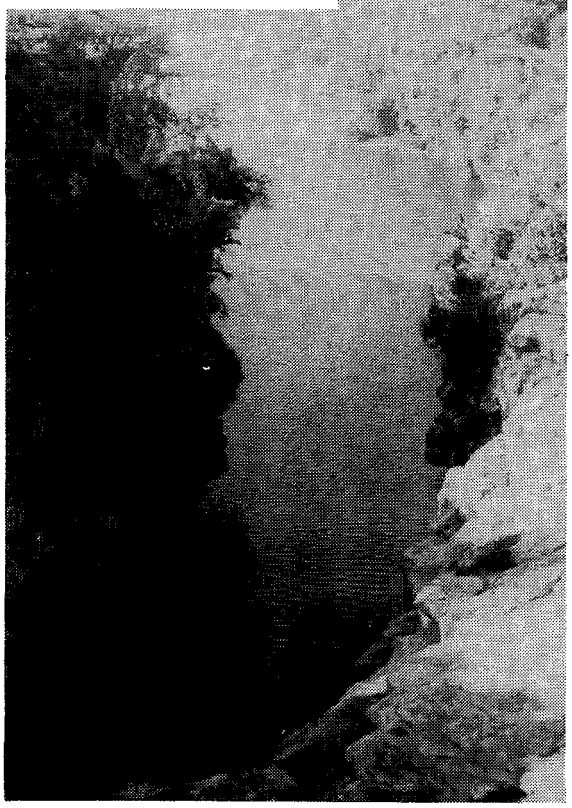
Local authority. Margate.

Estuary uses. The lagoon is used extensively for paddle boating and swimming, although primary use is made of the sandbar since this comprises the popular Uvongo bathing beach area. Beaches along this part of the south coast are far and few between because the rocky nature of the coast precludes beach formation.



A postcard reproduction (with the permission of Art Publishers (Pty) Ltd) illustrating the recreational value of the Vungu lagoon.

9 June 1977



22 April 1978



A view of the Vungu lagoon from above the falls before and during floods.

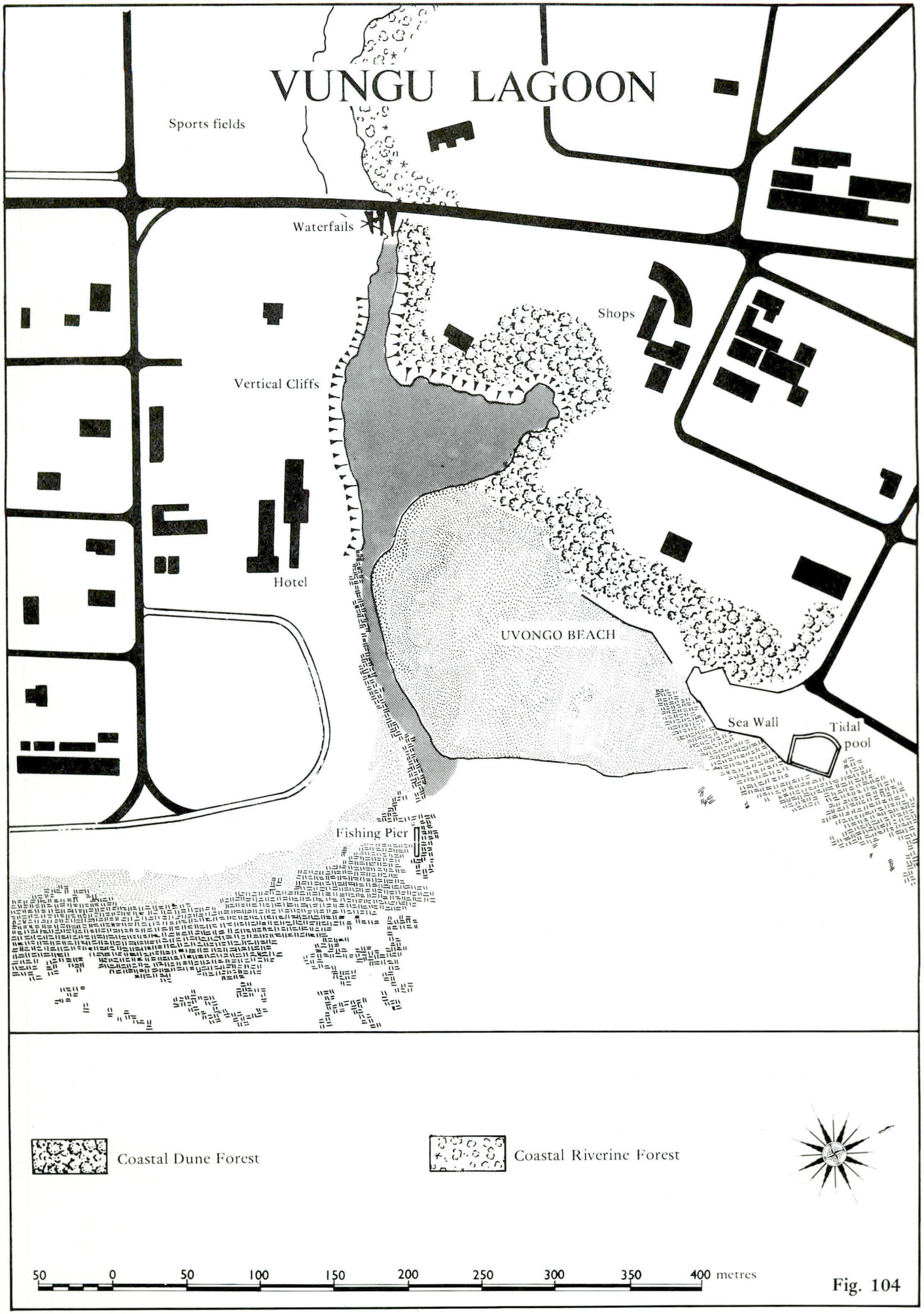

VUNGU LAGOON
Sports fields
Waterfalls
Shops
Vertical Cliffs
Hotel
UVONGO BEACH
Sea Wall
Tidal pool
Fishing Pier
Coastal Dune Forest
Coastal Riverine Forest
50 0 50 100 150 200 250 300 350 400 metres

Fig. 104

Morphometry of lagoon (see Fig. **104**).

Area. 1,13 ha

Axial length. 175 m

Shoreline length. 600 m

Width.
Maximum: 125 m
Mouth: 5 m during low flow periods.
Floodplain: Not applicable.

Bathymetry. The Vungu lagoon is one of the deepest estuarine systems in Natal because of the scouring action of the waterfall. Divers estimate the bottom to be at 27,5 m (Smale, pers. comm.). The channel to the sea can be 0,6 m deep ([118]).

Geomorphology

Geology. The catchment is comprised of Table Mountain Sandstone, gneiss and granite ([17, 101, 236]). In addition to these, Dwyka conglomerates are also reported ([101, 245]).

The falls comprise a quartzitic sandstone cliff ([17, 189]). They extend as sheer walls, around both sides of the lagoon.

Nature of bottom materials. According to Day ([118]) the bottom materials in 1950 were composed of clean sand, but what the actual bottom (i.e. at 27 m) comprises is unknown.

Sandbar characteristics. The bar comprises a broad (175 m wide) expanse of sand between the sea and the lagoon, and is a very popular bathing beach. The channel is against the southern bank, and at low tide, becomes a series of rapids flowing from lagoon. Breaching as such is unnecessary, because the mouth is often partially open ([145]) and sea water regularly enters the lagoon at high tide ([118]).

The Vungu sandbar is unstable and liable to periodically disappear as a result of wave action. To prevent this from occurring (since the presence of the beach for holidaymakers is vital to the town's economy) various attempts have been made to stabilize the beach. Such measures include the building of a groyne in 1965 to force the sea to enter on the southern side of the bar. The groyne now lies buried beneath the beach. Extensions to the groyne were made in 1971. In addition to this, a sea wall (on the northern side of the bar) has been built. Stones were placed at the foot of the wall to dampen the erosive effects of incoming waves at high tide.

Configuration of adjacent shore ([132]).
Beach type — well sheltered, cove.

Average beach slope — 4°
Average beach width — 189 m
Average sand grain size — 298 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents are present in the near vicinity of the lagoon.

Physico-chemical characteristics

There is no information available on the physico-chemical characteristics of the Vungu lagoon.

However, because the Vungu lagoon is so deep, salinity and temperature stratification, and periods of oxygen depletion are likely to occur at depth. Salinities of 20‰ have been recorded in the lagoon by Jackson in September 1975 (pers. comm.). Data on the water chemistry of the Vungu river, 7 km above the lagoon is available ([206]). These results are presented as Table **98**. For some reason Kemp mentions that these results were indicative of sea water contamination.

The Margate quarries above the lagoon wash stone to prevent dust ([17]) and the waste water runs into the river. Possible pollution from brickworks upstream has been reported (Hopwood, pers. comm.) and sand extraction from the riverbed occurs ([17]). Such activities are all likely to adversely affect the clarity of the river water.

Public health aspects

Bacteriology. Marine outfalls and sewers discharge into the sea north and south of the lagoon ([145]), and contamination of the lagoon may occur at high tide. Bacteriological information

Table 98. Physico-chemical characteristics. ([206])

Locality: Vungu river Distance above lagoon : 7km	SUMMER 1970	WINTER 1970
Hydrogen ion concentration (pH)	7.5	7.8
Saturated pH value	9.5	9.4
Conductivity micromhos/cm	177	203
Total dissolved solids ppm (calcd.)	107	123
Dissolved oxygen mg/litre	8.7	9.6
% Saturation	101	102
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.0	1.9
Kjedahl nitrogen mg/litre	0.3	nil
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.50	0.19
Phosphates "	0.10	0.09
Total alkalinity "	24.9	25.0
Total hardness "	33.9	32.1
Calcium "	3.2	3.4
Magnesium "	6.3	5.7
Sodium "	22.2	26.7
Potassium "	0.9	1.0
Sulphates "	1.5	8.6
Chlorides "	39.4	45.2
Silica "	-	-
Iron "	-	-
Fluorides "	0.2	0.1
Free carbonic acid (as ppm carbon dioxide)	1.5	0.8
Temperature ^{o}C	23.0	18.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

provided by van den Berg (Chief Health Inspector, Margate) points to the fact that the Vungu river immediately above the lagoon is faecally polluted. However, data obtained in the early 1970's from the river 7 km above the lagoon ([208]) (see Table **99**) indicated that no faecal pollution was evident. This suggests that the river only becomes polluted near the coast. The township of Uvongo is meant to be on conservancy tanks, the contents of which are transported to the Margate sewage works (van den Berg pers. comm.).

Table 99. Bacteriology of the Vungu river (7 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* 1 /100 ml	Total Coliforms per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C & 24 hours @ ambient.	Confirmed	
March 1971			32	1 100
July 1971			97	1 700
3 Feb 1972	112	104		
21 Feb 1972	96	150	233	
3 July 1972	142	**480**	10	
31 July 1972	350	120		
17 Aug 1972	130	39		
8 Jan 1973	**5 360**	1 800		

Values in bold are significant of disturbance.

Bilharzia. Both van den Berg and Jackson (pers. comm.) have examined the Vungu river for evidence of bilharzia snails, and recommend that contact with the water is inadvisable. Impoundment of the lower reaches of the river (by weirs) appears to have led to a great increase in the number of bilharzia snails above the falls. *Biomphalaria pfeifferi* were present in September 1975 (Jackson, pers. comm.). Although the lagoon is unsuitable for bilharzia snails (because of its depth and salinity), this does not mean to say that during the rainy season contact could not become dangerous. At such times the lagoon becomes dominated by river water coming over the falls.

BIOTIC CHARACTERISTICS

The biotic characteristics of the Vungu river as opposed to those of the lagoon, are fairly well known ([17, 101, 180, 206]).

Flora

There is nothing of great botanical value around the lagoon unless cliff dwelling plants such as the Uvongo lily (*Streptocarpus haygartii*) ([17]) occur.

However, the 28 ha Vungu river reserve is a valuable area of coastal riverine forest above the lagoon. Within the reserve are several plants which are seldom seen in any part of Natal. The tree *Rhynchocalyx lawsonoides* is a good example ([17]). There are 116 species of trees and shrubs in the reserve. *Cola natalensis*, *Trichilia dregeana*, *Bachmannia woodii*, *Gerrardina foliosa* and *Pleurostylia capensis*, (to name a few) are all trees of particular botanical interest in the Vungu reserve ([17]). In parts protea savannah occurs, notable amongst which is *Protea roupelliae*, and *P. multi-bracteata* ([101]).

Fauna

Very little is known about the fauna of the Vungu lagoon. Being so deep, information of this nature would be of great interest. Only Day's unpublished results are available ([118]), and represent a brief survey in 1950 during which only the bottom fauna was collected. Day's survey revealed two species of crabs (under stones), six species of molluscs and a cirripede (from the rock faces of the lagoon), the sand prawn (*Callianassa*) and three species of fish.

The mollusc *Neritina natalensis* was collected within the lagoon by Jackson (pers. comm.) in September, 1975.

Information on the aquatic fauna of the Vungu river, 7 km above the lagoon is available ([206]). The results suggest that in June 1972, satisfactory environmental conditions for aquatic life occurred above the lagoon. Details on the mammal and bird life of the Vungu river reserve is also available ([17, 101]). At one stage crocodiles and hippo apparently lived in the Vungu river ([101]).

Fish: Of the fish collected from the lagoon in 1950 ([118]), it is of interest to note the presence of a conger eel (*Conger conger*) and the "dusky sleeper" (*Eleotris fusca*). In April 1977, a gravid female perch (*Acanthopagrus berda*) was collected in the mouth of the lagoon by Joubert (pers. comm.). This is of interest because whilst the juveniles of this species use lagoons as nurseries, spawning within a lagoon is seldom heard of.

Another important fish utilizing the Vungu river and the lagoon, is the eel *Anguilla mossambica*. The elvers arrive in "tens of thousands" around December to January each year, and actually ascend the falls (Jubb, pers. comm.).

SYNTHESIS

Although there is more understood about the Vungu river than there is about the lagoon, *in toto* our general state of knowledge of the Vungu system is fair. However, being a very unusual lagoon because of its depth, and one of scientific interest, with definite conservation potential, a far more thorough understanding of the system is needed. Even without the results of such surveys, it is safe to conclude that the Vungu lagoon and the river above it, have significant resource value.

The fact that both the lagoon and the river are faecally polluted, and bilharzia infested, are matters which should be in the local authorities own interest to overcome.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																								BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other												Flora			Fauna								Food Webs
VUNGU ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids							★				★				★										←	★	→					
Source of Information		-	Summary of available information																																		
Day	1950	118		●																							●	●								
Harris	1953	145					●								●																					
Cowgill	1967	101	●		●			●		●									○	●				○				○	○							
Midgley & Pitman	1969	223	●		●																															
Kemp *et al*	1970 to 1973	206	●		●						○				○											○										
Fromme	1970 to 1975	132								●																										
Ninham Shand & Partners	1971	245	●																																	
Loxton, Hunting & Assoc.	1971	213	●		●																															
Orme	1971	257	●																																	
NTRPC	1974	236	●					●		●																										
Jackson	1975	pers. comm.				●																					○									
Gevers	1976	134						●																												
Anon	1976	17						●											○	●				○				○	○							
Jubb	1976	pers. comm.																										●								
Dykes (Jeffares & Green)	1977	pers. comm.			●																															
Joubert	1977	pers. comm.																										●								
van den Berg	1977	pers. comm.													○																					
Hopwood	1978	189						●																○					○							
Aerial photos (Scogings)		No.																																		
1:10 000 Job No. 261	1976	365, 347, 350		●																				●												
1:25 000 Job No. 262	1976	454	●																					●												

2.1.12.10 **KONGWENI**

Synonyms

Margate lagoon; Inkongweni (Ward, pers. comm.).

Zulu meaning

inKhongweni is said to mean "the place of entreatment" having been derived from the reputation given to local tribesmen who were noted for their stinginess ([289]). According to Jackson (pers. comm.) the word means "where the bushbuck live" and is indicative of the type and density of vegetation that used to occur along the river.

Location

30°51'30"S; 30°22'15"E.

Accessibility

The Kongweni lagoon is 145 km south west of Durban and 17 km south west of Port Shepstone. There is a classified airport at Margate.

Secondary roads provide easy access to almost any point of the lagoon.

Bridges

There is a footbridge over the middle reaches of the lagoon. The national road crosses the Kongweni river just above the head of the lagoon.

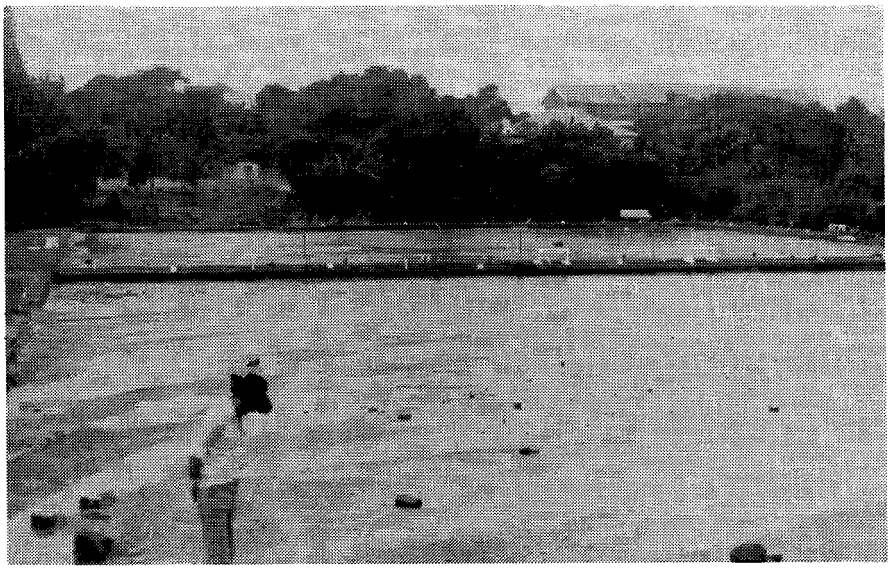
ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 18 km^2

River length. 6 km

Mean annual run-off. Urbanization of the catchment is likely to result in increased run-off characteristics. However, no quantitative estimates are available to verify this.



Urbanization of the Kongweni catchment could well contribute to the reason why flooding of the river in April 1978 resulted in inundation of the bowling greens.

Flow. No record.

Flood history. No record. Although the new swimming pool and go-cart track at the mouth of the lagoon are in a particularly hazardous area (Cowan, pers. comm.), floods in April 1978 (after 305 mm of rain in 8 hours) by-passed these facilities without creating any damage. Their physical presence however, seems to have forced the river (when in flood) to shift its northern bank — with the result that the car park and flats established there, will have to be protected from any further erosion (Johnson, pers. comm.).

Dams.
Existing: There are two very small dams on the river.
Proposed: None.

Siltation. No record.

Land ownership/use. The Kongweni lagoon is surrounded by Margate, a boom town and prime resort area on the Natal south coast. Consequently much of the catchment area is in a semi-developed or urbanized state. The Margate sewage works are located 1,5 km above the lagoon.

Both banks are completely built up as a residential area, including holiday flats and various commercial centres.

On the southern bank are bowling greens near the upper reaches of the lagoon, and at the mouth, a swimming pool, putt-putt course and go-cart track.

Local authority. Margate Town Board.

Estuary uses. Although the Kongweni lagoon is not used for any specific recreational purpose, the sandbar constitutes the most important part of the Margate bathing beach area. The floodplain is also the focal point of many recreational facilities.

Morphometry of lagoon (see Fig. **105**).
Area. 1,42 ha

Axial length. 700 m

Shoreline length. 1,5 km

Width.
Maximum: 40 m
Mouth: No record.
Floodplain: 60 m

Bathymetry. No record.

Geomorphology
Geology. From interpretations by the Department of Geological Survey ([236]), both catchment and lagoon are made up of Table Mountain Sandstone. However, just south of the lagoon, granite outcrops on the coast ([134]).

Nature of bottom materials. No record.

Sandbar characteristics. The Kongweni sandbar is 300 m long and (if permitted to do so) would be south extending, under natural conditions. However, the channel to the sea is artificially maintained in a northerly position, to prevent it from interfering with the go-cart track, putt-putt course and swimming pool, on the floodplain.

This has resulted in almost permanent closure ([239]) and has impaired bathing conditions by changing beach gradients (Cowan, pers. comm.). NRIO recommended that the lagoon should be opened regularly to allow flushing ([239]).

Configuration of adjacent shore ([132]).
Beach type — sheltered asymmetrical cove.

Average beach slope — 3°
Average beach width — 136 m
Average sand grain size — 307 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents in the near vicinity of the lagoon are reported to be absent.

Physico-chemical characteristics
There is virtually no information available on the physico-chemical characteristics of the Kongweni lagoon.

Salinities of 10‰ were reported from the lagoon by Jackson in August 1976 (pers. comm.) and the river is reported to be heavily polluted by NRIO ([239]).

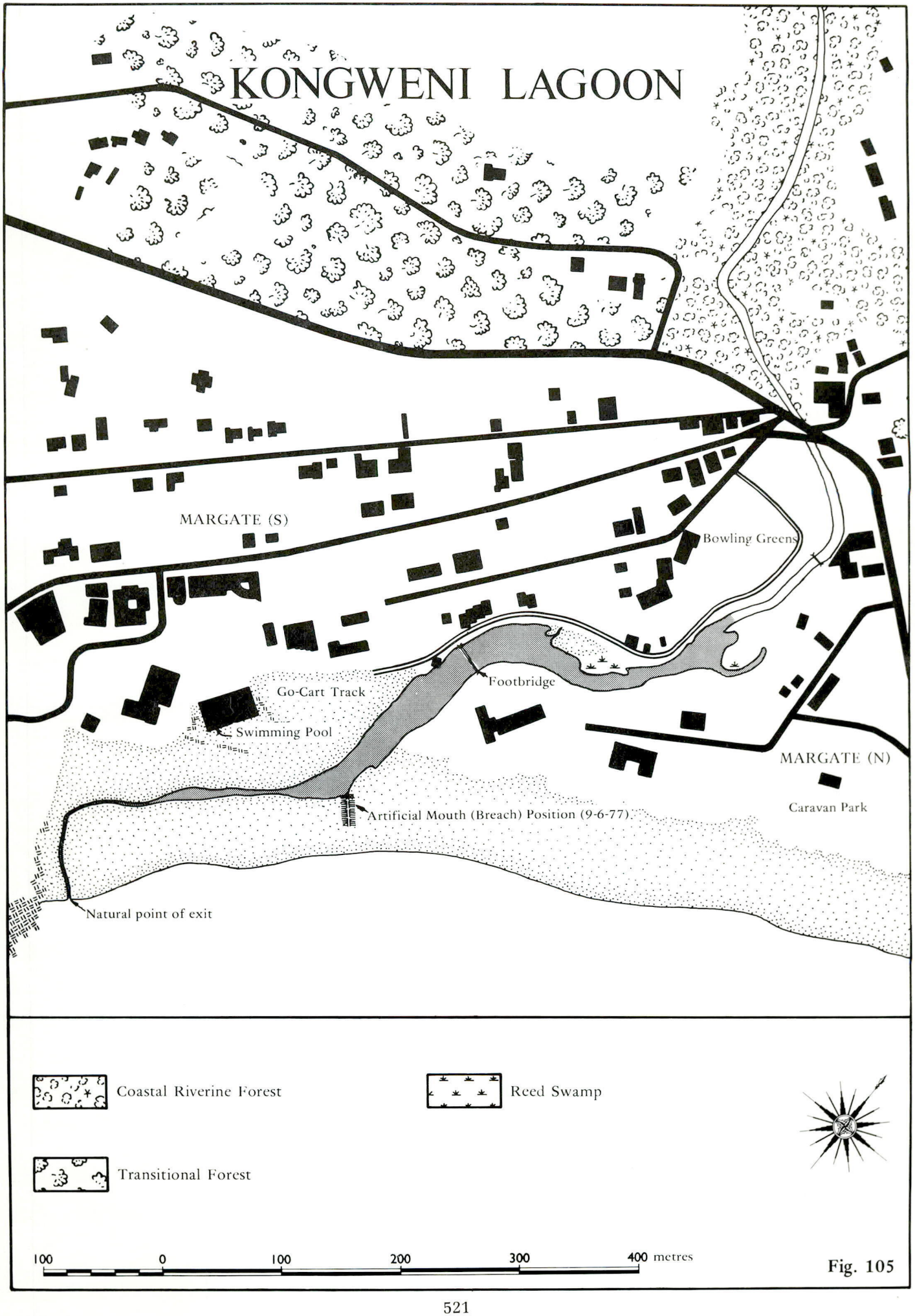

KONGWENI LAGOON
MARGATE (S)
Bowling Greens
Footbridge
Go-Cart Track
Swimming Pool
MARGATE (N)
Caravan Park
Artificial Mouth (Breach) Position (9-6-77)
Natural point of exit
Coastal Riverine Forest
Reed Swamp
Transitional Forest
100 0 100 200 300 400 metres

Fig. 105

Public health aspects

Bacteriology. Ever since the surveys of Harris ([145]) in the 1950's, the Kongweni lagoon has been recognised as carrying a high bacterial load.

In 1973, the Margate sewage works started piping sewage effluent to a marine outfall positioned 1 km north of the lagoon. Leaks still periodically account for high levels of faecal pollution, but the primary sources are septic tanks and the lack of toilet facilities for Bantu employees (van den Berg, pers. comm.). Attempts to fence off the edge of the river have been made and toilets are being built at gathering places such as bus stops.

Bilharzia. van den Berg and Jackson (pers. comm.) both maintain that bilharzia is rife in the Kongweni river. *Physopsis* (on 23 September 1975) and *Biomphalaria pfeifferi* (on 17 April 1973) have been collected in the river by Jackson, and in van den Berg's opinion, bilharzia can be contracted even at the mouth of the lagoon. The situation has been aggravated by several factors:

- river impoundment,
- by the discharge of a nutrient laden sewage effluent into the river (pre 1973).
- by the destruction of riverine vegetation (see under flora), and
- the proximity of an African bus stop.

BIOTIC CHARACTERISTICS

Flora

As a result of urban encroachment, the flora of the Kongweni lagoon is virtually non-existent and certainly unimportant.

The only plant community of any significance in the vicinity of the lagoon (although severely disturbed itself), is a fringe of riverine vegetation immediately above it. Being zoned as public open space, the suggestion has been made that this stream be declared a municipal botanical garden ([189]). This would have advantages, because according to Jackson (pers. comm.), the significance of the riverine vegetation, lies in the indirect "control" such vegetation had on bilharzia snails. In other words, in its undisturbed state the heavily wooded, shady, Kongweni stream supported a community amongst which were predators which kept the bilharzia snails in check. Once this vegetation became disturbed, and the river became dammed and used for sewage disposal, ecological relationships of this sort became disrupted. Snails proliferated, which once infected, gave rise to bilharzia.

Fauna

The molluscs, *Assiminea bifasciata* and *A. hidalgoi* were recorded as present in the lagoon by Jackson in August 1976 (pers. comm.). Other than this, information on the fauna of the Kongweni lagoon, or the river above it, is non-existent. However, it can be assumed to be unimportant in this respect.

SYNTHESIS

Our general state of knowledge of the Kongweni lagoon is very poor. The lagoon is polluted and has been highly disturbed and modified. In its present degraded environmental condition, it is of no resource value. Before the Kongweni lagoon becomes a liability rather than an asset to the Local Authority, attention should be paid to its water quality, with emphasis placed on the control of bilharzia and faecal pollution.

Degradation of the Kongweni lagoon has arisen from:-

- urban encroachment,
- sewage pollution,
- floodplain encroachment,
- manipulation of the mouth, and the
- destruction of riparian vegetation.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora		Fauna							Food Webs
KONGWENI			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids															★																	
Source of Information	Summary of available information																															
Harris	1953	145													●																	
Fromme	1970 to 1975	132								●																						
Jackson	1973 to 1976	pers. comm.				●						●											●		●	●						
NTRPC	1974	236						●																								
NRIO	1975	239					●			●	●																					
Gevers	1976	134						●																								
van den Berg	1977	pers. comm.									●				●											●						
Cowan	1977	pers. comm.			●					●																						
Hopwood	1978	189						●																								
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	369		●																			●									
1:25 000 Job No. 262	1976	453	●																													

Synonyms
None.

Zulu meaning
No record.

Location
30°52'45"S; 30°21'30"E.

Accessibility
By road, the Uvuzana lagoon is 20 km south west of Port Shepstone, and 148 km south west of Durban. On the southern bank there is an access road down to the mouth of the lagoon.

Bridges
There are no bridges across the lagoon, but the national road crosses the Uvuzana river directly above it.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 7 km²

River length. 2,5 km

Mean annual run-off. No record.

Flow. No record.

Flood history. No record.

Dams.
Existing: None.
Proposed: None.

Siltation. (See under nature of bottom materials).

Land ownership/use. The catchment is principally influenced by sugar cane farms. Surrounding the lagoon is Margate (to the north) and Baven-on-sea (to the south). Land adjacent to the water's edge is zoned as Admiralty Reserve.

Local authority. Margate Town Board.

Estuary uses. The lagoon is not used for any purpose. As far as the local authority is concerned, it may as well not exist, since they give it no attention and attribute no value to it.

Morphometry of lagoon (see Fig. **106**).
Area. 0,6 ha

Axial length. 225 m

Shoreline length. 700 m

Width.
Maximum: 45 m
Mouth: No record.
Floodplain: 120 m

Bathymetry. No record.

Geomorphology
Geology. Both catchment and lagoon are made up of granite ([236]).

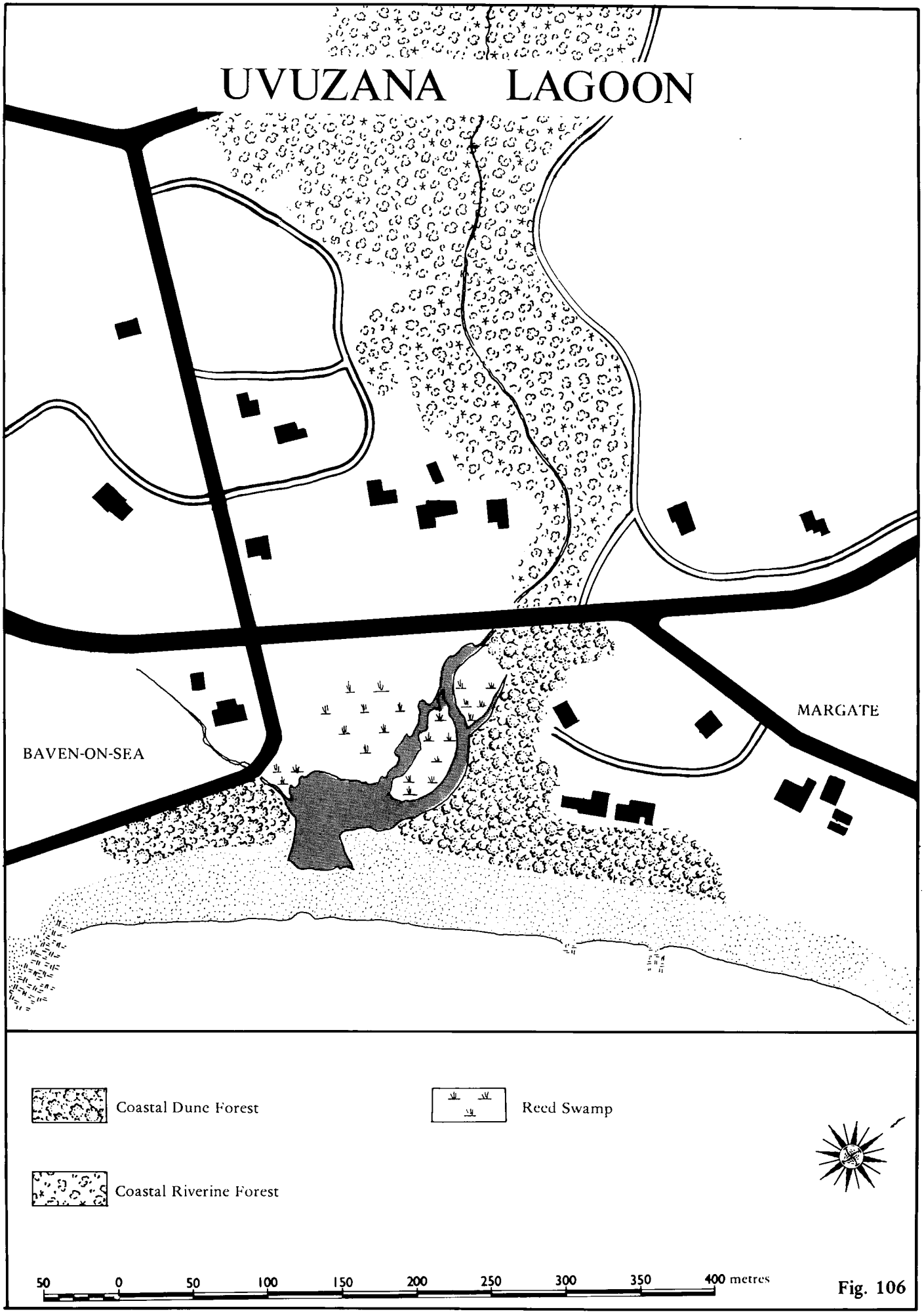

UVUZANA LAGOON
BAVEN-ON-SEA
MARGATE
Coastal Dune Forest
Reed Swamp
Coastal Riverine Forest
50 0 50 100 150 200 250 300 350 400 metres

Fig. 106

Nature of bottom materials. According to Cowan (pers. comm.) the floor of the lagoon used to be sandy but in the last decade has become increasingly muddy. This may well be an influence of sugar cane farming in the catchment.

Sandbar characteristics. There is a short (70 m long) south extending bar across the mouth of the lagoon. It is very infrequently open, and only topped by high spring tides. Breaching is unnecessary.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

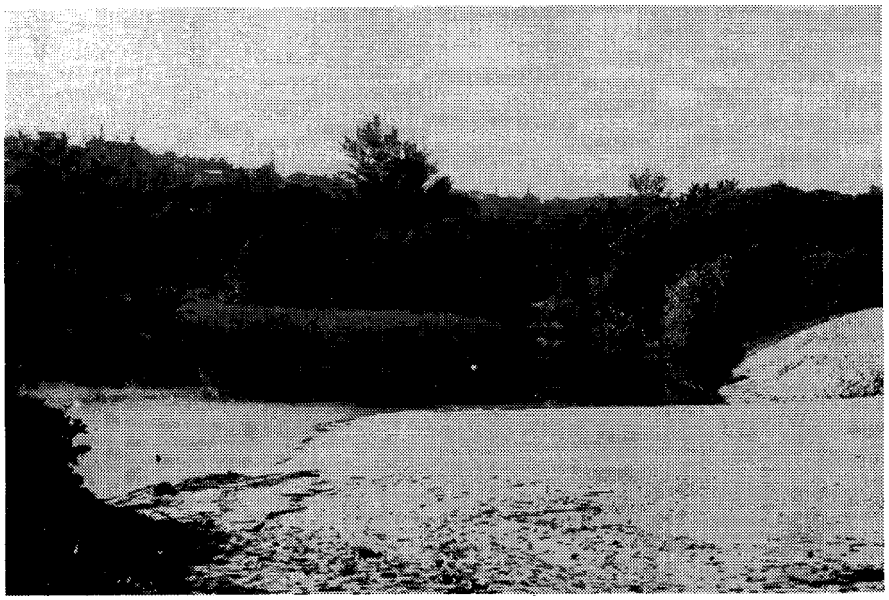
Physico-chemical characteristics. No record.

Public health aspects. No record.

BIOTIC CHARACTERISTICS

Flora

The plant communities around the lagoon and above it are undisturbed. In the centre of the lagoon is a small reed covered island. *Mimusops caffra* and *Hibiscus* occurs on the water's edge.



An impression of the plant communities surrounding the Uvuzana lagoon.

Construction of the south coast freeway is liable to disturb the riverine forest community above the lagoon.

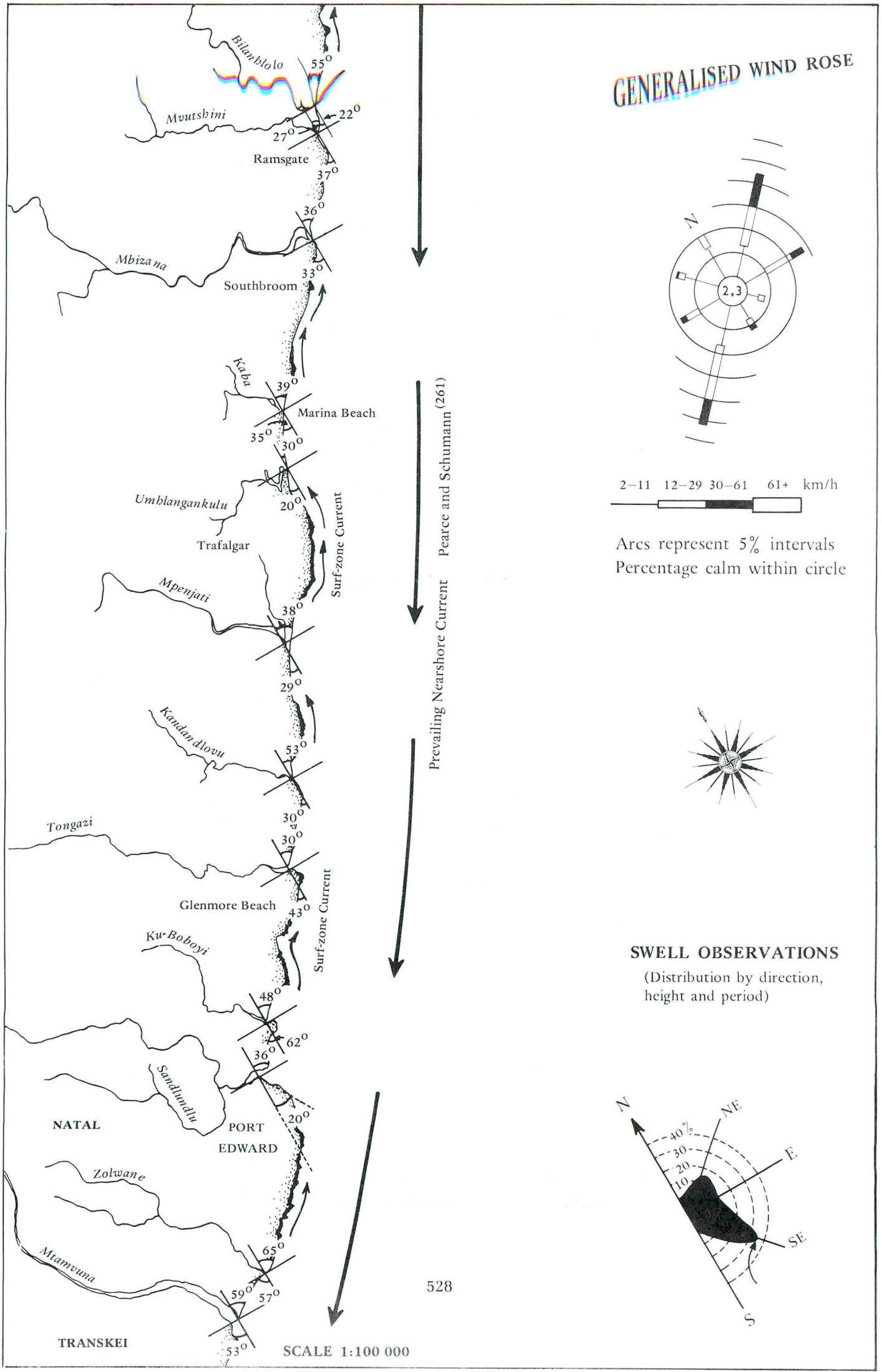
Fauna

No record.

SYNTHESIS

Virtually nothing is known about the Uvuzana lagoon. However, as an estuarine resource, it is not considered to be of any value — largely because of its small size and silted condition. Being protected by Admiralty Reserve, the lagoon is botanically well endowed, but does not support any community which is not commonly represented elsewhere along the coast. In conclusion therefore, there is no valid reason for research effort to be expended upon the Uvuzana lagoon.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other						Flora			Fauna							Food Webs
UVUZANA			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																																	
Source of Information	Summary of available information																																
NTRPC	1974	236						●																									
Cowan	1977	pers. comm.								●																							
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	372		●																			●										
1:25 000 Job No. 262	1976	451	●																														


Bilanhlolo
55°
Mvutshini
22°
27°
Ramsgate
37°
36°
Mbizana
33°
Southbroom
Kaba
39°
Marina Beach
35°
30°
Umhlangankulu
20°
Trafalgar
Surf-zone Current
Mpenjati
38°
29°
Kandandlovu
53°
30°
Tongazi
30°
Glenmore Beach
43°
Surf-zone Current
Ku-Boboyi
48°
62°
36°
Sandlundlu
20°
NATAL
PORT
EDWARD
Zolwane
65°
Mtamvuna
59°
57°
TRANSKEI
53°
Prevailing Nearshore Current
Pearce and Schumann (261)
GENERALISED WIND ROSE
N
2,3
2–11 12–29 30–61 61+ km/h
Arcs represent 5% intervals
Percentage calm within circle
SWELL OBSERVATIONS
(Distribution by direction, height and period)
N
NE
E
SE
S
40%
30
20
10
SCALE 1:100 000

2.1.13.1

BILANHLOLO and MVUTSHINI

Introduction

Lying only 500 m apart, information on the Bilanhlolo and the Mvutshini lagoons can be conveniently reviewed simultaneously, as both have very similar characteristics.

Synonyms

Bilanhlolo

(i) Ibilanhlolo ([257]); variations thereof are Ibilanhlola and Ibilanhloto (Natal Archives).
(ii) Bulanhloya (1:500 000 series of Natal).
(iii) "Blue Lagoon" and "Ramsgate Lagoon" are both locally used names.

Mvutshini — Little Bilanholo ([257]) or "Little Billy".

Zulu meaning

Bilanhlolo — An onomatopeic word meaning "the river that boils alarmingly" ([289]) due to the manner in which the water seems to bubble and boil, or "chuckle" over the rocky river bed.

Mvutshini — No record. However, in Tongaland there is a lake called Mvutshini which means "the place of hippos" ([289]). Although an unlikely looking place, it is not impossible that at some time in the past, a hippo took up residence in the Mvutshini lagoon. Hippo once lived in the Vungu river ([101]) which is only 8 km north of the Mvutshini lagoon.

Location

Bilanhlolo — 30°53'30"S; 30°21'15"E.

Mvutshini — 30°53'45"S; 30°20'45"E.

Accessibility

Bilanhlolo — By road the lagoon is 22 km from Port Shepstone, or 150 km from Durban. Provision has been made on the northern bank for vehicular access to the mouth of the lagoon.

Mvutshini — By road the lagoon is 151 km south west of Durban. Only pedestrian access is provided for.

Bridges

Bilanhlolo — The national road crosses the lagoon on a curved bridge 150 m from the mouth. There is also a footbridge across the head of the lagoon, 400 m from the mouth.

Mvutshini — The national road crosses the lagoon on a curved bridge 100 m from the mouth. In neither case are any adverse effects detectable.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area.

Bilanhlolo: 19 km^2

Mvutshini: 6 km2

River length.

Bilanhlolo: 12 km (personal estimate).

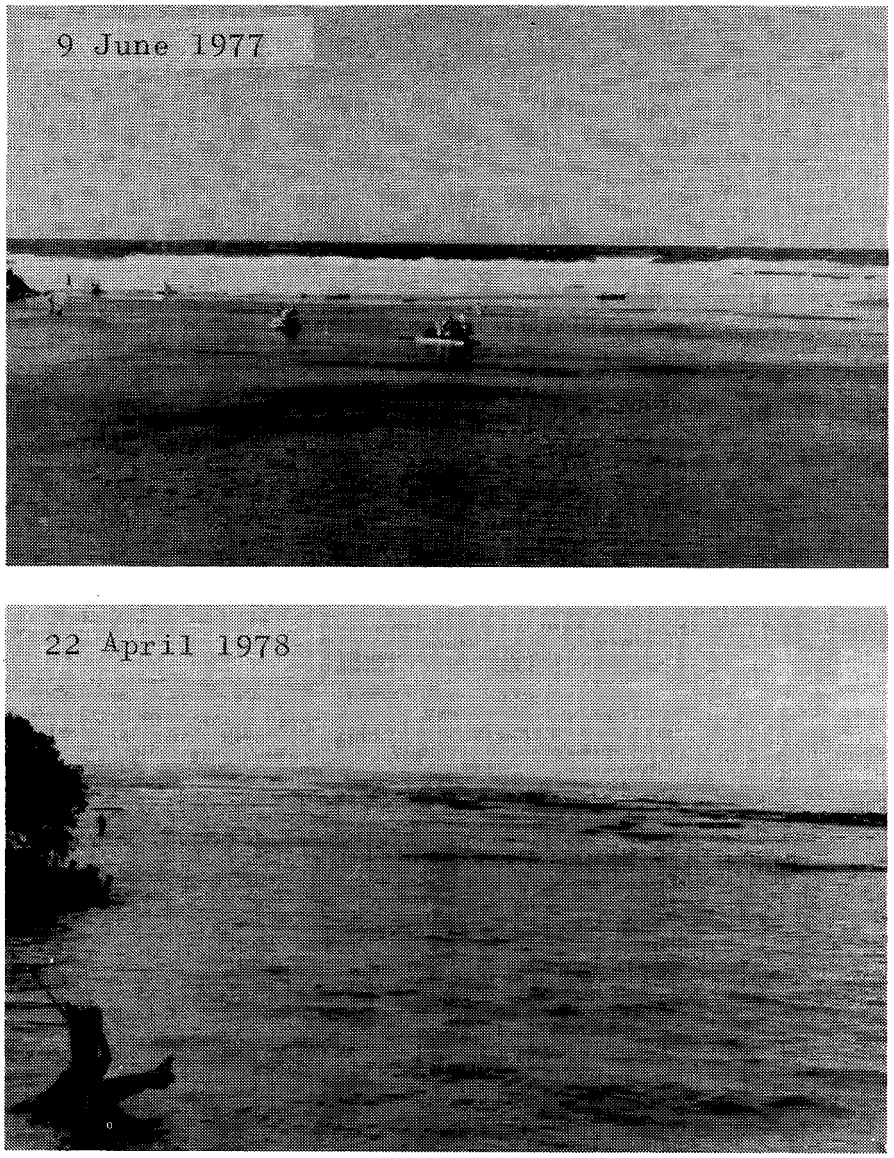
Mvutshini: 6,5 km

Mean annual run-off. No record for either lagoon.

Flow. No record for either lagoon.

Flood history.

Bilanhlolo: Quantitative estimates of flood discharges have not been made. However, in April 1978, flood levels rose almost to the foot of the restaurant alongside the lagoon (pers. obsv.).



Transformation of the Bilanhlolo lagoon before and after floods.

Mvutshini: Depending on the formula used, a 1:50 year flood has been estimated to discharge from 63 m^3/sec. to 102 m^3/sec. (Dykes, pers. comm.). A realistic figure is probably 72 m^3/sec.

Dams. No dams exist nor have any been proposed above either lagoon.

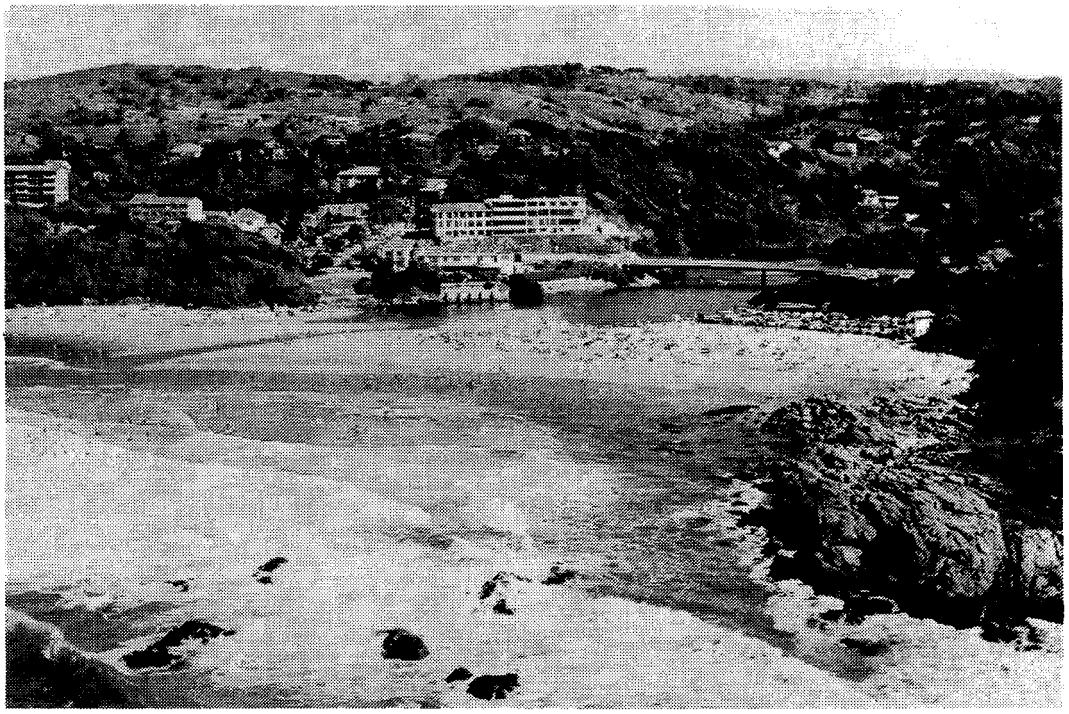
Siltation. No record for either lagoon. Only the Bilanhlolo is liable to have siltation problems because of the larger, sugar cane influenced catchment.

Land ownership/use. Within the catchment areas of both lagoons, sugar cane is farmed. On the Bilanhlolo, 2,6% of the catchment area is made up of the Kwaxolo Bantu reserve. In the Mvutshini catchment, 15% of the area is Bantu influenced. Of the two lagoons, the surrounds of the Bilanhlolo are the most intensively developed. They lie in the centre of Ramsgate, which is a popular resort area on the south coast. Restaurant, hotel, flat and residential development surrounds the Bilanhlolo lagoon, and the construction of more flats has been proposed.

Local authority. In both cases, the Margate Town Board.

Estuary uses.

Bilanhlolo; Paddle boats are used extensively on the Bilanhlolo lagoon. The sandbar is also a popular bathing beach, and children swim in the lagoon.



A view of the Bilanhlolo lagoon showing its recreational value to holidaymakers. (A postcard reproduction with permission of Art Publishers (Pty) Ltd).

Mvutshini: The Mvutshini lagoon is not used for any specific purpose. However, 250 m south of the lagoon is a ski-boat launching site, from which 30 to 35 boats operate.

Morphometry of lagoon (see Fig. **107** & **108**).

Area.
Bilanhlolo: 2,6 ha.
Mvutshini: 0,88 ha

Axial length.
Bilanhlolo: 500 m
Mvutshini: 250 m

Shoreline length.
Bilanhlolo: 1,2 km
Mvutshini: 650 m

Width.

Bilanhlolo	**Maximum:**	100 m
	Mouth:	10 m during low flow periods, but during high spring tides may become 50 m wide.
	Floodplain:	100 m
Mvutshini	**Maximum:**	70 m
	Mouth:	No record.
	Floodplain:	There is no floodplain as such because the lagoon lies within a steeply sided valley.

Bathymetry.
Bilanhlolo: Estimated to be ± 3 m below the bridge (pers. est., June 1977).
Mvutshini: Estimated to be ± 2 m below the bridge (pers. est., June 1977).

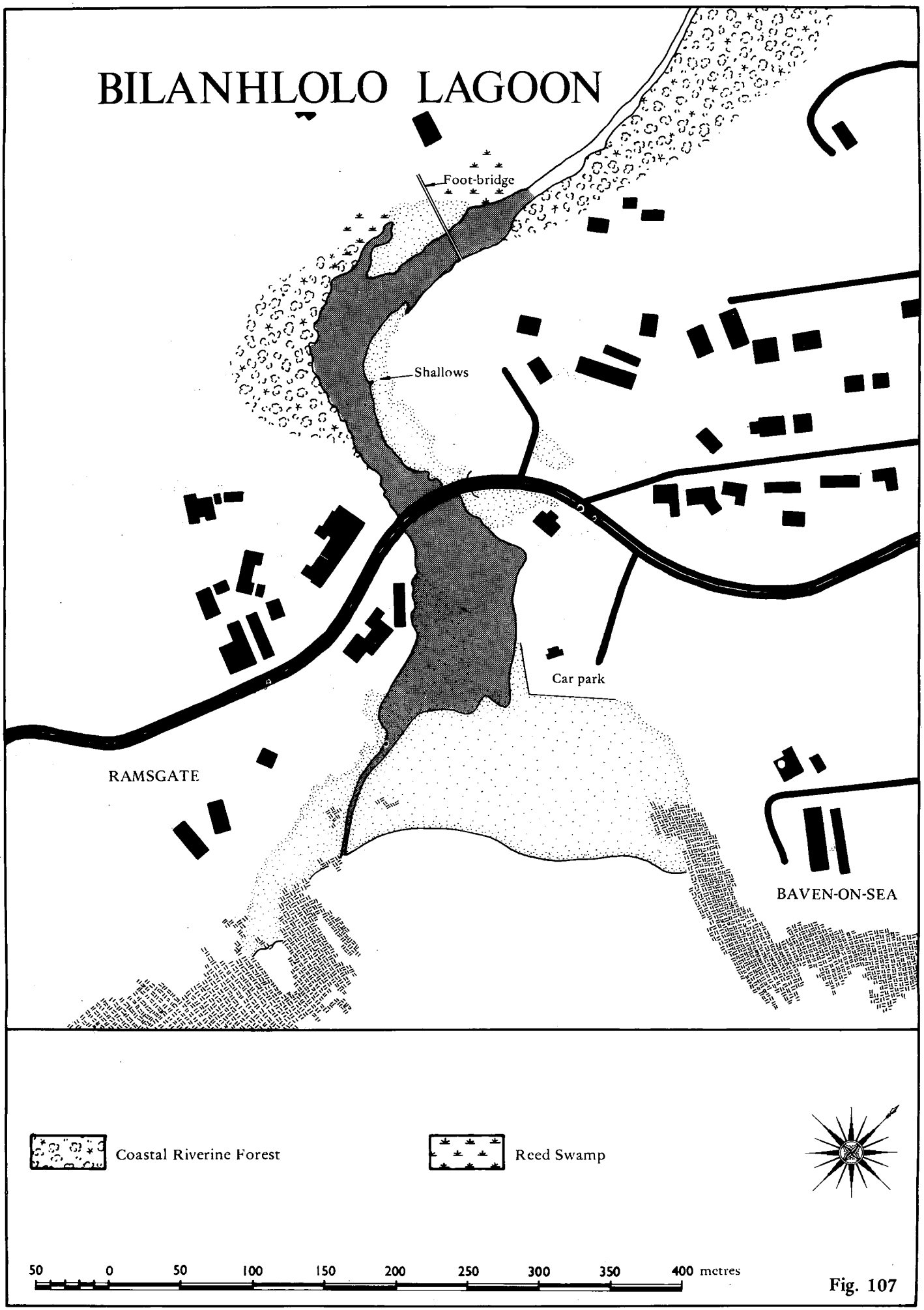

BILANHLOLO LAGOON
Foot-bridge
Shallows
Car park
RAMSGATE
BAVEN-ON-SEA
Coastal Riverine Forest
Reed Swamp
50 0 50 100 150 200 250 300 350 400 metres

Fig. 107

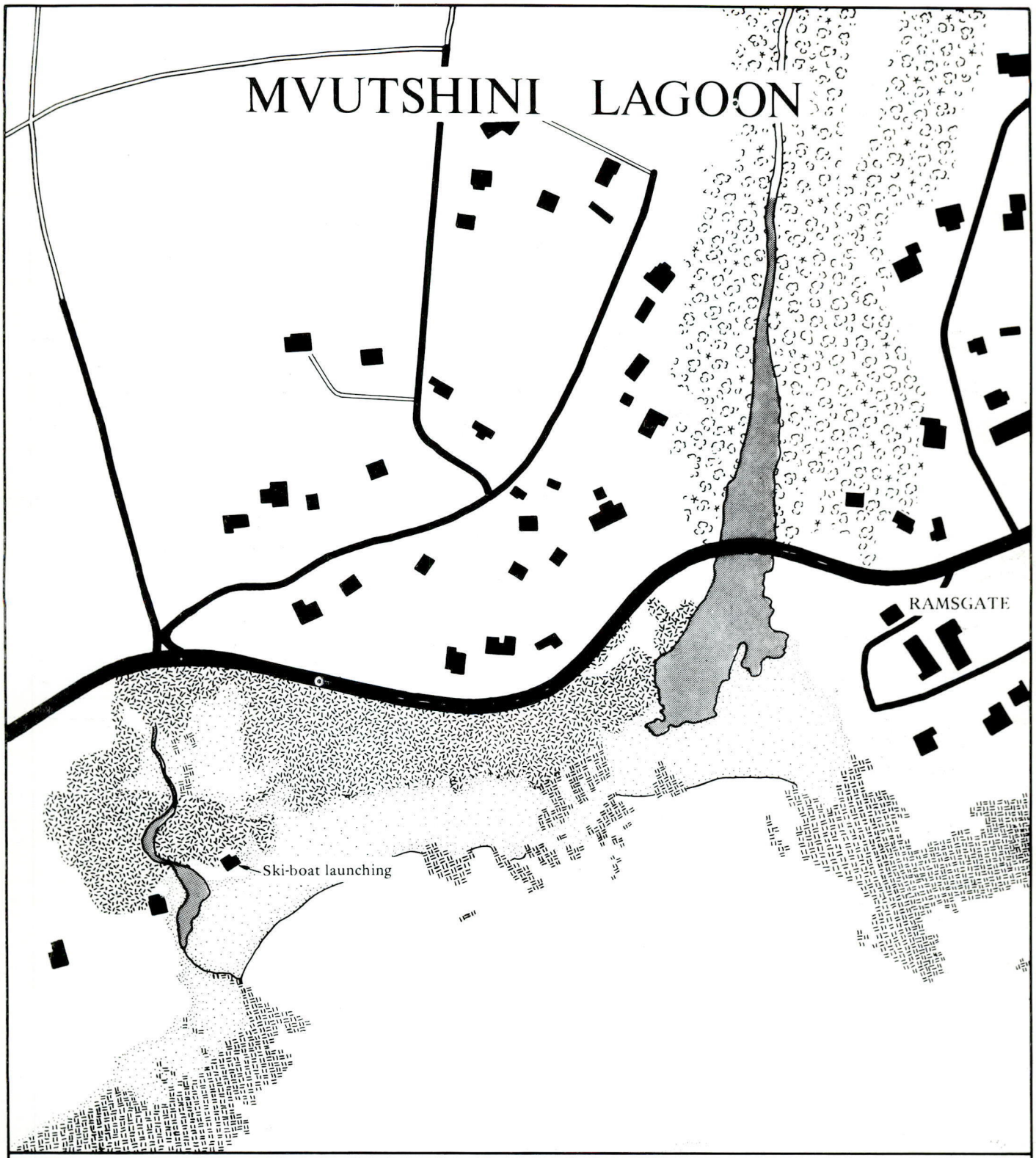

MVUTSHINI LAGOON
RAMSGATE
Ski-boat launching
Coastal Riverine Forest
Coastal Dune Pioneer
50 0 50 100 150 200 250 300 350 400 metres

Fig. 108

Geomorphology

Geology. In both cases the catchment and lagoon are surrounded by granite ([238]). Bedrock lay at 12 m below mean sea level beneath the Mvutshini lagoon ([257]).

Nature of bottom materials.

Bilanhlolo: No record, but probably very similar to those underlying the Mvutshini (see Fig. **109**). Fairly large sand banks have formed on both sides of the lagoon in its upper reaches.

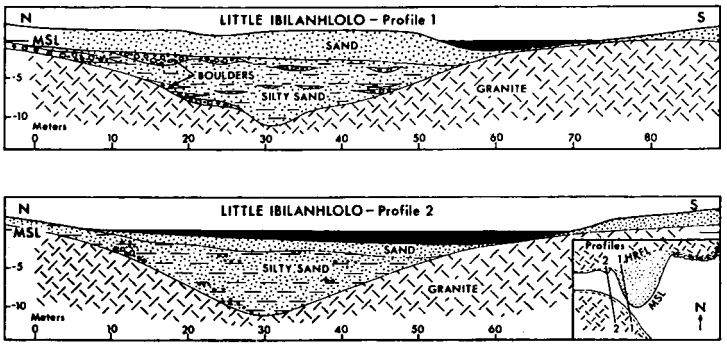


Fig. 109. Cross sections through the Mvutshini lagoon (after Orme ([257])).

Mvutshini: Bottom material in the Mvutshini lagoon (see Fig. **109**) comprises silty sand containing many granite boulders ([257]). Near the mouth, marine sand overlies these deposits, the depth of which thins rapidly as one moves away from the mouth.

Sandbar characteristics.

Bilanhlolo: The sandbar is generally 200 m long, and south extending. The mouth can adopt a central position (as in aerial photos, dated 12 June, 1976) but this is atypical. It is normally towards the southern end of the bar. The latter is occasionally opened artificially to prevent the rising lagoon from inundating the lawn, septic tanks and footbridge of the restaurant (Cowan, pers. comm.).

Mvutshini: The lagoon lies impounded behind a 125 m long, south extending sandbar, forming a beach at the back of a sheltered cove. It is generally closed to the sea, but at high spring tide, sea water overtops the bar.

The lagoon is never breached artificially.

Configuration of adjacent shore.

Bilanhlolo: ([132])

Beach type — well sheltered cove.

Average beach slope — 5°
Average beach width — 124 m
Average sand grain size — 301 microns

} indicative of moderate surf zone conditions.

Mvutshini: No record, but almost certainly similar to the conditions described for the Bilanhlolo.

Surf zone currents. Rip currents are apparently absent in the near vicinity of the Bilanhlolo lagoon ([132]).

Physico-chemical characteristics

In both cases there is no information available on the physico-chemical characteristics of either lagoon or the river above. On 9 June 1977 the water in both lagoons was remarkably clear (pers. obsv.). Salinities of 10‰ were recorded in the Bilanhlolo lagoon by Jackson on 11 August 1976 (pers. comm.).

Public health aspects

Bacteriology.

Bilanhlolo: The results of a bacteriological survey in early 1954 by the Provincial pathologist, indicated that there was considerable contamination of the lagoon from septic tanks ([145]). Since then, conservancy tanks have replaced septic tanks, but van den Berg (Chief Health Inspector of Margate, pers. comm.) is of the opinion that the lagoon is still polluted. During high water level periods, the smell of sewage from septic tanks located too close to the water's edge, becomes detectable (pers. obsv. April 1978).

Mvutshini: No record.

Bilharzia.

Bilanhlolo: No bilharzia snails were found either in the lagoon or the river above it by Jackson in August 1976 (pers. comm.). However, the Chief Health Inspector of Margate considers the river to be infected with bilharzia. A warning sign at the headwaters of the lagoon has been erected (van den Berg, pers. comm.).

Mvutshini: No bilharzia snails were found either in the lagoon or the river above it by Jackson in April 1971 (pers. comm.). The Mvutshini lagoon is also considered to be bilharzia free by van den Berg (pers. comm.).

BIOTIC CHARACTERISTICS

Flora

Neither lagoon supports any noteworthy plant community. However, where the valleys become steeply sloping, coastal forest communities have remained undisturbed.

Fauna

Bilanhlolo: The molluscs *Assiminea bifasciata* and *Neritina natalensis* were taken from the lagoon by Jackson in August 1976 (pers. comm.). The sand prawn (*Callianassa kraussi*) also occurs (pers. obsv.).

Mvutshini: No record.

SYNTHESIS

Our state of knowledge of both the Bilanhlolo and the Mvutshini lagoon is poor. However, other than their recreational value, neither are considered to have any significant nursery function despite both being in fair environmental condition. Bacteriological surveys are necessary in order to guard against faecal contamination of the Bilanhlolo lagoon. It has been pointed out by Clark ([83]) that for soil cleansing to be effective, septic tanks should not be located closer than 46 m from the water's edge.

Problems in the Bilanhlolo lagoon relate to sewage contamination, the artificial control of water levels, and siltation. The Mvutshini lagoon is problem free.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry					Other							Flora			Fauna							Food Webs
BILANHLOLO and MVUTSHINI			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids															★																	
Source of Information	Summary of available information																																
Harris	1954	145													●																	
Fromme	1970 to 1975	132								●																						
Jackson	1971	pers. comm.				●																				●						
Orme	1971	257						●		●																						
NTRPC	1974	236						●																								
Dykes (Jeffares & Green)	1977	pers. comm.			●																											
van den Berg	1977	pers. comm.													●																	
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	375		●																				●								
1:25 000 Job No. 262	1976	451	●																													

2.1.13.2 **MBIZANA**

Synonyms

The name Mbizane appears on the 1:250 000 sheet No. 3030 and has been adopted by Kemp *et al* ([208]); NRIO ([239]) use the name Imbezane.

Zulu meaning

The name comes from the word emBhizano which means either "the place of potholes in the rocks" or, "a river overflowing with ample water" ([289]).

Location

30°35'45"S; 30°20'15"E.

Accessibility

By road, the northern bank of the Mbizana lagoon is 26 km south west of Port Shepstone, or 153 km south west of Durban.

At this point the national road swings inland to cross the Mbizana river (on a recently completed bridge) 1,5 km above the lagoon. Vehicular access through Southbroom to the mouth of the lagoon, on its southern bank, is thus possible.

Bridges

There are no bridges across the Mbizana lagoon. It should be noted that this is virtually the first lagoon south of Manzimtoti (120 km further north) to be unaffected in this manner. From the Mbizana south, none of the lagoons are bridged.

Although Orme ([257]) mentions a rail bridge being washed away in the 1959 floods, there has never been a railway bridge over the Mbizana, nor has the road bridge ever been washed away (Fearnhead, pers. comm.).

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 142 km^2 ([213]); 150 km^2 ([206, 245, 257]) 160 km^2 ([223]).

River length. 26 km ([206, 245, 257]).

Mean annual run-off. 17 x 10^6 m^3 ([213]) to 23,4 x 10^6 m^3 ([223]).

Flow. A rough estimate of the average flow in 1970 was ,37 m^3/sec. ([206]).

Flood history. The Mbizana is characterized by violent flash floods. Depending on the formula used, 1:50 year floods have been calculated to discharge from 415 m^3/sec. to 759 m^3/sec. A realistic figure would be ± 660 m^3/sec. (Dykes, pers. comm.). Flood waters have been known to overtop the roadbridge above the lagoon, rendering it impassable to traffic. Floods bring down much trash in the form of reeds, sugar cane, and dead animals (Engle, pers. comm.).

Dams.

Existing: None.

Proposed: A dam site with a total capacity of 21,93 x 10^6 m^3 ([236]), has been located at "Bushyvales", 4,4 km above the lagoon ([245]).

Siltation: Annual siltation at the Bushyvales dam site is estimated to be 0,11 x 10^6 m^3 ([236]). The consequences of this high rate of siltation are clearly apparent from aerial photos of the Mbizana lagoon. The steep gradient of the lagoon floor confines tidal exchange to the lower reaches. Silt sources are attributed to sheet erosion in the Bantu reserve (Location No. 4) and to bank erosion occurring nearer the coast where sugar cane has been planted onto the edges of the river.

Land ownership/use. 70% of the Mbizana catchment is Bantu influenced (comprising the Kwaxolo reserve or Location No. 4) and destined to become incorporated into KwaZulu in the near future. In the lower catchment (or coastal areas) sugar cane farms are encountered.

Although the residential area of Ramsgate lies immediately north of the lagoon, the northern bank has remained undeveloped due to it having been zoned as Admiralty reserve. South of the lagoon is the residential area of Southbroom.

Local authority. On the northern bank, the upper and lower reaches of the lagoon are controlled by the Margate Town Board. In the middle reaches, the land is privately owned.

The entire southern bank is controlled by the Southbroom Health Committee.

Estuary uses. Utilization of the lagoon is limited to canoeing and paddling, although the sandbar comprises the Southbroom bathing beach area. Sand is excavated from the river bed, 1 km above the lagoon.

Morphometry of lagoon (see Fig. **110**)

Area. 12,4 ha

Axial length. 1,5 km

Shoreline length. 3,9 km

Width.
Maximum: 300 m
Mouth: (under normal conditions) — 6 to 7 m wide.
(during flood conditions) — up to 200 m wide } (Fearnhead pers. comm.).

Floodplain: 400 m

Bathymetry. On 31 August 1977, the maximum depth in the lagoon was 2,5 m (pers. obs.), but depths vary naturally according to whether the mouth is open or closed, the state of tide, etc. Under normal conditions, the mouth is 0,4—0,6 m deep, but during floods becomes deepened to 2 m (Fearnhead, pers. comm.). NRIO have described the mouth as very shallow, with the average depth varying from 3 m (after floods) to 1,5 m above chart datum ([239]).

Geomorphology

Geology. The river system lies on Table Mountain Sandstone formations and old granites ([245]). The lagoon is surrounded by granite ([238]) which outcrops on the water's edge on the southern bank, in the middle reaches of the lagoon.

Nature of bottom materials. In the main channel coarse fluvial sand is encountered, whilst towards the edges of the lagoon, the sand becomes muddier and clay like. At the mouth, washover marine sand becomes evident (Fearnhead, pers. comm.).

Sandbar characteristics. Under normal conditions the Mbizana sandbar is 350 m long and south extending. After studies conducted in 1972 and 1973 NRIO ([238, 239]) concluded that the sand spit and river mouth were very stable features. However, after severe floods (as in February 1977) the whole bar can be swept away and the mouth develops on the northern side. It is interesting to note that under such circumstances, the sandbar begins to reform on the southern bank, and gradually migrates northwards, until the flood channel is closed. The lagoon then fills and eventually spills out in its normal position at the southern end of the bar (Fearnhead, pers. comm.).

More often than not the lagoon is closed, in which case the sea overtops the bar only at high tide. However, after a good scour (as in February 1973) drainage from the lagoon can persist for 17 months ([239]).

Breaching: The Southbroom Health Committee ignore requests made to open the mouth because of the labour involved, and because the mouth created becomes closed again by the sea within one or two days. However, when lagoon levels are high (usually in July) children habitually empty the lagoon in the interests of "good fun". Another reason for opening the lagoon, is to flatten the beach because this temporarily eliminates the backwash and improves the bathing (Fearnhead, pers. comm.). Channels are dug at the southern end of the bar at the natural point of exit.

There used to be a deep channel directly opposite the mouth of the lagoon, due to scour in the lee of the rocky headland which protrudes into the sea immediately south of the mouth. This became sanded up once a tidal pool was built upon these rocks, right in the mouth of the lagoon, in 1963. It was built before the advent of shark nets (for over R8 500) to provide "safe bathing" (Engle, pers. comm.). Its construction appears to have altered sand transport and the current patterns within the Mbizana bight (Fearnhead, pers. comm.). This has an adverse affect on tidal exchange and transport mechanisms for marine/estuarine organisms within the lagoon.

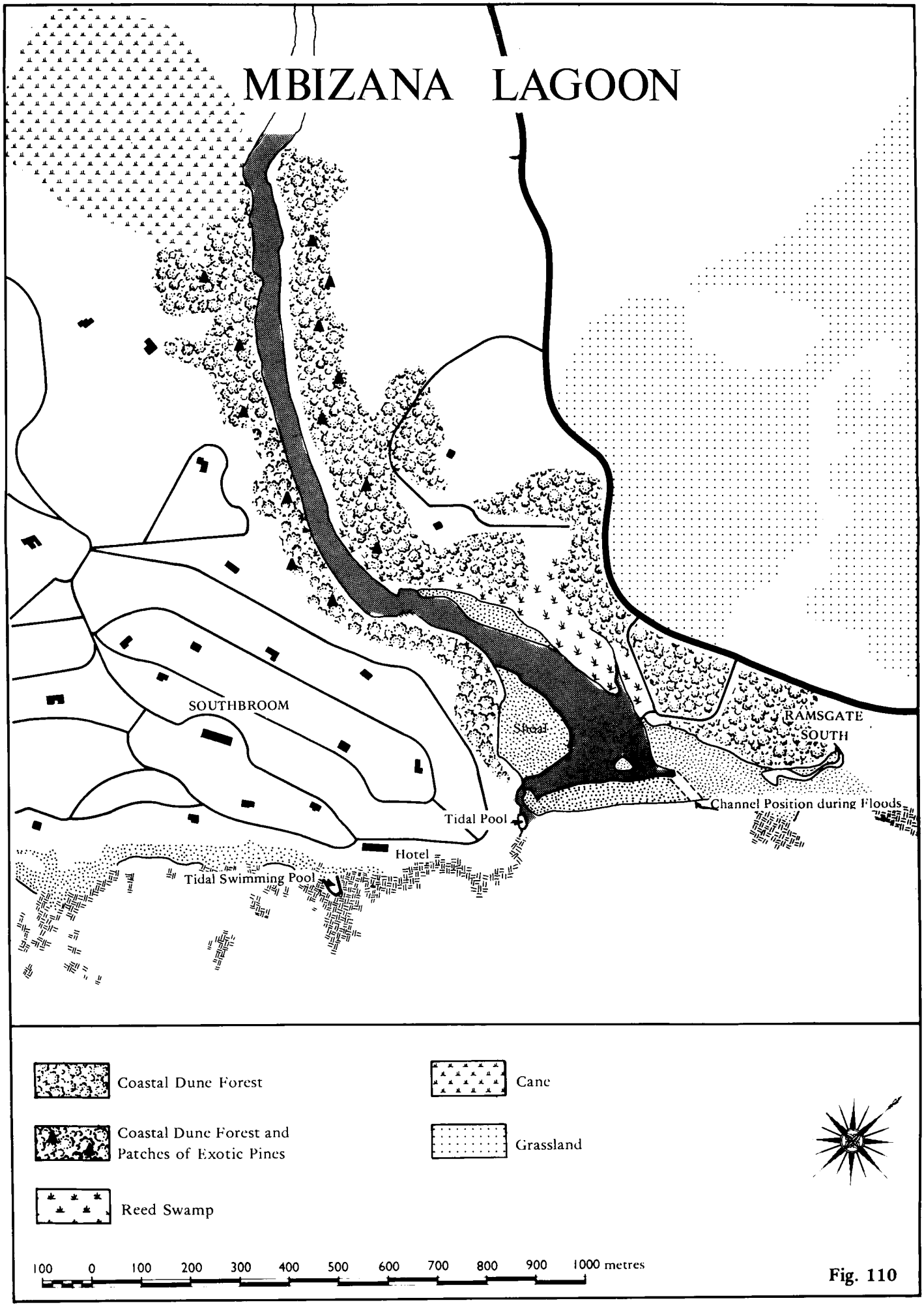
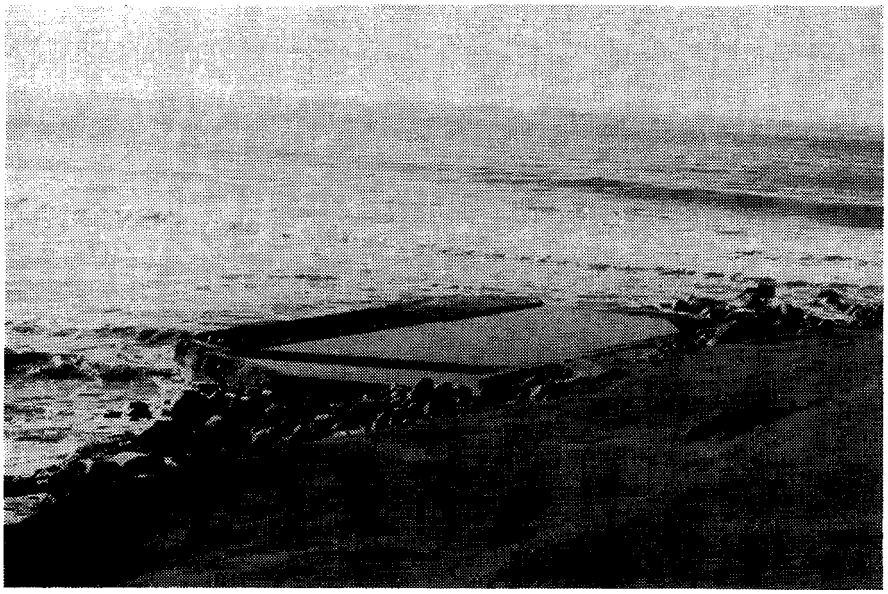

MBIZANA LAGOON
SOUTHBROOM
Shoal
RAMSGATE SOUTH
Channel Position during Floods
Tidal Pool
Hotel
Tidal Swimming Pool
Coastal Dune Forest
Coastal Dune Forest and Patches of Exotic Pines
Reed Swamp
Cane
Grassland
100 0 100 200 300 400 500 600 700 800 900 1000 metres

Fig. 110



Adverse effects have arisen as a result of the construction of a tidal pool in the vicinity of the mouth of the Mbizana lagoon.

Configuration of adjacent shore ([132]).
Beach type — sheltered bight.

Average beach slope — 8°	indicative of
Average beach width — 75 m	rough surf
Average sand grain size — 658 microns	zone conditions.

Surf zone currents. Inshore there is a north going nearshore eddy. When the mouth of the lagoon is open, backwash is non-existent, but when closed, the beach profile steepens and backwash develops. The direction has changed since the tidal pool was constructed (Fearnhead, pers. comm.). Rip currents are absent in the near vicinity of the lagoon ([132]).

Physico-chemical characteristics

There is no information on the physico-chemical characteristics of the Mbizana lagoon, although on the 26 September 1975 Jackson (pers. comm.) recorded salinities of 17,5‰ in the lagoon.

Some information on the chemistry of the river water 1 km above the lagoon is available ([206]). From the results (see Table **100**) no signs of any disturbance were evident in 1970. The practice of extracting sand from the bed of the river at this particular point, may adversely affect water clarity in the lagoon.

Public health aspects

Bacteriology. Bacteriological information from the Mbizana lagoon is totally lacking. However, boils are reported to be common after bathing in the lagoon (Levin, pers. comm.) which is indicative of some unacceptable bacteriological condition. Despite this, data collected from the Mbizana river 1 km above the lagoon during the early 1970's (see Table **101**) shows no signs of faecal pollution, or serious organic enrichment.

Bilharzia. Although no snails were found by Jackson (pers. comm.) in either the lagoon or the river above it in September 1975, a notice at the mouth warns of the inadvisability of contact with the water.

BIOTIC CHARACTERISTICS

Flora

Indigenous coastal vegetation on the northern bank of the Mbizana lagoon, is well preserved and worthy of protection, although in places exotics such as pine trees have become established on the water's edge. Proposals for this area to become a municipal nature reserve (Fearnhead, pers. comm.) have merit. Hopwood ([189]) has suggested that consideration could be given to linking this area to Langler's Estate which is ± 40 ha of coastal forest above the road bridge.

In the lower reaches of the lagoon, a *Phragmites* reedswamp has become established, but only

Table 100. Physico-chemical characteristics. ([206])

Locality: Mbizana River Distance above lagoon : 1.0km	SUMMER Feb 1970	WINTER July 1970
Hydrogen ion concentration (pH)	7.98	7.95
Saturated pH value	9.1	9.1
Conductivity micromhos/cm	220	288
Total dissolved solids ppm (calcd.)	134	166
Dissolved oxygen mg/litre	9.2	9.8
% Saturation	108	103
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.3	0.1
Kjedahl nitrogen mg/litre	0.2	nil
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.27	0.17
Phosphates "	0.12	0.08
Total alkalinity "	45.7	40.0
Total hardness "	37.8	40.0
Calcium "	4.3	5.1
Magnesium "	6.6	6.6
Sodium "	31.4	40.0
Potassium "	1.1	1.4
Sulphates "	5.0	10.8
Chlorides "	40.9	61.3
Silica "	-	-
Iron "	-	-
Fluorides "	0.3	0.2
Free carbonic acid (as ppm carbon dioxide)	1.0	0.9
Temperature °C	24.0	18.8
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

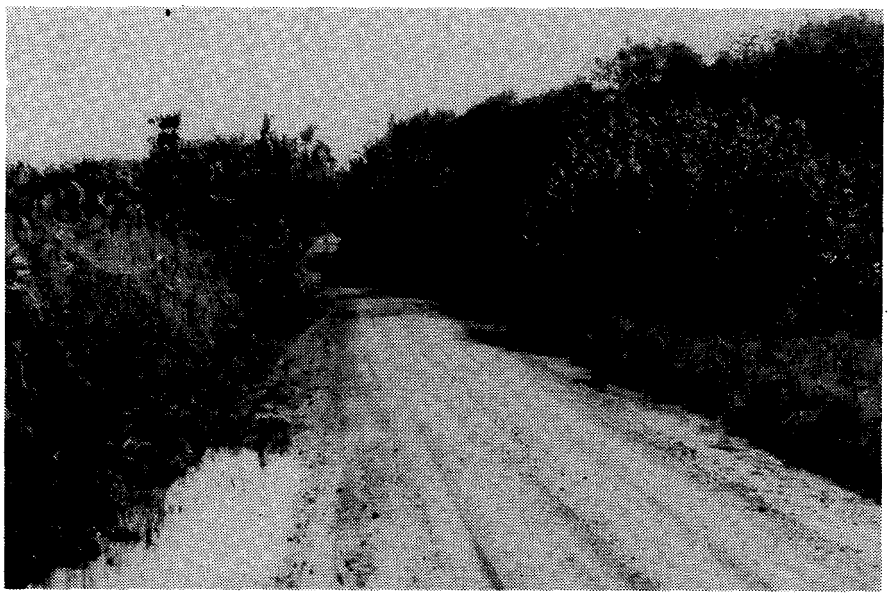
Values underlined significant of disturbance.

since the lagoon has become silted up. It is just as well to note that an access road to the beach has been built across wetland communities on the northern bank and is flooded at high lagoon levels. Badly sited roads such as this are the sort of thing that gives rise to the need for the artificial control of lagoon levels (for significance see section 3.2.4).

Table 101. Bacteriology of the Mbizana river (1 km above the lagoon).

Date	Total Plate Count per ml x 10^3		*E. coli* 1 /100 ml	Total Coliforms per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed	
March 1971			294	2 900
July 1971			178	1 000
3 Feb 1972	126	101	1 300	
21 Feb 1972	128	**320**	1 425	
3 July 1972	70	17	140	
31 July 1972	70	52		
17 Aug 1972	30	45		
8 Jan 1973	290	220		

Values in bold are significant of disturbance.



"Shore Road" on the northern bank of the Mbizana lagoon disrupts wetland communities.

On the southern bank, the marginal vegetation is undisturbed other than just above the head of the lagoon where sugar cane comes down to the water's edge. It is interesting to note that even

where the sugar cane washed down by floods has re-established itself amongst lagoonal communities, bank instability is evident.

Fauna

Although there is no data on the fauna of the Mbizana lagoon, it is said to support little estuarine life (Fearnhead and Maurice, pers. comm.). Results from a survey in June 1972 of the aquatic fauna 1 km above the lagoon ([206]), confirm that conditions are poor and disturbed. The numbers of animals present and the species diversity were very low. This was not the case some 40 years ago, when, prior to it becoming silted, a wide variety of organisms normally associated with estuaries were present. Broadhead mullet (*Mugil cephalus*) were particularly abundant and in the 1940's it was possible to fish in over 3 m of water above the road bridge, and make good catches of perch (*Acanthopagrus berda*), grunter (*Pomadasys commersonni*) and kob (*Argyrosomus hololepidotus*) (Fearnhead, pers. comm.). Netting by Wallace ([329]) in 1975 revealed juveniles of only 7 of the main species of estuarine fish in Natal. Five of these were different types of mullet.

On 31 August 1977, eight species of estuarine associated birds were evident (pers. obsv.) and birdlife in the forested verge of the lagoon was abundant. Also present are water mongoose, duiker, bushbuck, various rodents, monkeys and leguaans (Fearnhead, pers. comm.).

SYNTHESIS

In conclusion our general state of knowledge of the Mbizana lagoon is poor, and based largely upon hearsay. Although degraded, and by comparison to what it was, a ruined estuarine system, the surrounds of the lagoon are well preserved and of definite resource value. A more thorough botanical understanding of the area is necessary, added to which a survey of life within the lagoon (for the sake of completeness) would be useful, particularly if the area is to become a nature reserve. For this reason, one should also endeavour to become more familiar with what birds and mammals occur in the same area.

The lagoon's primary ailment is silt, obviously arising from the erosion of Location No. 4 in the catchment. If built, the Bushyvales dam would act as a silt trap and reduce the problem to a certain extent. It is important that a lesson should be learnt from the decision to construct a tidal pool in the mouth of the Mbizana lagoon. Apart from the pool becoming infilled by silt, it has considerably altered circulation in the Mbizana bight, and restricts the movement of estuarine organisms to and from the lagoon.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other						Flora			Fauna							Food Webs
MBIZANA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																							★	←★			★		→		
Source of Information	Summary of available information																															
Fearnhead	1940 to 1978	pers. comm.		●	●		●			●																	●		●			
Midgley & Pitman	1969	223	●		●																											
Kemp *et al*	1970 to 1972	206	●		●						○				○										○	○						
Fromme	1970 to 1975	132								●																						
Orme	1971	257	●																													
Ninham, Shand & Partners	1971	245	●					●																								
Loxton, Hunting & Assoc.	1971	213	●		●																											
NRIO	1973 to 1975	238 & 239		●			●			●																						
NTRPC	1974	236						●		●																						
Wallace	1975	329																										●				
Jackson	1975	pers. comm.				●																										
Dykes (Jeffares & Green)	1977	pers. comm.	●		●																											
Hopwood	1978	189						●											●				●									
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	378		●						●													●									
1:25 000 Job No. 262	1976	449	●	●																												

Synonyms
Mkobi ([189]); Mkobe (1:250 000 Sheet No. 3030); Khaba (Ward, pers. comm.).

Zulu meaning
Umkhobi means "the river where the wild vines (*Rheicissus rhomboidea*) grow" ([289]).

Location
30°56'S; 30°18'30"E.

Accessibility
The Kaba lagoon is 2 km from the national road, 34,3 km south of Port Shepstone and 162 km south west of Durban. Provision has been made for vehicular access down to the mouth of the lagoon on both the northern and the southern bank.

Bridges
There are no bridges across the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 12 km^2

River length. 9 km

Mean annual run-off. No record.

Flow. No record.

Flood history. The lagoon has none of the features of a flood scoured system, however, after heavy rain, flooding of the Kaba river can be extremely dramatic (Levin, pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. No record. However, reed encroachment (upon what was formerly a wide, reed-free body of water, Levin, pers. comm.) is symptomatic of artificially high rates of siltation.

Land ownership/use. 33% of the catchment is made up of the Kwaxolo Bantu Reserve (Location No. 4) and destined to become incorporated into KwaZulu in the near future.
In the lower reaches of the catchment, sugar cane farms and banana plantations are common. It is well known that the latter are particularly vulnerable to soil erosion.
North of the lagoon is the southern extension of Southbroom, whilst to the south is the settlement of Marina Beach. Both are residential areas. The "SYSU" Holiday Camp (belonging to the Iscor Workers Union) also overlooks the lagoon from the southern side.
Land immediately adjacent to the lagoon is zoned as public open space.

Local authority. The Southbroom Health Committee control the northern bank, and the Marina Beach Health Committee control the southern bank.

Estuary uses. The Kaba lagoon was once used extensively for aqua-planing and water-skiing. There are plans to revive this activity. There is a tea garden on the northern bank from which boats and canoes are hired to holidaymakers.

Morphometry of lagoon (see Fig. **111**)
Area. 2,4 ha

Axial length. 500 m

Shoreline length. 1,5 km

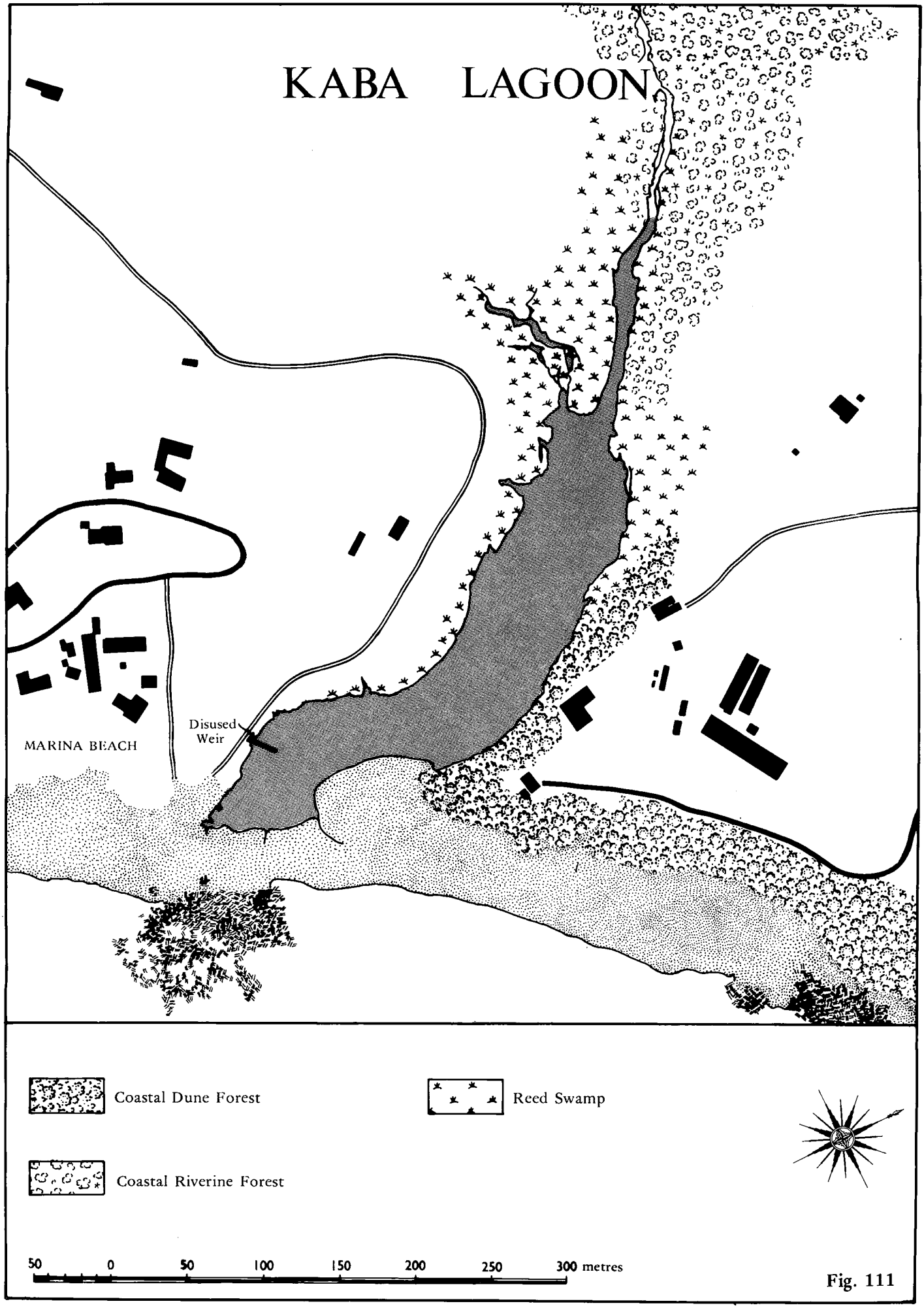

KABA LAGOON
MARINA BEACH
Disused Weir
Coastal Dune Forest
Reed Swamp
Coastal Riverine Forest
50 0 50 100 150 200 250 300 metres

Fig. 111

Width.
Maximum: 75 m
Mouth: No record.
Floodplain: 150 m

Bathymetry. The lagoon is no deeper than 1,75 m (Levin, pers. comm.).

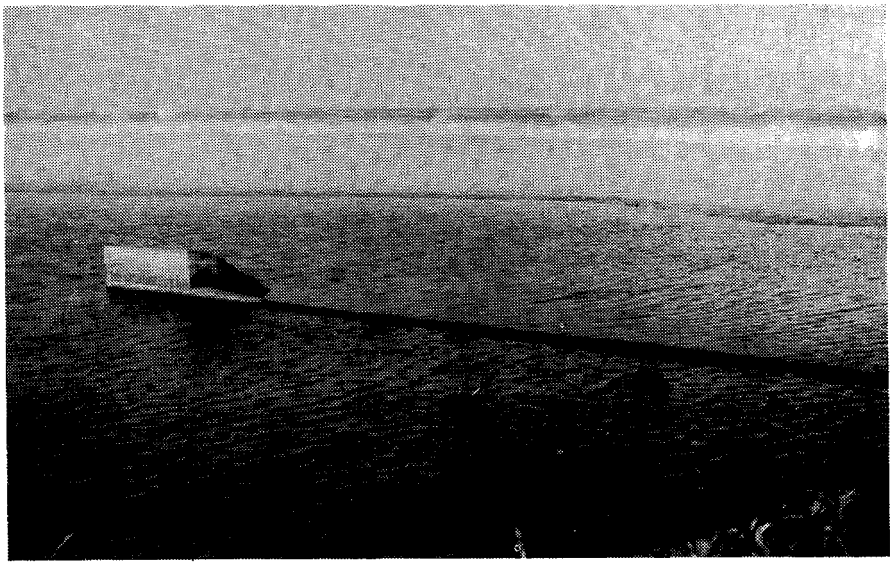
Geomorphology

Geology. Both catchment and lagoon are made up of granite ([236]).

Nature of bottom materials. No record.

Sandbar characteristics. The Kaba sandbar is 150 m long and south extending. The channel leads to the sea across a rock sill at the southern end of the bar. Although stable, the whole bar has been known to disappear after floods (Levin, pers. comm.). There is a weir extending from the southern bank, across the mouth. It was built (with the permission of the Department of Water Affairs) by the local authority in 1952 to increase lagoon levels during the dry season so as to facilitate aquaplaning. It has now become disused and surrounded by silt and sand.

The lagoon is generally closed, but the sea overtops the sandbar at high spring tide.



A disused weir at the mouth of the Kaba lagoon.

Configuration of adjacent shore ([132]).
Beach type — sheltered bight.

Average beach slope — 6°
Average beach width — 97 m
Average sand grain size — 578 microns

} indicative of rough surf zone conditions.

Surf zone currents. Rip currents are reported as present in the near vicinity of the lagoon.

Physico-chemical characteristics

No record.

Public health aspects

Bacteriology. No record.

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

The most conspicuous plant community in the Kaba lagoon is a *Phragmites* reed swamp that has gradually developed on both the northern and southern bank since the lagoon has shallowed

through infilling. Reeds are particularly extensive in the upper reaches of the lagoon. A fringe of riparian forest above the lagoon has remained relatively undisturbed. Coastal forest communities near the mouth are disturbed by township development.

Fauna

Mullet and mud bream (*Sarotherodon mossambicus*) have been caught in the lagoon, whilst crabs and sand prawns are said to be numerous. Exploitation of the edible crab (*Scylla serrata*) by trapping occurs (Levin, pers. comm.).

SYNTHESIS

There is virtually nothing known about the Kaba lagoon or the river above it. Before any decision is taken to use the lagoon for water sports, a careful check of the bacteriological quality, and of whether bilharzia occurs, should be made. In its present environmental condition, the Kaba lagoon is probably not an important estuarine resource.

The system is adversely affected by weir construction and siltation.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physiography		Physics			Geomorphology			Chemistry				Bacteriology	Other						Flora		Fauna								Food Webs
KABA			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids															★																	
Source of Information	Summary of available information																															
NTRPC	1974	236						●																								
Fromme	1970 to 1975	132								●																						
Levin	1977	pers. comm.		●	●					●										●						●	●					
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	382		●																			●									
1:25 000 Job No. 262	1976	447	●																													

2.1.13.4 **UMHLANGANKULU**

Synonyms

Although unnamed on the 1:50 000 sheet 3030 CD, and referred to as the Mhlangamkulu on the 1:500 000 map of Natal, care must be taken to ensure that this lagoon is not confused with the Mhlangamkulu 35 km to the north (see Section 2.1.12.2). Use of the name Umhlangankulu ([46]) is recommended to distinguish between the two.

Zulu meaning

uMhlangakhula is said to mean "great reedy river" ([289]).

Location

30°56'45"S; 30°18'E.

Accessibility

By road, the Umhlangankulu lagoon is 162 km south west of Durban, and 34 km south west of Port Shepstone.

It lies 2 km east of the national road. Being the focal point of the "San Lameer" property development, provision has been made for access to the water's edge at several points.

Bridges

There are no bridges across the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 10 km^2

River length. 6,5 km

Mean annual run-off. No record.

Flow. No record.

Flood history. No record — although described to be abnormally severe (1:25 year frequency) in February 1977 (Deacon, pers. comm.). Similar floods occurred in April 1978 (Heydorn, pers. comm.).

Dams.

Existing: Prior to being washed away by floods in February 1977, a small farm dam did exist upstream (Deacon, pers. comm.).

Proposed: None.

Siltation. No quantitative information is available, however heavy siltation took place after floods in February 1977. The previous owner of the estate (Mr G. H. Langeler) had built sand/silt traps on the inflowing rivers to prevent siltation of the lagoon. Nevertheless, dredging of the lagoon has been necessary. This was done by dividing the lagoon into small sections using berms and pumping these dry before excavating each section. The depth of the lagoon was increased to ± 1,5 m in this way. Ecological opinions consulted ([48, 147]) concluded that dredging was unlikely to affect the system adversely, providing it was confined to mid-water areas and avoided near the mouth.

Land ownership/use. 16% of the catchment comprising Location No. 4 (or the Kwaxolo Reserve) is Bantu influenced and destined to become incorporated into KwaZulu. The rest of the catchment area is farmland, amongst which banana plantations are conspicuous. The lagoon is part of a 134 ha estate, today owned by Sanlam who (for R40 million) are developing a private, exclusive township called "San Lameer". It is interesting to note that the estate was previously owned by a Mr G. H. Langeler and that it was presented as a gift to the Natal Parks Board of Trustees to be used for the benefit of the public (African Wildlife Vol. 1 No. 3 p.50). Commercial exploitation was not envisaged. Nevertheless, Sanlam are intent on developing the area in such a way that the natural assets with which it has been endowed, shall not be ruined. "San Lameer" will consist of 1 200 dwellings arranged in 8 characteristically different units. Only 40% of the site is to be developed, with a maximum density of 20 units/ha.



Dredging in progress (31 August 1977).

Local authority. The owners (Sanlam) and the Natal Town & Regional Planning Commission control development of the site until the formation of a Homeowners Association.

Estuary uses. The Umhlangankulu lagoon has always been a private lagoon, occasionally used for boating, swimming and angling, but principally as a tranquil sheet of water from which great aesthetic enjoyment was derived. Its future uses will remain essentially similar to those described.

Morphometry of lagoon (see Fig. **112**)

Area. 5,8 ha

Axial length. 850 m

Shoreline length. 2,6 km

Width.
Maximum: 100 m
Mouth: During floods the mouth can become 75 m to 100 m wide (Deacon, pers. comm.).
Floodplain: Not applicable.

Bathymetry. In places the lagoon is 2,5 m deep (Heeg, pers. comm.).

Geomorphology

Geology. Both catchment and lagoon are made up of Archaean granite ([236]).

Nature of bottom materials. Although no data exists on this subject, after studying the benthos of the lagoon in 1975 ([147]), Heeg (pers. comm.) describes the bottom materials as coarse, muddy sands. This opinion is confirmed by van Wyk (pers. comm.), although the latter considers that rock occurs on the bottom in certain places, and that the sand changes to fine mud in the backwaters of the lagoon.

Sandbar characteristics. The Umhlangankulu lagoon lies behind a 250 m to 350 m long north extending sandbar. This is due to the lack of rock protection south of the system. The mouth normally opens south of a promontory (called "Centre Rocks") at the northern end of the bar. On occasions (e.g. January 1978) the channel may migrate north of Centre Rocks, (Heydorn, pers. comm.), in which case the mouth then becomes temporarily rock defended.

The level of the lagoon is normally permitted to fluctuate naturally, although during the course of dredging, the water level was lowered on one occasion by the contractors. The mouth generally opens briefly 5 or 6 times a year. At one stage consideration was given to the construction of breakwaters in order to maintain permanent contact with the sea.

The construction of a weir at the mouth of the lagoon (to increase water levels) was also proposed, but considered inadvisable for ecological reasons ([48, 147]).

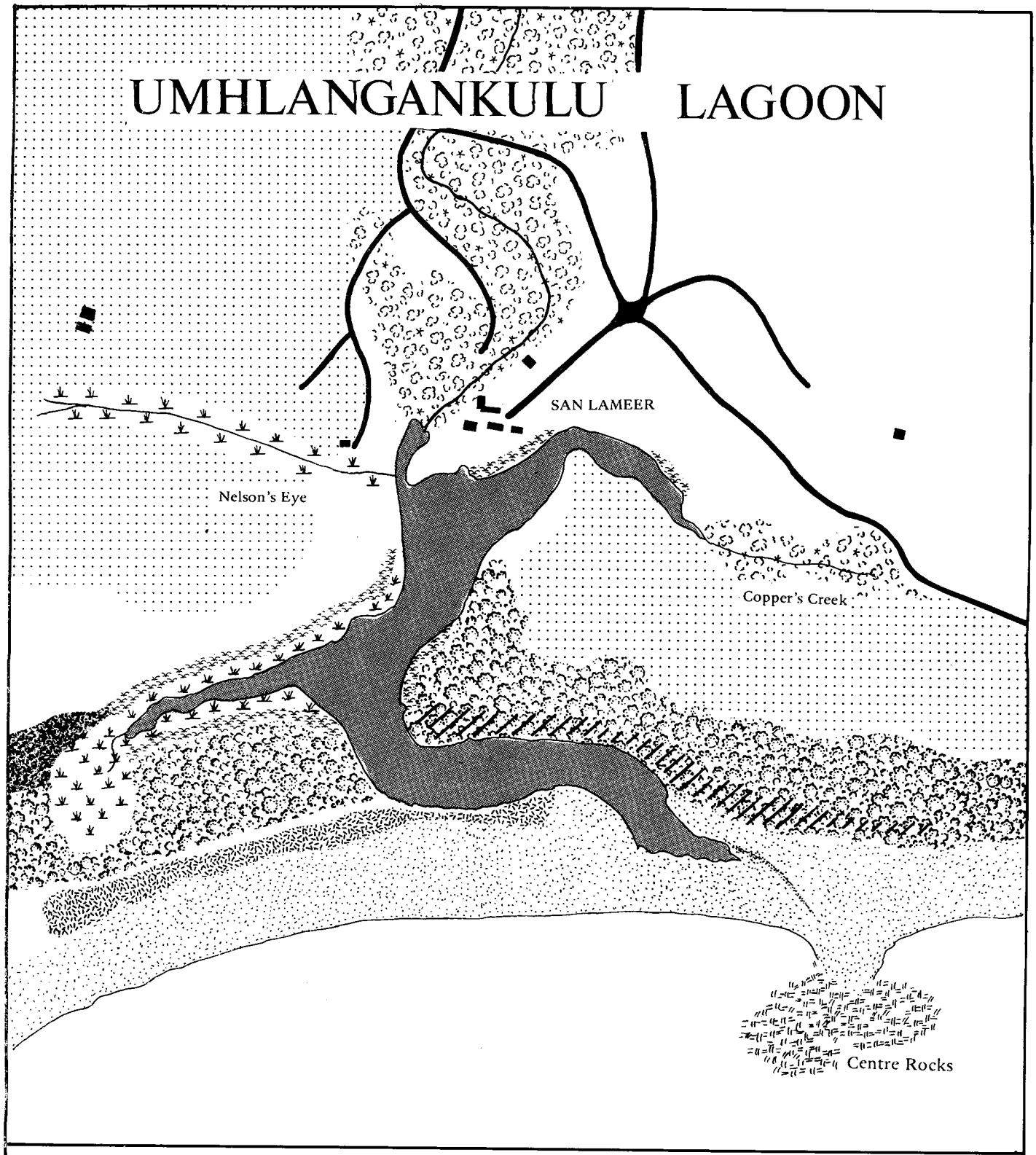

UMHLANGANKULU LAGOON
SAN LAMEER
Nelson's Eye
Copper's Creek
Centre Rocks
Coastal Dune Forest
Coastal Riverine Forest
Coastal Dune Pioneer
Strelitzia Community
Reed Swamp
Hibiscus
Swamp Forest
Grassland
100 0 100 200 300 400 500 metres

Fig. 112

Configuration of adjacent shore [132].
Beach type — sheltered bight.

Average beach slope — 5°	indicative of
Average beach width — 85 m	moderate surf
Average sand grain size — 415 microns	zone conditions.

Additional information on the movement of sand, and beach erosion opposite the Umhlangankulu lagoon is provided by Hill, Kaplan, Scott and partners [186].

Surf zone currents. Rip currents in the near vicinity of the lagoon are reported as absent.

Physico-chemical characteristics

Breen [45, 46] was commissioned to report on the water quality of the Umhlangankulu lagoon in 1975. Considerable attention was given to the physico-chemical characteristics of the inflowing rivers. An attempt to summarize this information (see Fig. **113**) has been made.

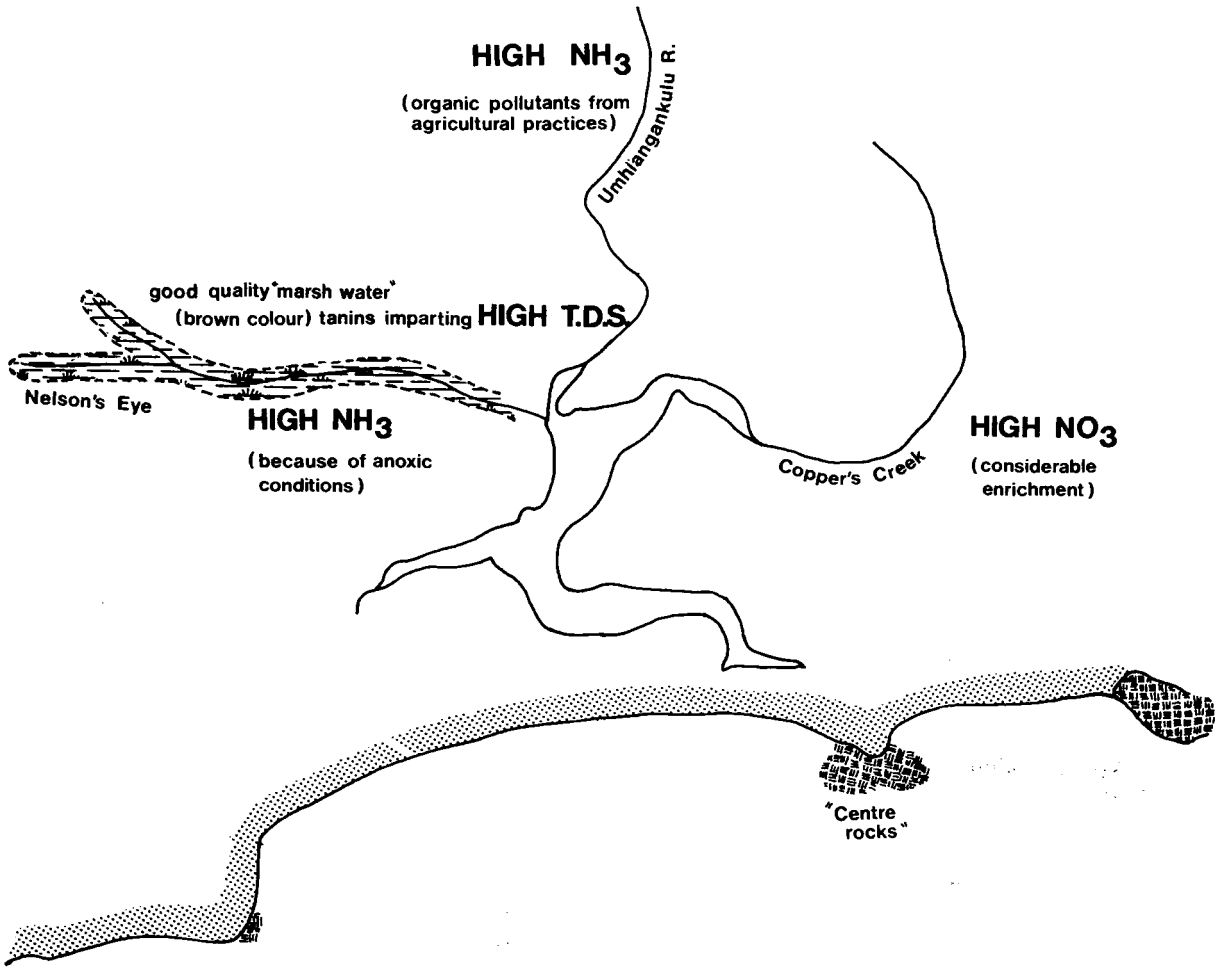


Fig. 113. Principal characteristics of the water entering the Umhlangankulu lagoon in 1975 (after Breen [45, 46]).

Considerable enrichment of the streams entering the lagoon, by nitrogen was evident. Phosphorus was shown to be limiting, and there was no evidence of toxic substances entering the lagoon.

The levels of nitrogen and phosphorus in the lagoon were considerably lower than those in the river, due to dilution. Characteristics such as the pH and salinity, naturally decrease in the vicinity

of river influences, and increase towards the mouth where the influence of sea-water becomes noticeable. The average of the various parameters measured (on 31 January 1975) from four stations in the lagoon, are presented below.

Salinity	=	12,6‰
Hydrogen ion concentration	=	6,7 pH units
Total suspended solids	=	42 milligrams/litre
Ammonia	=	131 micrograms/litre
Nitrate	=	277 micrograms/litre
Ortho-phosphate	=	12,5 micrograms/litre
Conductivity	=	8 025 micromhos/cm

Public health aspects

Bacteriology. There is no information available on the bacteriological characteristics of the Umhlangankulu lagoon. However, from various chemical characteristics in June 1975 ([45]) seepage from septic tanks in the catchment area was suspected. The San Lameer township is to use french drains until such time as it can link into a regional sewage scheme with Trafalgar (Deacon, pers. comm.). Water quality problems can be anticipated, and consequently bacteriological surveys should be undertaken and regularly maintained in the future.

Bilharzia. In June 1975, a stream survey failed to reveal the presence of bilharzia host snails ([147]). However, standing bodies of fresh water (such as golf course water traps) adjacent to the lagoon, were considered as potential sites for such snails in the future (Heeg, pers. comm.).

Mosquitoes. A report on this subject ([50]) concluded that the breeding of mosquitoes would not occur in the lagoon. However marsh areas and water retained in the leaf bases of certain plants present problems in this respect.

BIOTIC CHARACTERISTICS

Flora

Breen's botanical surveys ([44, 47, 49]) have been invaluable in providing a great deal of information on the flora of the Umhlangankulu lagoon and its surrounds. These surveys were undertaken because of the developers wish to preserve such characteristics.

Being topographically diverse, the Umhlangankulu lagoon is from a botanical point of view, an important area, and well endowed by a great variety of plants.

The following communities were identified around the lagoon:

(a) Saline reedswamp/salt marsh
(b) *Hibiscus tiliaceus* community
(c) Freshwater reed/grass swamp
(d) Swamp forest
(e) Hygrophilous forest
(f) Wet grassland
(g) Transitional dune forest
(h) *Strelitzia nicolai* community

Amongst these communities, the swamp forest and hygrophilous forest have considerable conservation value. *Barringtonia racemosa* occurs despite the fact it has been suggested that this tree does not occur south of Sezela ([30]) (which is over 100 km north of the Umhlangankulu).

Phytoplankton: The phytoplankton is more typical of a fresh waterbody than a marine environment ([46]). It comprises 14 species, the majority of which are diatoms. With *Microcystis* present, the phytoplankton assemblage was indicative of mesotrophic conditions.

Fauna

Lower trophic levels.

Benthos. A scuba survey in June 1975 ([147]) revealed that the sand prawn (*Callianassa kraussi*) was the principal benthic organism in the lagoon. *Callianassa* were particularly abundant (120/m^2 to 160/m^2) in the littoral shallows and near the mouth. Deeper water supported a strikingly lower density, but in these areas, the edible crab *Scylla serrata* occurs.

On 11 August 1976, the molluscs *Assiminea bifasciata* and *A. hidalgoi* were collected in the lagoon (Jackson, pers. comm.).

Higher trophic levels.

Fish. 19 species of fish were recorded as present in June 1975 ([147]) — eight of which were different types of mullet. Good angling species were poorly represented and of a small size. Consequently angling in the lagoon is considered to be unrewarding and attributed to the infrequency of contact with the sea. Amongst the fresh water species present, was *Tilapia rendalli,* a species not normally found anywhere near a lagoon influenced by sea water.

Birds. 15 out of the 60 species of birds recorded in February 1975 ([31]) were closely associated with the lagoon, although species such as various gulls and terns were conspicuous by their absence. Fish eagles have been seen to occur.

Mammals: Various buck, monkeys, otters and even aardvark are said to occur in the vicinity of the lagoon. Monkeys in the residential area of San Lameer, are likely to prove a problem in the future. Van Wyk (pers. comm.) also considers that monkeys destroy the nests and eggs of birds.

SYNTHESIS

Due to the involvement of the Natal University (Pietermaritzburg) as consultants on the San Lameer project, our understanding of the Umhlangankulu lagoon is good. Important data voids are bacteriology (because of the obvious implications if the water body is to be used for recreation) and a knowledge of the sources and the amount of silt emanating from the catchment (because of the implications of maintenance dredging). Routine monitoring of water quality should commence so as to perceive pollution in its earliest stages, and to give peace of mind to both developer and resident.

Being semi-developed and newly dredged, in its present environmental condition, the lagoon and its surrounds are disturbed. Although the lagoon is not considered to provide an important nursery function for estuarine organisms, as a botanical resource, the surrounds of the Umhlangankulu lagoon are held in high esteem. Irresponsible development (such as paying insufficient attention to the ecological implications of infilling, spoil and sewage disposal) and pressure on the environment by the ultimate population of some 3 000 people for whom the developers hope to provide, are potential threats to such values. However as an exercise in "environmentally conscious property development" much should be learnt from the San Lameer project.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other						Flora			Fauna								Food Webs
UMHLANGANKULU			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids										★					★																	
Source of Information	Summary of available information																															
Fromme	1970 to 1975	132								●																						
NTRPC	1974	236						●																								
Breen	1975	44,47 49														●		●			●		●									
Heeg & Blaber	1975	147								●																●	●					
Blaber	1975	31																										●				
Jackson	1976	pers. comm.																								●						
Breen	1976	45,46 48,50	●	●		●					●	●				●							●	●								
Hill, Kaplan, Scott & Partners	1976	186								●																						
Deacon	1977	pers. comm.			●		●																									
van Wyk	1977	pers. comm.																		●			●				●	●	●			
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	384		●																			●									
1:25 000 Job No. 262	1976	447	●																													

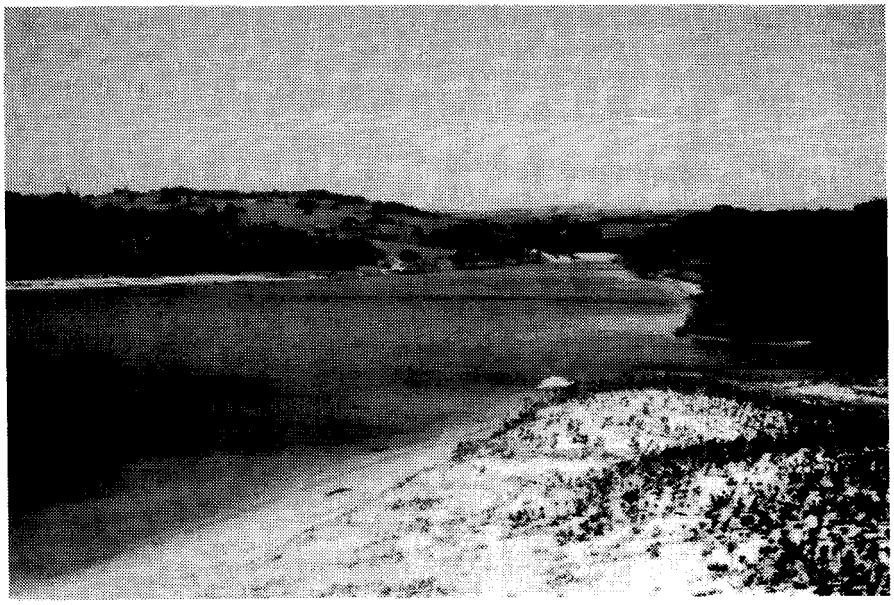
2.1.13.5 **MPENJATI**

Synonyms
No record.

Zulu meaning
The lagoon derives its name either from a reedy type of grass (called Mphenjati) growing in its vicinity, or from "the place of the warring buffalos" ([289]).

Location
30°58'15"S; 30°17'E.

Accessibility
By road, the Mpenjati lagoon is 38 km south west of Port Shepstone and 165 km south west of Durban. Provision has been made for vehicular access to the water's edge on both the southern and northern banks.



A view looking from the mouth along the length of the Mpenjati lagoon (photo by A.E.F. Heydorn Jan 1978).

Bridges
There are no bridges across the Mpenjati lagoon, however the national road bridge crosses the river ± 100 m above the head of the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 78 km^2 ([213]); 83 km^2 ([206, 245, 257]); 101 km^2 ([223]).

River length. 18 km ([206, 245, 257]).

Mean annual run-off. 15 x 10^6 m^3 ([213]) to 17,8 x 10^6 m^3 ([223]).

Flow. A rough estimate of the average flow in 1971 was ,51 m^3/sec. ([206]).

Flood history. No record.

Dams.
Existing. None.

Proposed: A dam site (with a total capacity of 15,14 x 10^6 m^3 ([236])) has been located 3 km above the lagoon at Grassmere ([245]).

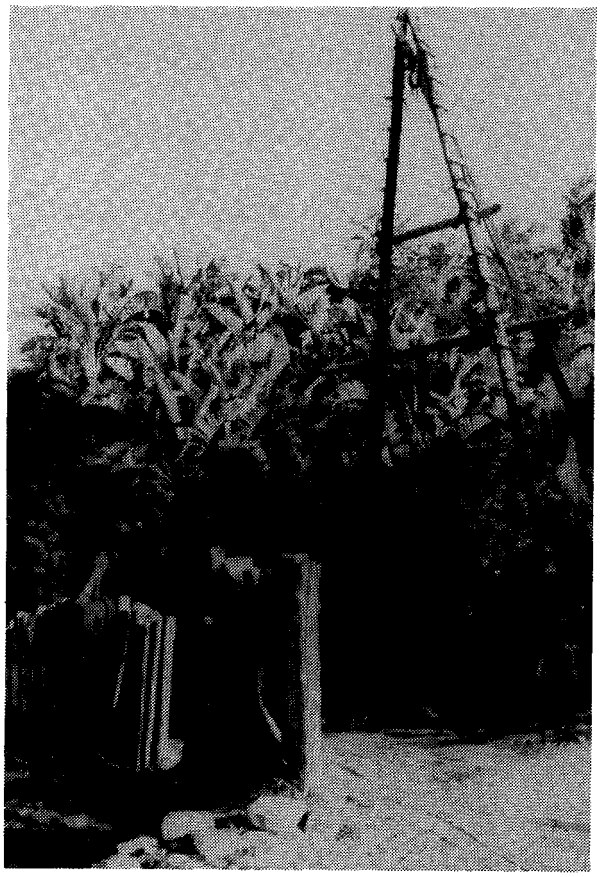
Siltation. Annual siltation at the Grassmere dam site has been estimated at 0,06 x 10^6 m^3/annum ([236]). This is a surprisingly low rate for a system so obviously affected by siltation. Van Duyn (pers. comm.) recalls that when the Mpenjati road bridge was under construction, the water was 4 m deep below the bridge. Today the water depth seldom exceeds 25 cm at this point.

Land ownership/use. 67% of the catchment, (comprising the Kwaxolo reserve or Location No. 4) is Bantu influenced and destined to become incorporated into KwaZulu in the near future. It is soil erosion in this area that has accounted for the silt and sand which has become deposited in the lagoon.

Being zoned as Admiralty Reserve, land around the lagoon is undeveloped, although to the north is Trafalgar, and to the south is Palm Beach. Both are sparsely developed coastal resorts.

Local authority. Palm Beach.

Estuary uses. Little use appears to be made of the Mpenjati lagoon, other than that made by Mr C. G. Sawyer who (since 24 October 1969) has the right to remove sand from the floor of the lagoon for construction purposes. Several sand extraction devices have been built unobtrusively on either side of the lagoon for this purpose.



A sand extraction device alongside the Mpenjati lagoon.

Morphometry of lagoon (see Fig. **114**).

Area. 11,6 ha

Axial length. 1,1 km

Shoreline length. 3,85 km

Width.
Maximum: 300 m
Mouth: No record.
Floodplain: 430 m

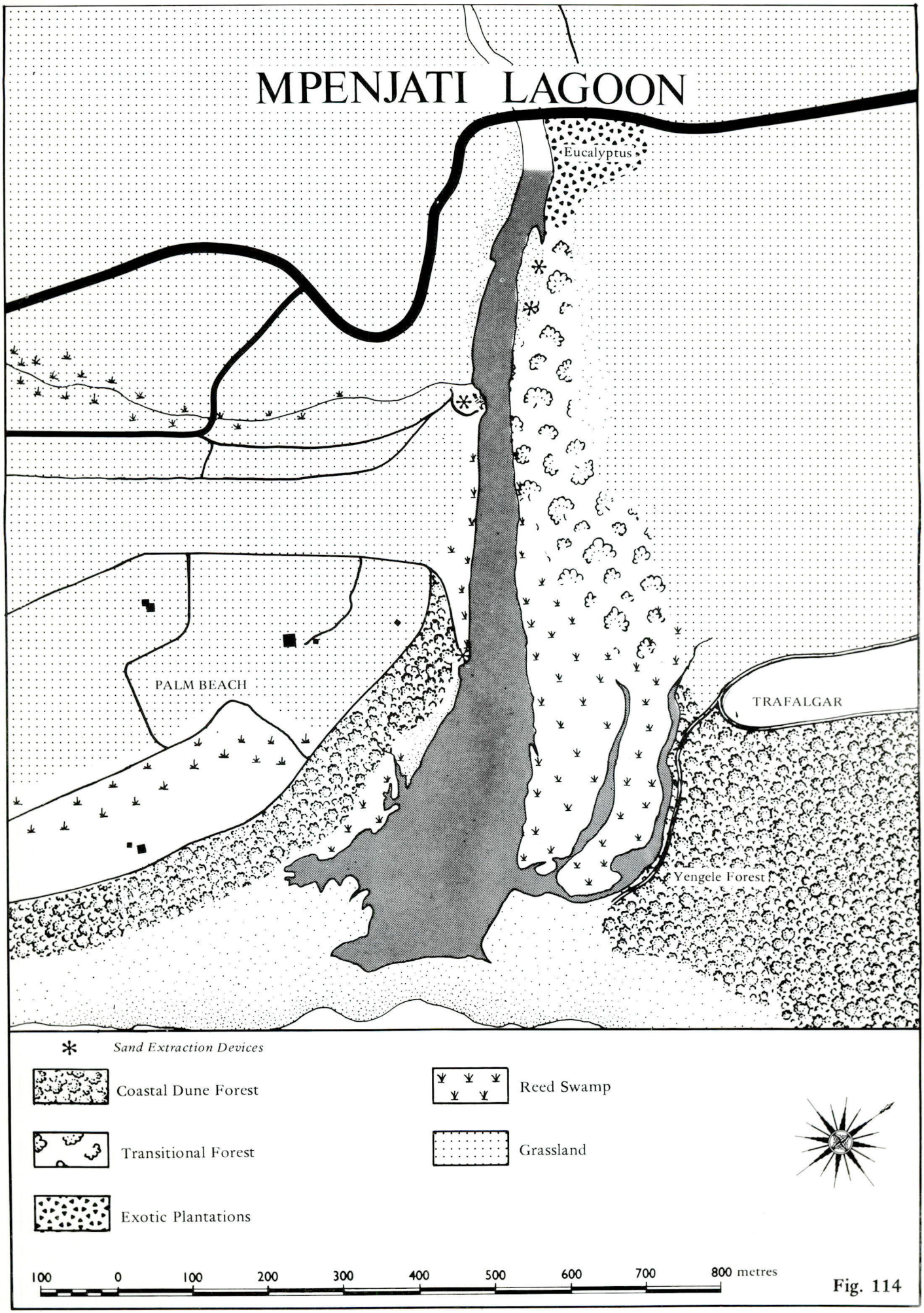

MPENJATI LAGOON
Eucalyptus
PALM BEACH
TRAFALGAR
Yengele Forest
Sand Extraction Devices
Coastal Dune Forest
Transitional Forest
Exotic Plantations
Reed Swamp
Grassland
100 0 100 200 300 400 500 600 700 800 metres

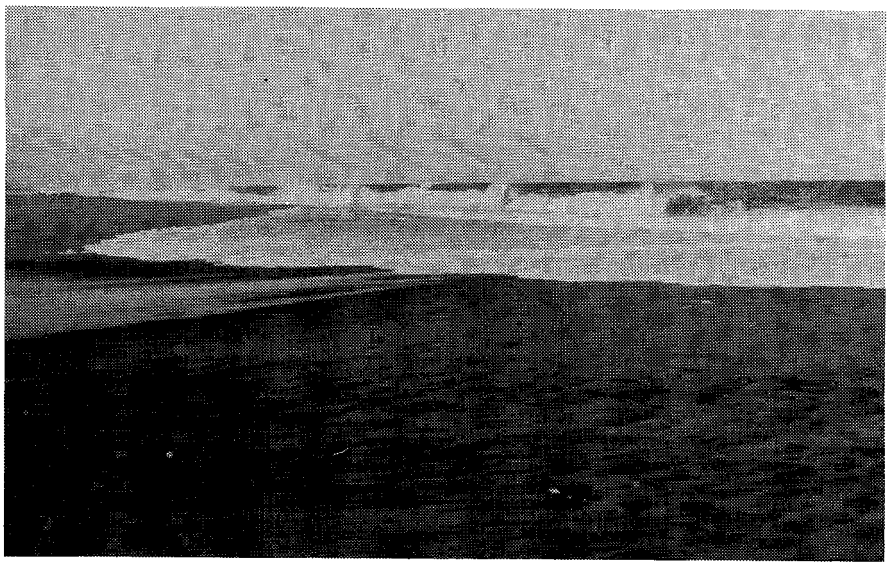
Fig. 114

Bathymetry. On 30 August 1977 the maximum depth recorded in the lagoon was 2,25 m (pers. obsv.).

Geomorphology

Geology. The Mpenjati river traverses Table Mountain Sandstone in the upper catchment, whilst nearer the coast the river and lagoon are surrounded by granite ([236, 245]). Cretaceous fossiliferous deposits are exposed on the coast, both north and south of the Mpenjati ([189]).

Nature of bottom materials. No record. However sand extraction would not be feasible if the bottom materials of the Mpenjati lagoon were not comprised of coarse river sand. Nearer the mouth, this may be overlain by marine sand which is washed over the bar. The nature of the bottom materials are such that they are unlikely to be conducive to the development of a rich benthic community.



High tides "topping" the bar at the mouth of the Mpenjati lagoon (30 August 1977).

Sandbar characteristics. With no rock protection either south or north of the system, the Mpenjati sandbar does not extend in any particular direction. Consequently the mouth position is variable. Although the mouth was closed on 30 August 1977, the sea could overtop the bar at high tide. Whether the Mpenjati sandbar is ever artificially breached, could not be established.

Configuration of adjacent shore. ([132])
Beach type — sheltered bight

Average beach slope — 3°
Average beach width — 153 m
Average sand grain size — 354 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents in the immediate vicinity of the lagoon are reported to be absent.

Physico-chemical characteristics

Although no information on the physico-chemical characteristics of the Mpenjati lagoon is available, the chemistry of the Mpenjati river was studied in 1971 100 m above the lagoon ([206]). From the results (presented as Table **102**) no signs of pollution or disturbance were evident.

On the 30th August 1977, the surface salinity in the lagoon was 4‰ (pers. obsv.).

Public health aspects

Bacteriology. Although there is no information available on the bacteriological characteristics of the Mpenjati lagoon, data from the river 100 m above the lagoon provides some indication of the likely conditions therein ([206]). The results (presented as Table **103**) showed no evidence of faecal pollution in the early 1970's and only sporadic organic enrichment.

Table 102. Physico-chemical characteristics. ([206])

Locality: Mpenjati river Distance above lagoon : 100m	SUMMER Feb 1971	WINTER July 1971
Hydrogen ion concentration (pH)	7.7	7.2
Saturated pH value	9.3	9.1
Conductivity micromhos/cm	150	200
Total dissolved solids ppm (calcd.)	89	137
Dissolved oxygen mg/litre	9.3	9.4
% Saturation	100	97
Oxygen absorbed mg/litre	-	-
Biological oxygen demand mg/litre	1.6	0.5
Kjedahl nitrogen mg/litre	0.2	0.4
Ammonia mg/litre	-	-
Nitrites mg/litre	-	-
Nitrates "	0.31	0.36
Phosphates "	0.20	0.10
Total alkalinity "	30.7	37.4
Total hardness "	29.5	46.0
Calcium "	3.4	5.1
Magnesium "	5.1	8.1
Sodium "	21.3	27.0
Potassium "	0.7	1.2
Sulphates "	4.4	10.0
Chlorides "	33.5	44.8
Silica "	-	-
Iron "	-	-
Fluorides "	0.1	0.1
Free carbonic acid (as ppm carbon dioxide)	1.1	7.1
Temperature °C	23.8	17.0
Turbidity (ppm silica scale)	-	-
Colour (APHA units)	-	-
Appearance	-	-
Odour	-	-

Values underlined significant of disturbance.

Bilharzia. *Physopsis* was collected by Jackson (pers. comm.) from tributaries of the Mpenjati river in July 1972. Consequently the likelihood of bilharzia exists.

Table 103. Bacteriology of the Mpenjati river (100 m above the lagoon.)

Date	Total Plate Count per ml x 10^3		*E. coli* 1 /100 ml	Total Coliforms per 100 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed	
March 1971			112	900
July 1971			327	6 900
3 Feb 1972	132	**150**	100	
21 Feb 1972	250	**400**	617	
3 July 1972	240	23	10	
31 July 1972	80	16	20	
17 Aug 1972	20	5		
8 Jan 1973	**1 160**	130		

Values in bold are significant of disturbance.

BIOTIC CHARACTERISTICS

Flora

A conspicuous halophytic community (dominated by *Juncus* and *Paspalum*) occurs on a low lying wetland area on the northern bank in the lower reaches of the lagoon. These detritus providing sources, are drained by two side channels which themselves create significant increments to the shoreline length. Similar contributions from a marsh area south of the lagoon, have been interfered with by road construction.



A view of the Yengele Forest, which lies immediately north of the Mpenjati lagoon.

However, of great botanical significance is the Yengele forest, situated on the coast, immediately north of the Mpenjati lagoon ([189]). This is a well preserved dune forest community, 25 ha in extent, amongst which is the tiny, but unique Black Lake ([189]).

Fauna

Other than Jackson (pers. comm.) having reported the presence of the mollusc *Assiminea* in July 1972, very little else is known about the fauna of the Mpenjati lagoon. Six estuarine associated species of birds were present on 30 August 1977, most conspicuous of which were Kelp gulls (on the sandbar) and Water dikkop (amongst *Scaevola* on the dunes).

From the animal communities studied in the river, 100 m above the lagoon in June 1972 ([208]) the marginal vegetation supported a rich, diverse community (comprising 50 species), whilst the bottom fauna were poorly represented and indicative of a disturbed habitat. 74% of the biomass was made up of the chironomid *Pentaneura*.

SYNTHESIS

Our state of knowledge of the Mpenjati lagoon is poor. In view of this, its size and satisfactory peripheral condition, ecological surveys of the lagoon are warranted. Should the results of such surveys be encouraging, then this factor, plus the considerable value of the Yengele forest, would identify the lagoon and its surrounds as being particularly worthy of protection.

The only obvious problem from which the Mpenjati lagoon suffers, is that of siltation or the gradual process of sanding up. There also appears to be no satisfactory solution to preventing the process from continuing.

Sand extraction as an activity, is not considered to be harmful to the system.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																					BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other							Flora			Fauna							Food Webs
MPENJATI ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																						◄	★	►	◄		★		►			
Source of Information	Summary of available information																																
Midgley & Pitman	1969	223	●		●																												
Fromme	1970 to 1975	132								●																							
Kemp *et al*	1971 to 1973	206	●		●						○				○										○	○							
Orme	1971	257	●																														
Loxton, Hunting & Assoc.	1971	213	●		●																												
Ninham, Shand & Partners	1971	245	●					●																									
Jackson	1972	pers. comm.																								○							
NTRPC	1974	236						●		●																							
Hopwood	1978	189						●	●														○										
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	388		●						●													●										
1:25 000 Job No. 262	1976	445	●																														

Synonyms
Umkandanhlovu

Zulu meaning
iKhandanlovu means "the place of the skull of an elephant" ([289]) due to an elephant skull which apparently lay there for many years.

Location
30°59'45"S; 30°16'E.

Accessibility
By road the Kandandlovu lagoon is 43 km south west of Port Shepstone and 170 km south west of Durban. It is most easily approached through Portobello which is 2,5 km from the national road. No provision has been made for vehicular access to the edge of the lagoon.

Bridges
There are no bridges across the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 11 km^2

River length. 8 km

Mean annual run-off. No record.

Flow. No record.

Flood history. No record.

Dams.
Existing: None.
Proposed: None.

Siltation. No record.

Land ownership/use. 48% of the catchment comprising the Kwaxolo reserve (or Location No. 4) and Nomnyatuli's location, is Bantu influenced, and destined to become incorporated into KwaZulu. Other than banana plantations just above the lagoon, the principal type of agricultural practice in the remainder of the catchment could not be established.

Having been zoned as Admiralty Reserve, land adjacent to the lagoon is undisturbed. The system is overlooked from both sides by the sparsely developed residential area of Portobello.

Local authority. Munster Health Committee.

Estuary uses. No record.

Morphometry of lagoon (see Fig. **115**)
Area. 1,8 ha

Axial length. 550 m

Shoreline length. 1,2 km

Width.
Maximum: 70 m
Mouth: No record.
Floodplain: 200 m

Bathymetry. No record.

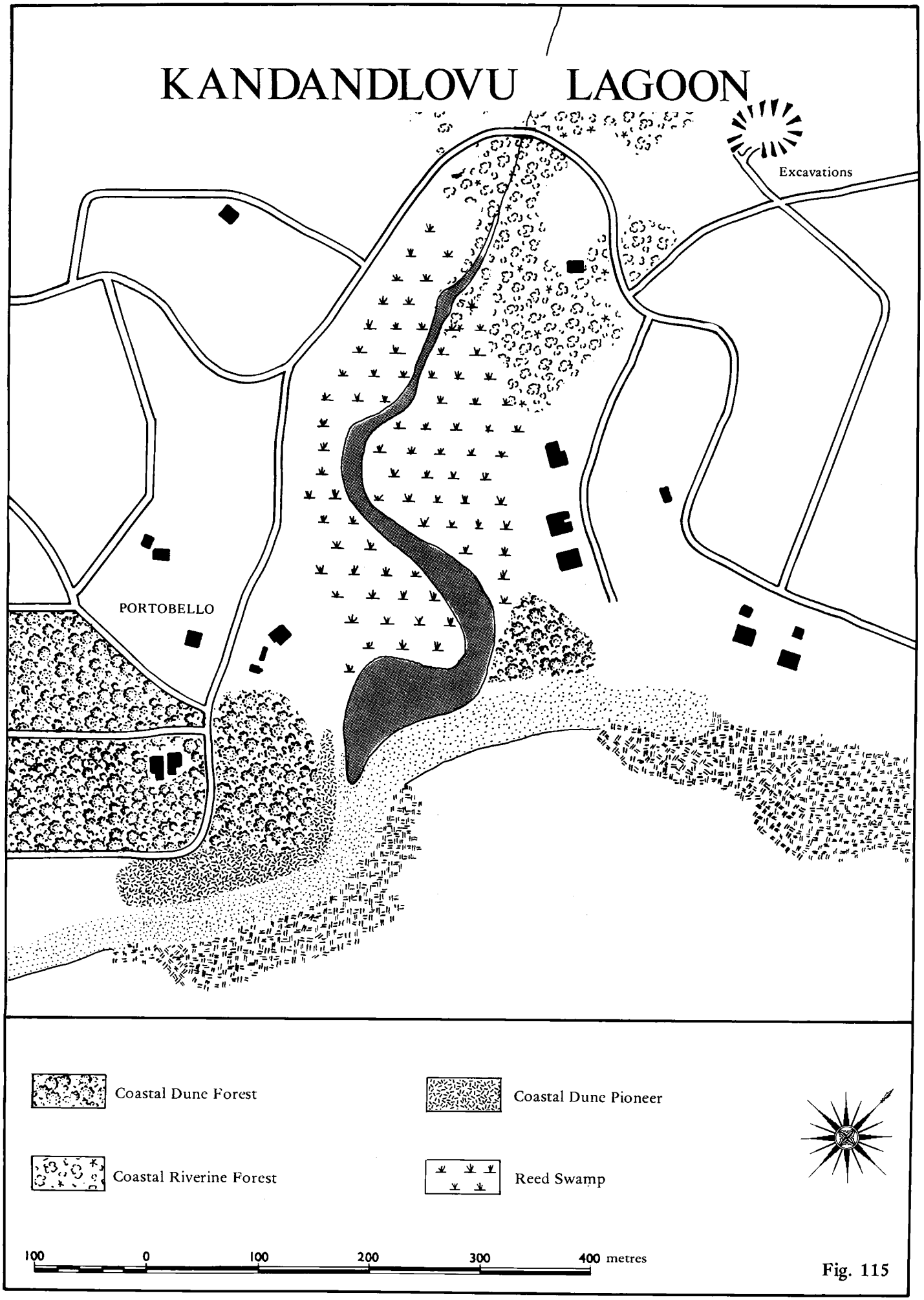

KANDANDLOVU LAGOON
Excavations
PORTOBELLO
Coastal Dune Forest
Coastal Dune Pioneer
Coastal Riverine Forest
Reed Swamp
100 0 100 200 300 400 metres

Fig. 115

Geomorphology

Geology. Both catchment and lagoon are made up of granite ([236]).

Nature of bottom materials. No record.

Sandbar characteristics. The Kandandlovu sandbar is 150 m long and south extending. It forms a beach at the back of a sheltered cove and remains closed for most of the year. Lagoon levels are presumably permitted to fluctuate naturally, since they do not appear to interfere with any activities on the floodplain or development alongside the lagoon.

Configuration of adjacent shore.
No record.

Surf zone currents. No record.

Physico-chemical characteristics

Salinities of 10‰ were recorded in the lagoon in July 1972 by Jackson (pers. comm.). Other than this, there is no information on the physico-chemical characteristics of the Kandandlovu lagoon or the river above it.

Public health aspects

Bacteriology. No record.

Bilharzia. A survey by Jackson (pers. comm.) in July 1972 failed to reveal the presence of bilharzia snails.

BIOTIC CHARACTERISTICS

Flora

The vegetation of the Kandandlovu lagoon is principally comprised of ± 5 ha of reed swamp in the upper and middle reaches. Above it, riparian vegetation alongside the Kandandlovu river is well preserved; and to the south of the lagoon, a 100 m wide strip of dune forest runs along the coast. Above this, the township of Portobello is beginning to spread. Elsewhere disturbed grassland communities surround the lagoon.



A view of the reedswamps surrounding the Kandandlovu lagoon (9 June 1977).

Fauna

The freshwater mollusc *Lymnaea* was collected from the lagoon in July 1972 by Jackson (pers. comm.), and Stannard (pers. comm.) reports that Marsh Harrier breed in the reed swamps. Other than this there is no information available on the fauna of the Kandandlovu lagoon.

SYNTHESIS

Our state of knowledge of the Kandandlovu lagoon is very poor. Despite this, there seems to be no reason why (at this stage) research effort should be expended on the lagoon. Other than silt (which is probably coming from banana plantations), it is problem free, in fair environmental condition and probably functioning quite satisfactorily. In a regional context, its contribution as an estuarine resource is considered to be negligible.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC									
			Physio-graphy		Physics			Geomor-phology			Chemistry					Bacteriology	Other							Flora			Fauna							Food Webs
KANDANDLOVU			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																																	
Source of Information	Summary of available information																																
Jackson	1972	pers. comm.				●		●																		●							
NTRPC	1974	236						●																									
Stannard	1977	pers. comm.																										●					
Aerial photos (Scogings)		No.																															
1:10 000 Job No. 261	1976	392		●																			●										
1:25 000 Job No. 262	1976	444	●																														

Synonyms
Thongazi; Intongazi.

Zulu meaning
No record.

Location
31°0'45"S; 30°15'30"E.

Accessibility
The Tongazi lagoon is 43 km south west of Port Shepstone, and 172 km south west of Durban. It lies 1,2 km from the national road. On the northern bank a track descends steeply down to the water's edge, and culminates in a slipway.

Bridges
A small footbridge has been built over the mouth of the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics
Area. 20 km^2

River length. 8,5 km

Mean annual run-off. No record.

Flow. No record.

Flood history. No record.

Dams.
Existing. None.
Proposed: None.

Siltation. No record.

Land ownership/use. 62,5% of the catchment comprising Nomnyatuli's location in Bantu influenced, and destined to become incorporated into KwaZulu in the near future. Near the coast sugar cane has been planted over much of the countryside.
The lagoon is surrounded by residential development in the form of Portobello (to the north) and Glenmore Beach (to the south). There is a hotel overlooking the Tongazi sandbar, and near the upper reaches of the lagoon, a school.

Local authority. Munster Health Committee.

Estuary uses. The lagoon is used by holidaymakers for swimming and angling.

Morphometry of lagoon (see Fig. **116**)
Area. 0,76 ha

Axial length. 350 m

Shoreline length. 725 m

Width.
Maximum: 40 m
Mouth: 2 m to 3 m wide during low flow periods.
Floodplain: Being confined between a steep (almost vertical) sided valley, there is no floodplain as such.

Bathymetry. No record.

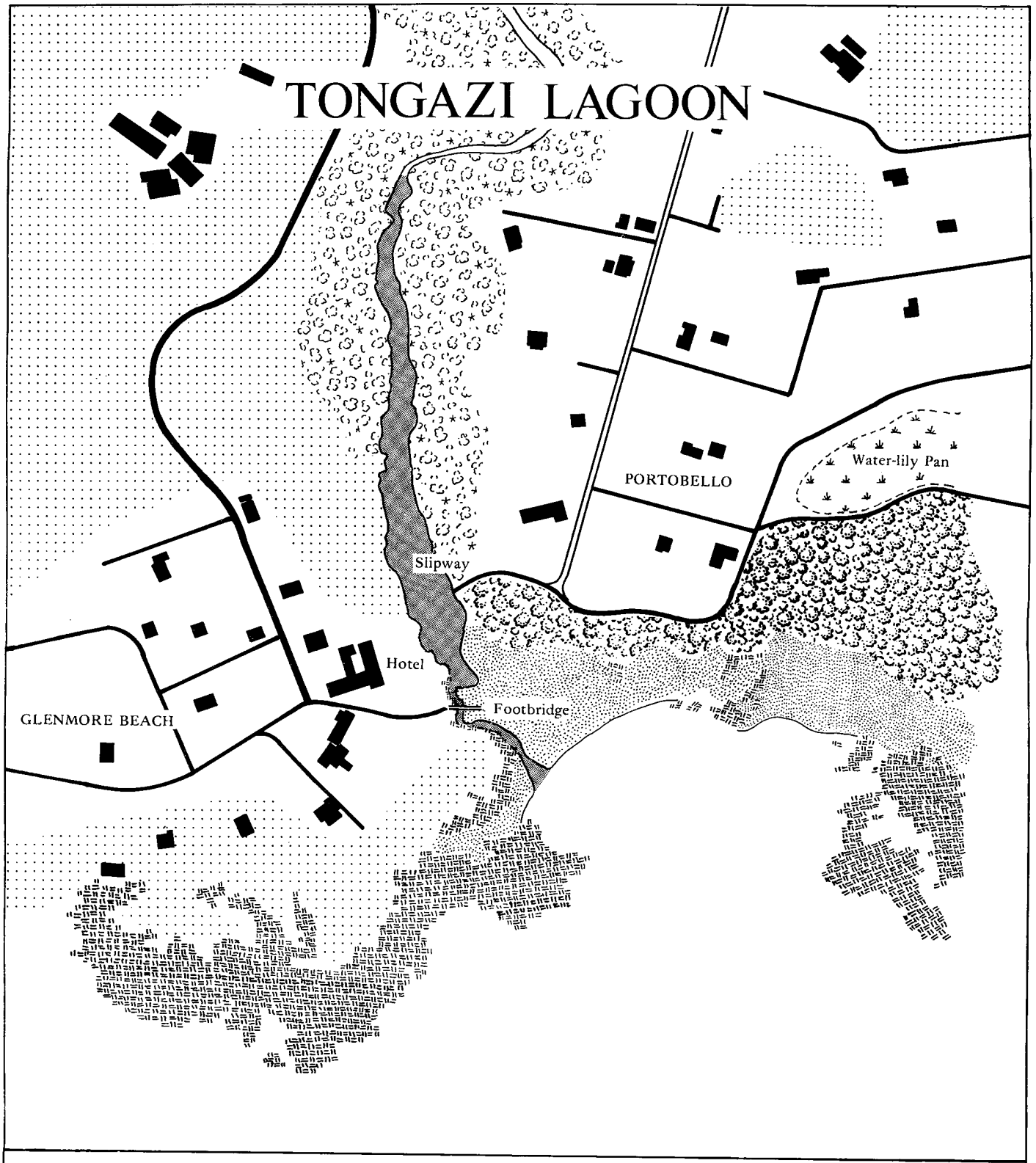

TONGAZI LAGOON
PORTOBELLO
Water-lily Pan
Slipway
Hotel
Footbridge
GLENMORE BEACH
Coastal Dune Forest
Grassland
Coastal Riverine Forest
100
0
100
200
300
400 metres

Fig. 116

Geomorphology

Geology. Both catchment and lagoon are made up of granite([236]). Cretaceous fossiliferous deposits are exposed on the coast south of the Tongazi ([189]).

Nature of bottom materials. No record.

Sandbar characteristics. The Tongazi sandbar is 75 m long and south extending, and comprises the bathing area of Glenmore Beach. Lying within a well sheltered cove, the mouth position is stable, and confined to the southern end of the bar. Although Jackson (pers. comm.) found the lagoon to be open to the sea on 3 June 1972, exchange is probably limited for most of the year to high tides overtopping the bar. Whether the bar is breached artificially, could not be ascertained.

Configuration of adjacent shore ([132]).
Beach type — well sheltered cove.

Average beach slope — 2°
Average beach width — 105 m
Average sand grain size — 239 microns
} indicative of calm surf zone conditions.

Surf zone currents. Rip currents are reported to be absent in the near vicinity of the lagoon.

Physico-chemical characteristics

On 3 June 1972, salinities of 3‰ to 11‰ were recorded in the lagoon by Jackson (pers. comm.). Other than this, there is no information on the physico-chemical characteristics of the Tongazi lagoon, or the river above it.

Public health aspects

Bacteriology. No record.

Bilharzia. In June 1972 Jackson (pers. comm.) found no evidence of bilharzia snails either in the lagoon or the river above it.

BIOTIC CHARACTERISTICS

Flora

A dense fringe of riverine forest runs alongside either bank of the lagoon in its upper reaches, and continues for a further 500 m on either side of the river above it. 250 m north of the lagoon is a small (± 4 ha) but well preserved remnant of coastal dune forest, immediately behind which is the "Portobello or Water-lily pan" (see Fig. 116). The latter has an outstanding reputation for its birdlife, this being due to the nature of the peripheral aquatic vegetation.

Fauna

Other than Jackson (pers. comm.) having recorded the presence of the molluscs *Lymnaea* and *Anisus* (on 3 June 1972) there is no information available on the fauna of the Tongazi lagoon.

Stannard (pers. comm.) has acquired a knowledge of the birdlife which frequents the "Water-lily pan". White-faced duck and purple gallinule breed here each year, and the following species occur:-

Dabchick
Lesser gallinule
Jacana
Moorhen
Yellowbill duck
White backed duck
Black duck
Purple heron
Bittern
Dwarf geese
Crested crane
Coot

As a refuge for both resident and migratory water fowl, this pan should be set aside and protected as a bird sanctuary. It is zoned as public open space.

SYNTHESIS

Our present state of knowledge of the Tongazi lagoon is virtually non-existent. The lagoon appears to be problem free and in fair environmental condition. It is an interesting lagoon in that the banks are precipitous and consequently surrounded by atypical lagoonal plant communities. If compared to a neighbouring but disturbed lagoon such as the Ku-Boboyi, a study of the Tongazi lagoon would make an interesting and useful comparison. Determination of its resource value must await the outcome of such surveys.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																								BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other							Flora			Fauna								Food Webs
TONGAZI			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles				
Data Voids																							★	←		★		→						
Source of Information	Summary of available information																																		
Fromme	1970 to 1975	132								●																									
Jackson	1972	pers. comm.				●																				●								
NTRPC	1974	236						●																										
Stannard	1977	pers. comm.																									●							
Hopwood	1978	189						●	●																									
Aerial photos (Scogings)		No.																																
1:10 000 Job No. 261	1976	394		●																			●											
1:25 000 Job No. 262	1976	443	●																															

KU-BOBOYI

Synonyms

None, but not to be confused with the Boboyi lagoon 35 km further north (see Section 2.1.12.6).

Zulu meaning

Presumably the Ku-Boboyi also owes its name to the type of grass (used for mat making) which grew on its banks ([289]).

Location

31°02'S; 30°14'E.

Accessibility

The Ku-Boboyi lagoon is 46,5 km south west of Port Shepstone and 175 km south west of Durban. It lies 1,5 km east of the national road.

Direct vehicular access to the lagoon is limited, although in its upper reaches there is a track along the northern bank.

Bridges

There are no bridges across the lagoon.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 4 km^2

River length. 4 km

Mean annual run-off. No record.

Flow. No record.

Flood history. No record.

Dams.
Existing: None.
Proposed: None.

Siltation. No record. The impression gained from aerial photography is that the lagoon is silted. This is almost certainly due to the influence of sugar cane adjacent to the lagoon.



An impression of the Ku-boboyi lagoon (10 June 1977). Note the sugar cane encroachment on the southern side.

Land ownership/use. The entire catchment of the Ku-Boboyi lies within a European owned farming area — much of which is made up of estates owned by Basson & Co.

On the northern bank of the lagoon is the sparsely developed residential area of Leisure Bay. Holiday cottages and a caravan site owned by the Transvaal Teachers Association, overlook the lagoon.

On the southern bank the land is privately owned by a Mrs Kaiser. It is used for the cultivation of sugar cane and bananas.

Local authority. Munster Health Committee.

Estuary uses. No record.

Morphometry of lagoon (see Fig. **117**).

Area. 1,1 ha

Axial length. 525 m

Shoreline length. 1,2 km

Width.
Maximum: 45 m
Mouth: No record.
Floodplain: 60 m

Bathymetry. No record.

Geomorphology

Geology. Both catchment and lagoon are made up of granite ([238]).

Nature of bottom materials. No record.

Sandbar characteristics. The Ku-Boboyi sandbar is 50 m long and south extending. The mouth is rock defended by a headland which protrudes from the coast into the sea immediately south of the lagoon. No information regarding how long the lagoon remains closed to the sea, or whether the water level is artificially controlled, could be found.

Configuration of adjacent shore. ([132])
Beach type — sheltered bight.

Average beach slope — 3°
Average beach width — 97 m
Average sand grain size — 302 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents in the near vicinity of the lagoon are reported as absent.

Physico-chemical characteristics

In the winter of 1972 Jackson (pers. comm.) recorded salinities of 20‰ in the Ku-Boboyi lagoon. Other than this there is no information on the physico-chemical characteristics of the lagoon or the river above it. However, from aerial photographs (dated 12 June 1976) it is clear that the water of Ku-Boboyi lagoon is more turbid than that in any neighbouring lagoon.

Public health aspects

Bacteriology. Although there is no information available on the bacteriological characteristics of the Ku-Boboyi lagoon, with the proximity of sugar cane, organic enrichment is probable.

Bilharzia. Jackson (pers. comm.) reported *Physopsis* as present in the river on 13 October 1974. A signboard at the mouth of the lagoon warns against contact with the water.

BIOTIC CHARACTERISTICS

Flora

From a botanical point of view the Ku-Boboyi lagoon is unimportant. There is a narrow fringe of *Phragmites* along either bank, but cane encroachment on the southern bank of the lagoon, has eliminated most of the original lagoonal plant communities.

For some 600 m above the lagoon a riverine forest community has remained undisturbed.

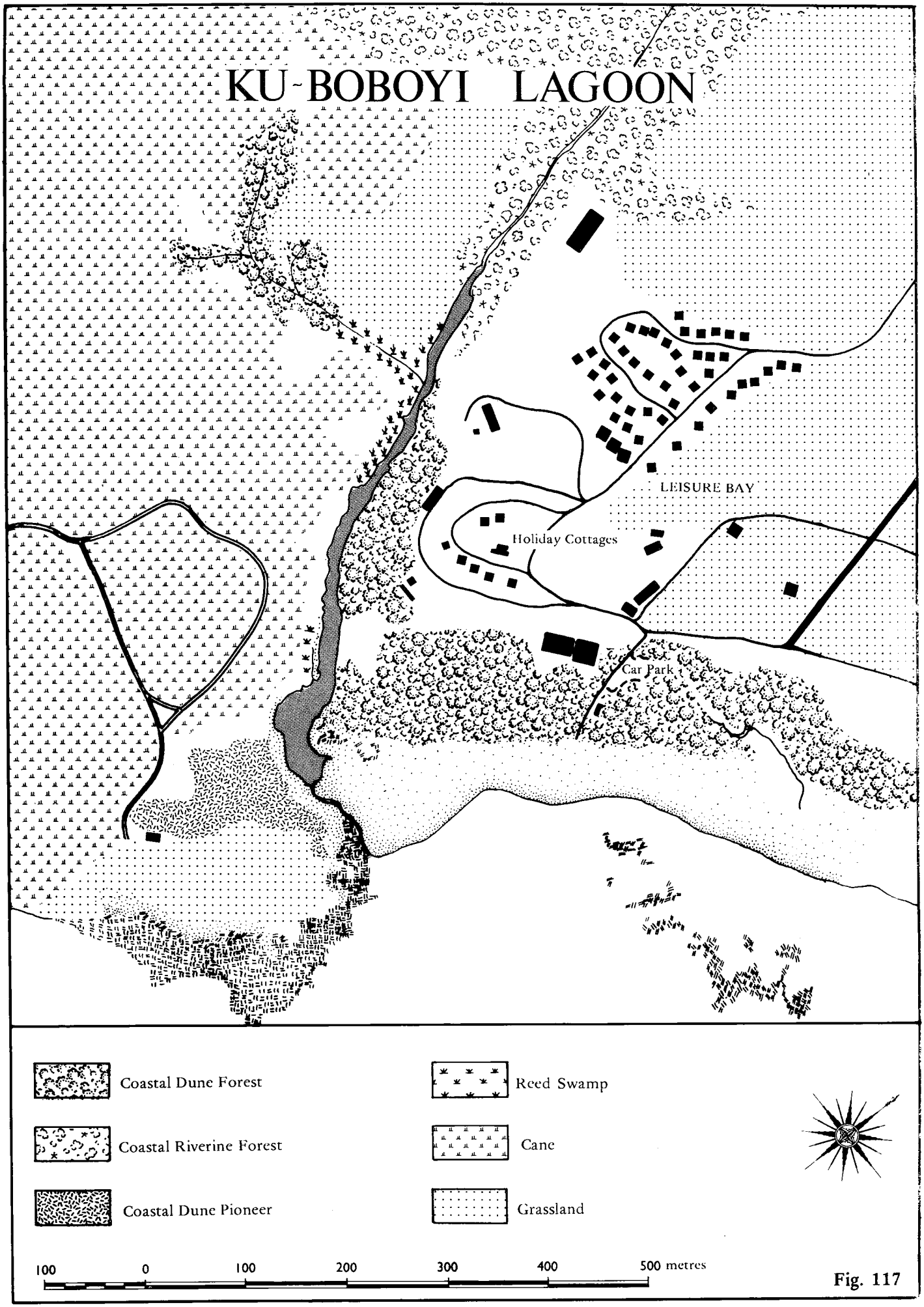

KU-BOBOYI LAGOON
LEISURE BAY
Holiday Cottages
Car Park
Coastal Dune Forest
Coastal Riverine Forest
Coastal Dune Pioneer
Reed Swamp
Cane
Grassland
100
0
100
200
300
400
500 metres

Fig. 117

Fauna

Apart from the knowledge that the mollusc *Neritina natalensis* was present on 13 October 1974 (Jackson, pers. comm.), nothing else is known about the fauna of the Ku-Boboyi lagoon.

SYNTHESIS

Our state of knowledge of the Ku-Boboyi lagoon is very poor. Nevertheless the Ku-Boboyi is an interesting lagoon in that it appears to illustrate how the proximity of sugar cane is immediately betrayed by certain characteristics such as disturbed vegetation, turbid water, siltation and in all likelihood, organic enrichment. The lagoon should be studied for the sake of comparison with neighbouring lagoons to confirm whether such speculation is correct.

The Ku-Boboyi lagoon is regarded as having become degraded to the extent that it no longer has any value as an estuarine resource.

| ESTUARY/LAGOON | | |

2.1.13.9 **SANDLUNDLU**

Synonyms

Inhlanhlinhlu — (P.W.D. road map (dated 1906) in the Natal Archives).

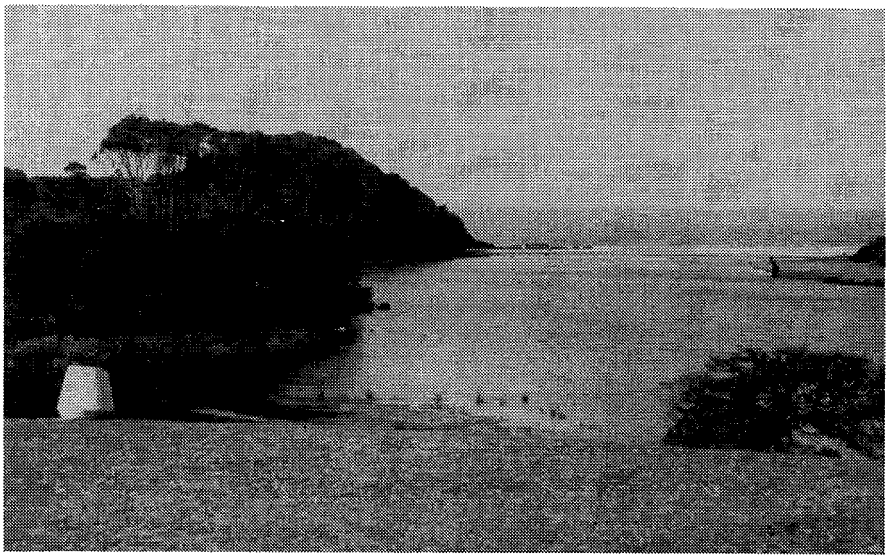
Zulu meaning

The Sandlundlu lagoon owes its name to a nearby hill "that is shaped like a hut" ([189, 289]). The same hill (rising 76 m above sea level) is also called "Tragedy Hill" or "North Sands Bluff".

Dunne ([125]), Stayt ([289]) and Hopwood ([189]) all provide somewhat differing historical backgrounds as to why the hill became known by this name.

Location

31°2'30"S; 30°13'30"E.



A view of the Sandlundlu lagoon from the front lawn of "Koelwaters" estate.

Accessibility

The Sandlundlu lagoon is 1,5 km from the national road, and lies just north of Port Edward. Consequently it is 49 km south west of Port Shepstone, and 178 km south west of Durban.

Being privately owned, access to the lagoon is restricted.

Bridges

There is a private road across the head of the lagoon which has been built upon a low level causeway. The latter acts as an artificial boundary between the lagoon and the river above it.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 19 km^2

River length. 7,5 km

Mean annual run-off. No record.

Flow. In recent years the river has been known to cease flowing in winter (van Duyn, pers. comm.).

Flood history. There is no quantitative information on flood discharges from the Sandlundlu river, but van Duyn (pers. comm.) has indicated that floods can be severe. They bring down much debris, in the form of sugar cane trash.

Dams.

Existing: Several small farm dams have been built for irrigation purposes above the lagoon (van Duyn pers. comm.).

Proposed: None.

Siltation. Although the water does not turn particularly muddy during the rainy season, a tremendous amount of sand has been transported into the lagoon since cane farming has started in the catchment (van Duyn, pers. comm.).

Land ownership/use. The Sandlundlu catchment is principally used for the production of sugar cane and bananas. The estates ("Cornhill Farm") making up this area are owned by Basson & Co.

The Sandlundlu lagoon and the land surrounding it (comprising an estate known as "Koelwaters") is privately owned by a Mr van Duyn ([125, 189]). Horses are paddocked on the southern bank of the lagoon.

South of the lagoon is a holiday chalet complex belonging to the South African Police, in which some 90 000 people are accommodated each year (de Klerk, pers. comm.). Just south of this point is Port Edward, the most southerly holiday resort on the Natal coast.

Local authority. The lagoon is presently controlled by Mr M. van Duyn. However, the Port Edward Health Committee would like to see the Sandlundlu lagoon become incorporated into their area, so that it could become an integral part of the facilities the town could offer holiday-makers.

Estuary uses. Mr van Duyn has half a dozen small boats on the Sandlundlu lagoon for hire and permits swimming at the mouth. He intends to develop a small park for 15 to 20 caravans on the southern bank, and has buried a cable beneath the lagoon, to provide electricity for hot water, lights, etc. He also intends to develop an island as a refuge for birdlife, by digging a canal around a group of trees on the northern bank (see Fig. **118**).

Morphometry of lagoon (see Fig. **118**).

Area. 4 ha

Axial length. 600 m

Shoreline length. 1,2 km

Width.
Maximum: 230 m
Mouth: 10 m during low flow periods; 75 m at high spring tide.
Floodplain: Not applicable.

Bathymetry. At present very few areas in the lagoon are deeper than 1,5 m (van Duyn, pers. comm.). It is deepest at the head of the lagoon where, in plunging over the causeway, the river has scoured a hole 3 m to 4,5 m deep.

Geomorphology

Geology. The upper catchment comprises Table Mountain Sandstone. Nearer the coast granite occurs ([236]).

Nature of bottom materials. Rocks outcrop along the northern bank of the lagoon, and the bottom materials consist of coarse sand (van Duyn, pers. comm.). At low water levels, a sand bank becomes exposed in the centre of the lagoon. Van Duyn has given serious consideration to dredging the lagoon at some stage in the future.

Sandbar characteristics. The Sandlundlu sandbar is much broader (at 200 m) than it is long. Lying within the protection of a cove, it does not extend in any particular direction. The lagoon can become closed for several months. Occasionally the bar is breached artificially to flush the lagoon in the dry season, and to lower the level if the causeway across the head of the lagoon becomes flooded (van Duyn, pers. comm.).

Configuration of adjacent shore ([132]).
Beach type — well sheltered cove.

Average beach slope — 3°
Average beach width — 122 m
Average sand grain size — 233 microns
} indicative of calm surf zone conditions.

Surf zone currents. Rip currents in the near vicinity of the lagoon are absent.

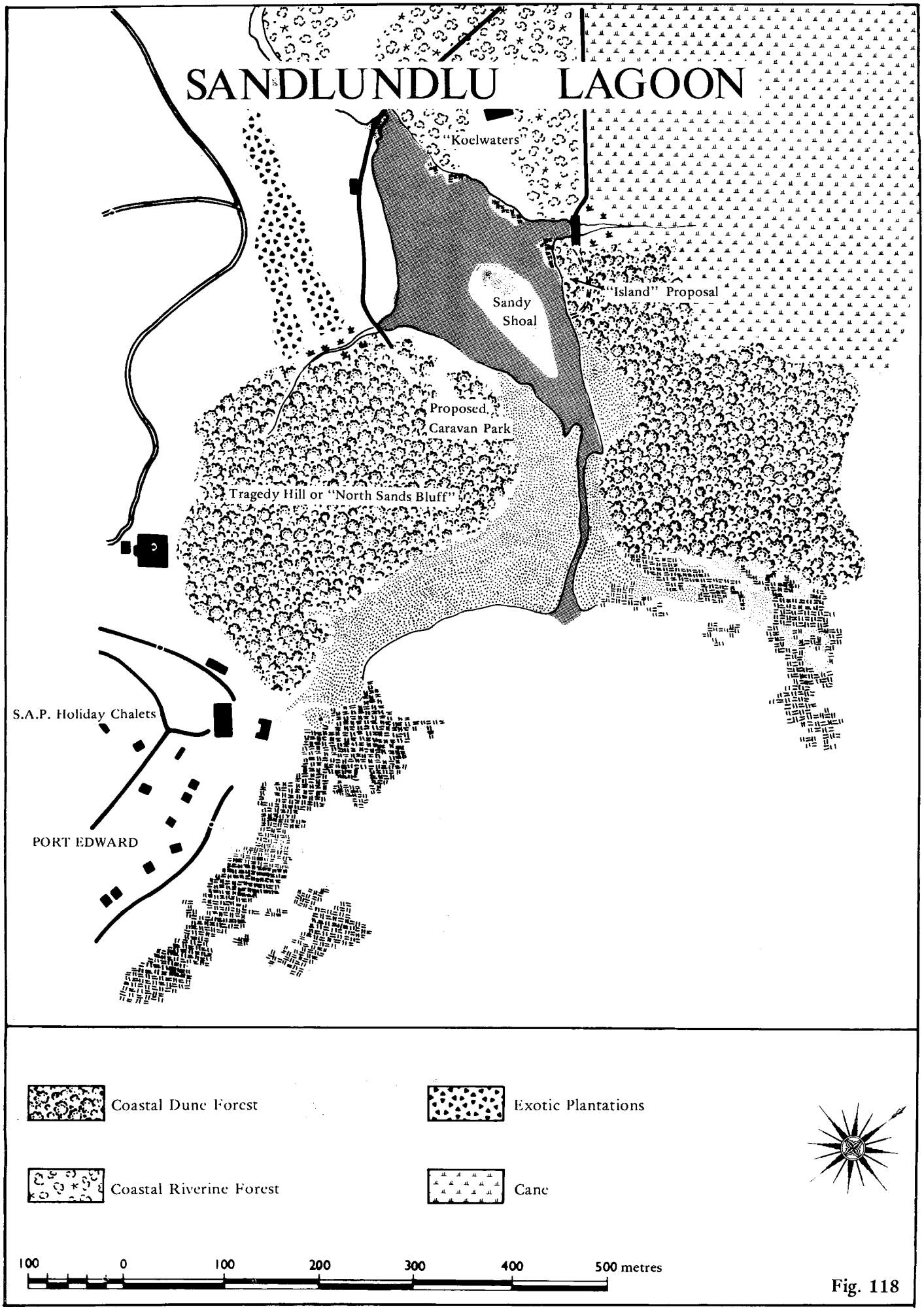

SANDLUNDLU LAGOON
"Koelwaters"
"Island" Proposal
Sandy Shoal
Proposed Caravan Park
Tragedy Hill or "North Sands Bluff"
S.A.P. Holiday Chalets
PORT EDWARD
Coastal Dune Forest
Exotic Plantations
Coastal Riverine Forest
Cane
100 0 100 200 300 400 500 metres

Fig. 118

Physico-chemical characteristics

Jackson (pers. comm.) recorded salinities of 20‰ in the lagoon on 5 July 1972. Other than this, there is no information available on the physico-chemical characteristics of the Sandlundlu lagoon or the river above it.

Van Duyn (pers. comm.) maintains that the water is generally very fresh because his horses find it sufficiently palatable to drink. He reports that if the lagoon remains closed for too long, the water begins to go green, which is a process suggestive of nutrient enrichment.

Public health aspects

Bacteriology. Although there is no quantitative data available on bacteriological conditions in the Sandlundlu lagoon, van Duyn (pers. comm.) has expressed concern about sewage contamination from the South African Police holiday resort and from french drains of the shopping centre on the national road. Sewage from Port Edward is apparently treated and discharged into the sea (de Klerk, pers. comm.).

Bilharzia. Both lagoon and river have been surveyed by the State Department of Health in July 1972, and declared bilharzia free because no vector snails were found to be present.

BIOTIC CHARACTERISTICS

Flora

Lagoonal plant communities are virtually non-existent, although 5 to 6 years ago a submerged macrophyte (*Ruppia*? or *Zostera*?) growing on the floor of the lagoon was plentiful. Since the lagoon has become sanded up, these plants have disappeared (van Duyn, pers. comm.).

The lagoon is surrounded by impressive dune forest communities, the most valuable of which is that covering Tragedy Hill. Three quarters of this hill is privately owned and thus likely to remain undisturbed. Above the lagoon a well preserved riparian forest community occurs.

Fauna

Lower trophic levels.

Benthos. The mollusc *Assiminea* was present in the lagoon on 5 July 1972 according to Jackson (pers. comm.). Crabs (*Scylla*) and sand prawns (*Callianassa*) are also plentiful (van Duyn, pers. comm.).

Higher trophic levels.

Fish: Angling can be rewarding particularly when the lagoon is open to the sea (van Duyn, pers. comm.). The following fishes have been caught on rod and line in the lagoon over the past few years: rock salmon (*Lutjanus* — largest 2,5 kg), various types of mullet (*Mugilidae*), bream (*Acanthopagrus*), springer (*Elops*), kingfish (*Caranx*) and sea pike (*Sphyraena*).

Mammals: Noteworthy amongst the mammals seen to be present in the vicinity of the lagoon are an otter, and on one occasion a caracal (van Duyn, pers. comm.).

Reptiles: Leguaans are common.

Birds: A pair of fish eagles are regularly seen in the vicinity of the lagoon (van Duyn, pers. comm.).

SYNTHESIS

Our state of knowledge of the Sandlundlu lagoon is very poor, and based almost entirely upon hearsay. However, the lagoon appears to be in a fair environmental condition, despite there being indications that it is sanding up and possibly contaminated in the dry season. Investigations to establish whether this is the case seem warranted. One of the benefits of private ownership is that the surrounds of the lagoon have remained undisturbed. The dune forest covering Tragedy Hill is one component of the area with considerable conservation potential.

The most serious of the various problems apparent in the lagoon, is siltation. This seems to have occurred once the farming of sugar cane began in the catchment area. The construction of a causeway across the head of the lagoon, has resulted in limiting its extent, as well as having led to the need to artificially control water levels.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC									
			Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other						Flora			Fauna							Food Webs
SANDLUNDLU			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids											★					★																
Source of Information	Summary of available information																															
Fromme	1970 to 1975	132								●																						
Jackson	1972	pers. comm.				●																					●					
NTRPC	1974	236						●																								
Van Duyn	1977	pers. comm.	●	●	●					●											●						●	●		●		
Hopwood	1978	189						●												●												
Aerial photos (Scogings)		No.																														
1:10 000 Job No. 261	1976	400		●						●														●								
1:25 000 Job No. 262	1976	441	●																													

Synonyms
Isolwane.

Zulu meaning
No record.

Location
31°4'30"S; 30°12'15"E.

Accessibility
The Zolwane lagoon is 53 km south west of Port Shepstone, and 181 km south west of Durban. Although the lagoon lies concealed immediately below the national road, it is privately owned and consequently inaccessible to the general public.

There is a private airstrip just south of the lagoon, between it and the Mtamvuna estuary.

Bridges
There are no bridges across the lagoon.

ABIOTIC CHARACTERISTICS
Catchment characteristics

Area. 7 km^2

River length. 6,5 km

Mean annual run-off. No record.

Flow. The Zolwane river flows perennially (Williams, pers. comm.).

Flood history. Although flash floods occur, they are not of any great magnitude and are of very short duration (Williams, pers. comm.).

Dams.
Existing: None.
Proposed: None.

Siltation. Due to the relatively undisturbed nature of its catchment, the system appears to be unaffected by siltation. The lagoon became discoloured only during the early 1960's when embankments were being constructed to carry the national road past the lagoon (Williams, pers. comm.).

Land ownership/use. Both catchment and lagoon are privately owned by the Rennie family. A small proportion of the property is on lease to a farmer for the purpose of growing bananas. When the lease expires in a few years time, it is not likely to be renewed. Bantu employees on the property keep a small herd of cattle on the land.

The property has changed hands through inheritance, so that the southern sector ("Hlatimi") is owned by the son (Mr S. Rennie), and the northern section ("Izolwane") by the daughter (Mrs Allday).

All parties have a strong desire to conserve the estate and to resist encroachment of any sort (such as the erection of sea communication masts by the Post Office Department) and once approached the Natal Parks Board to take control of the area.

It is rumoured that use of the airstrip for defence purposes is likely to be made and that a border post between Natal and the Transkei will have to be established on the property in the future.

Local authority. Being privately owned, there is no local authority in control of the Zolwane lagoon.

Estuary uses. The lagoon is used for swimming and by Bantu employees for bathing and the laundering of clothes.

Morphometry of lagoon (see Fig. **119**).

Area. 0,5 ha

Axial length. 210 m

Shoreline length. 475 m

Width.
Maximum: 40 m
Mouth: 2 m during normal, low flow periods.
Floodplain: Not applicable.

Bathymetry. The maximum depth recorded on 31 August 1977, was 3 m (pers. obsv.).

Geomorphology

Geology. The Zolwane catchment is made up of Table Mountain Sandstone ([236]) and includes one of the "Red Desert" areas of Natal ([189]). Granite surrounds the lagoon and outcrops as vertical cliffs on a portion of the northern bank.

Nature of bottom materials. Bottom materials in the lower reaches of the lagoon appear to be composed of marine sands presumably washed in at high tide. Rocks become apparent on the bottom of the lagoon towards the upper reaches (pers. obsv.).

Sandbar characteristics. The Zolwane sandbar is a diminutive (40 m long) south extending bar. The channel to the sea, winds across the beach over the southern end of the bar.

Directly opposite the lagoon is a distinct channel (called "Rennie's Cove") between rocks on the coast. On a high spring tide it is possible to surf from the sea through "Rennie's Cove" and into the lagoon (Williams, pers. comm.). This information provides some insight into the considerable exchange that occurs with the sea in an undisturbed estuarine environment. Furthermore, breaching is unnecessary because it is very seldom that the mouth is closed, due to perennial flow of the river. Consequently there is a regular exchange of water at each tide.

Configuration of adjacent shore. No record.

Surf zone currents. No record.

Physico-chemical characteristics

There is no information on the physico-chemical characteristics of the Zolwane lagoon, or the river above it. Salinity measurements on 31 August 1977 (with the mouth closed) showed the surface water to be fresh. Being 3 m deep and in regular contact with the sea, salinity stratification is probable. With the bottom visible at 3 m, the clarity of the water in the lagoon was impressive.

Public health aspects

Bacteriology. There is no information available on the bacteriological characteristics of the Zolwane lagoon. At only one stage in the past (when a temporary road camp was constructed above the lagoon) was there reason to become concerned about faecal contamination (Williams, pers. comm.).

Bilharzia. No record.

BIOTIC CHARACTERISTICS

Flora

On the northern bank of the lagoon, open grassland predominates, and *Casuarina* have spread down to the water's edge in its upper reaches. Near the mouth of the lagoon, holiday makers and fishermen, seeking access to Rennie's Cove, have cut a track through the Admiralty Reserve.

On the southern bank is a beautifully preserved coastal dune forest, amongst which *Hibiscus tiliaceus*, *Mimusops caffra*, *Strelitzia nicolai* and *Phoenix* palm, occur along the water's edge.

The late Mr F. Rennie spent much time trying to re-establish vegetation such as *Casuarina* and *Acacia cyanophylla* (the Port Jackson willow) on the red desert areas in the catchment (Williams, pers. comm.). In some respects his efforts have detracted from one of the main features of these unique areas, namely, their completely barren form.

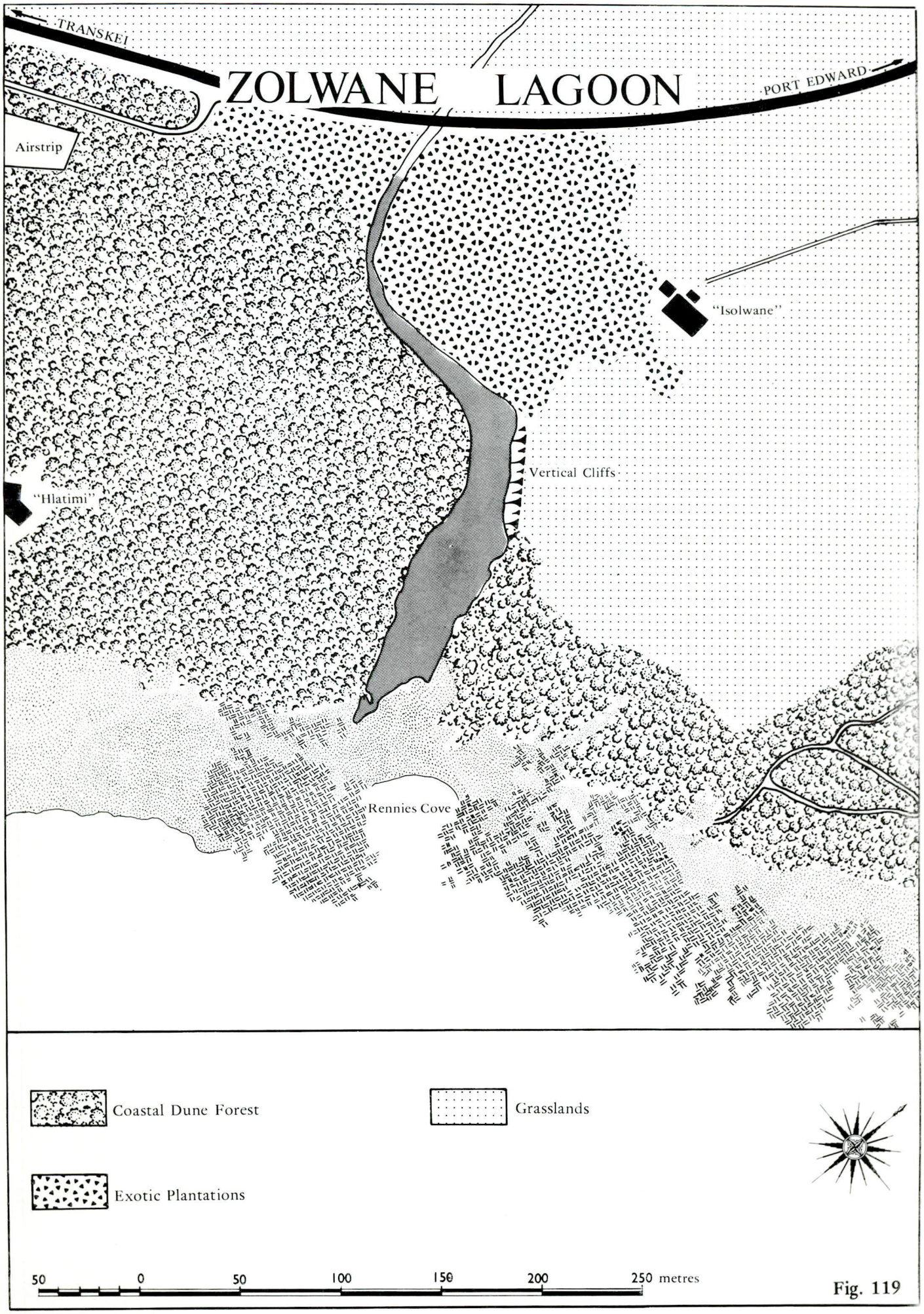

TRANSKEI
ZOLWANE LAGOON
PORT EDWARD
Airstrip
"Isolwane"
Vertical Cliffs
"Hlatimi"
Rennies Cove
Coastal Dune Forest
Grasslands
Exotic Plantations
50 0 50 100 150 200 250 metres

Fig. 119



A general impression of the Zolwane lagoon (31 August 1977).

Fauna

There is no documented information on the fauna of the Zolwane lagoon, however several shoals of small fish (of an undetermined species) were much in evidence on 31 August 1977 (pers. obsv.). Although various kingfishers occur along the water's edge, the birdlife of the area is essentially forest associated, amongst which the Narina trogon is noteworthy (Williams, pers. comm.).

Blue duiker or "mPiti" (*Cephalophus monticola*) and vervet monkeys (*Cercopithecus*) occur in the forest adjacent to the lagoon. Water leguaans (*Varanus*) were also very much in evidence, leaping into the water from crevices in overhanging rocks.

SYNTHESIS

Our general state of knowledge of the Zolwane lagoon is very poor and almost completely based upon hearsay. Nevertheless it is a well preserved lagoon, with definite conservation potential, largely because of the undisturbed dune forest that extends southwards towards the Mtamvuna estuary. There is however, no reason to suggest that at this stage the lagoon should be studied in any detail. Despite being small, the Zolwane lagoon leaves an indelible impression in that it serves to illustrate what so many of the lagoons on the lower south coast of Natal must once have been like. It also shows that private ownership of the lagoon (especially when the catchment area is also privately owned) has the advantage of generally ensuring that the system remains undisturbed.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																						BIOTIC										
			Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	Other						Flora			Fauna								Food Webs
ZOLWANE			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles		
Data Voids																																		
Source of Information	Summary of available information																																	
NTRPC	1974	236						●																										
Williams	1977	pers. comm.		●	●		●													●								●	●					
Hopwood	1978	189	●					●																										
Aerial photos (Scogings)		No.																																
1:10 000 Job No. 261	1976	405		●																			●											
1:25 000 Job No. 262	1976	439	●																															

Synonyms

Umtamvuna ([164]) is a commonly used synonym.

Zulu meaning

eMtamvuma means the "waters that reap or consume" ([289]).

Location

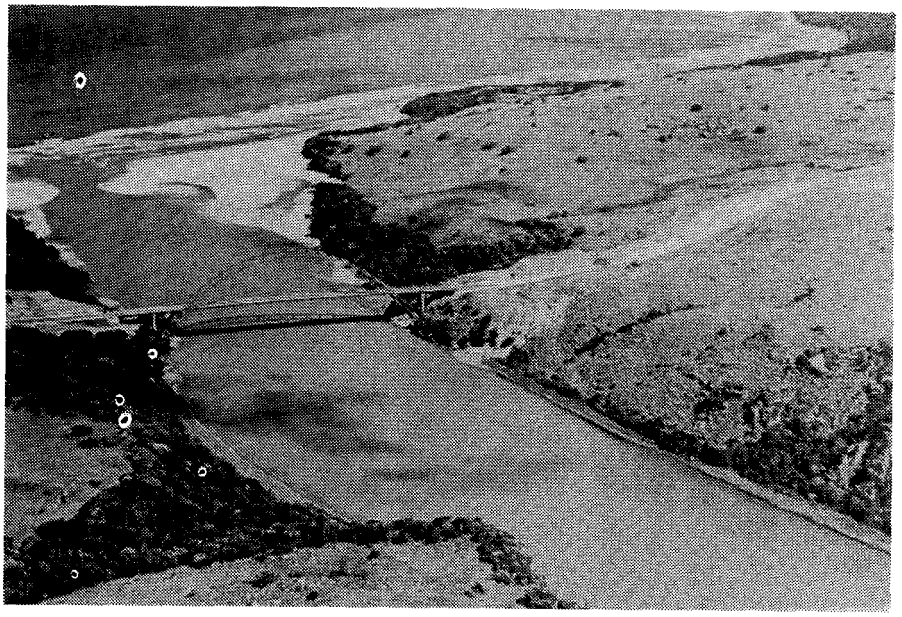
31°4'45"S; 30°11'45"E. The Mtamvuna is the only contiguous estuarine system in Natal, flowing along the boundary separating Natal and the Transkei.

Accessibility

By road the Mtamvuna estuary is 55 km south west of Port Shepstone, and 182 km south west of Durban.

The mouth is accessible by road from the Transkei. The middle reaches of the estuary are accessible using the old road, which originally led to a ferry (or pont) crossing 2,5 km above the mouth.

There is a private airstrip located above the estuary mouth on the northern bank.



An aerial view of the lower reaches of the Mtamvuna estuary. Notice the suspension bridge and the mouth in an atypical northerly position. (A postcard reproduction with the permission of Art Publishers (Pty) Ltd).

Bridges

The national road crosses the estuary on an arched steel suspension bridge (the C. A. Mitchell bridge) which was completed in 1961.

ABIOTIC CHARACTERISTICS

Catchment characteristics

Area. 1 561 km^2 ([223]); 1 580 km^2 ([213]); 1 585 km^2 ([236, 245, 257]); 1 630 km^2 ([164]). Although recorded as 159 km^2 in ([206]), this is presumably a printing error.

River length. 161 km ([206]); 163 km ([245, 257]).

Mean annual run-off. 243 x 10^6 m^3 ([223]) to 319 x 10^6 m^3 ([213]).

Flow. A rough estimate of the average flow in 1970 was 8,5 m^3/sec. ([206]).

Flood history. The 1959 floods are reported to have carried the ferry (or pont) out to sea ([125]). With the estuary being confined within a gorge, it is only in the vicinity of the camp site and caravan park that a flood danger exists. Levels in the estuary naturally rise rapidly if the mouth is closed.

Dams.
Existing: None.
Proposed: (1) The Edwaleni dam site (with a total capacity of 288 x 10^6 m^3) has been located 38 km above the estuary.
(2) The Mission dam site (with a total capacity of 265 x 10^6 m^3) has been located 64 km above the estuary.

Both are dubious in terms of economic viability ([236]).

Siltation. Annual siltation at the Edwaleni dam site has been estimated at 0,76 x 10^6 m^3 ([236]). Both van der Elst and Cooper (pers. comm.) consider the estuary to be severely silted. It is not clear whether mouth closure (see under sandbar characteristics) is a phenomenon related to siltation rates, because certain authorities are adamant that the estuary never used to close. Others maintain that it has always done so, but that the bar is becoming wider and the channel shallower.

Land ownership/use. 78% of the catchment is Bantu influenced, and consequently dominated by subsistence agriculture. 54% of the catchment is in the Transkei.
The land around the estuary is largely undeveloped.
On the northern bank (in Natal) is a holiday resort comprising the "Pont" caravan park; and a camping site (belonging to the Transvaal Teachers Association). The northern bank is zoned as Admiralty Reserve, and public open space. It has been proposed that the environs of the estuary be linked to the Mtamvuna Nature Reserve, and administered by the Natal Parks Board ([189]). The introduction of animals is anticipated once the area has been fenced. Foot and horseback trails are to be developed through the forest areas.
A marine reserve has been proposed on the coast adjacent to the Mtamvuna estuary ([189]).
South of the estuary (in the Transkei) is Mzamba Beach.

Local authority. Port Edward Health Committee.

Estuary uses. The Mtamvuna estuary is considered to be part of a wilderness area ([189]) as well as "a sportsman's paradise" because of its yachting and water skiing potential ([125]). It is attractive for these purposes because the estuary is deep and obstacle free. It has a poor reputation amongst the angling fraternity. The Mtamvuna area is also used for a children's survival course.

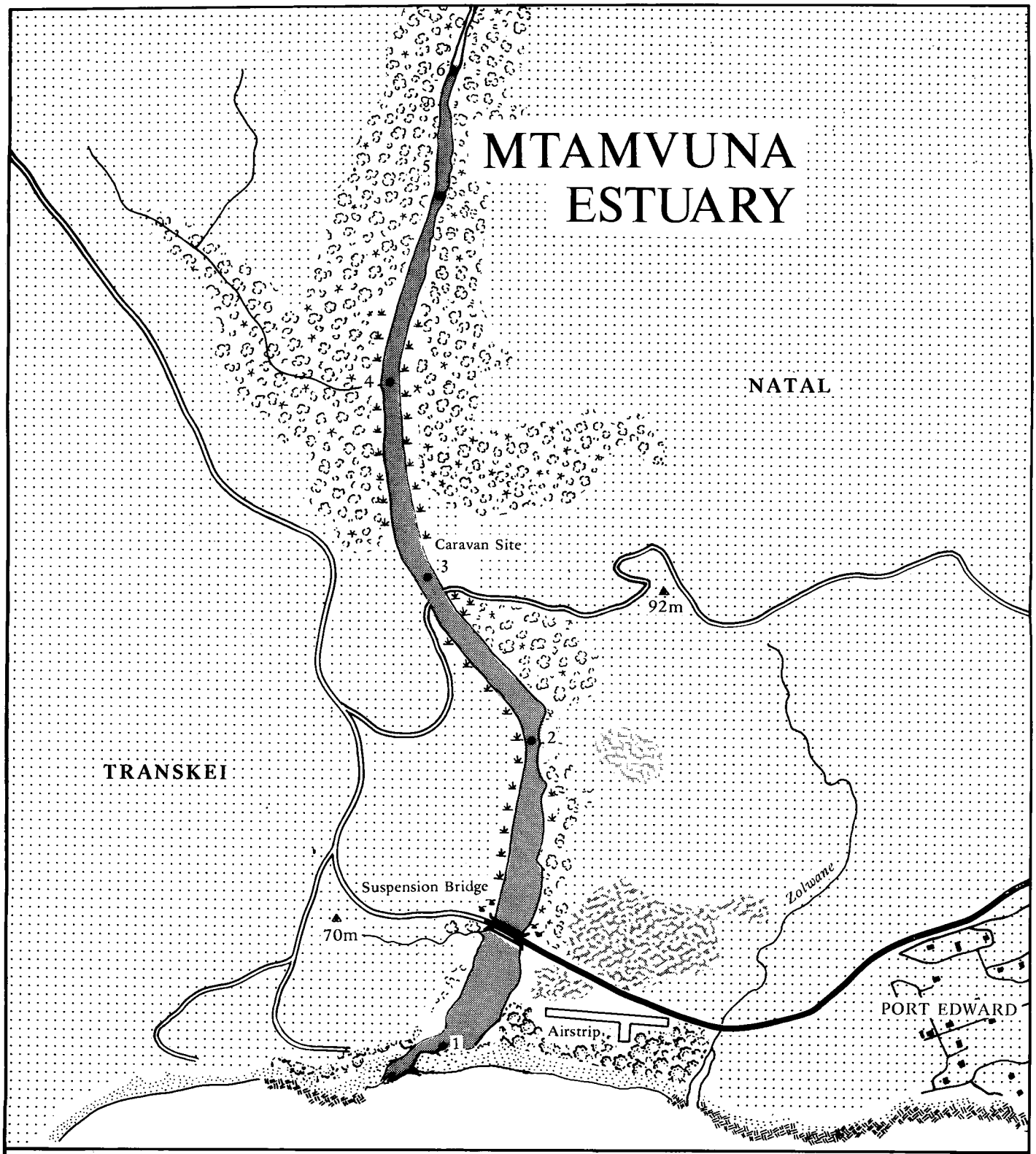
Morphometry of estuary (see Fig. **120**).
Area. The estuary extends to some rapids at Station 6 ([164]). At this point its area is 52,7 ha.

Axial length. 5 km to 5,25 km ([164]).

Shoreline length. 10,3 km

Width.
Maximum: 235 m
Mouth: Normally 25 m but widening considerably during floods.
Floodplain: Being confined between the sides of a steep gorge, there is no floodplain formation alongside the estuary.

Bathymetry. The maximum depth of the estuary at low tide is 10 m beneath the face of some cliffs at Station 5 ([164]). It is interesting that the depths recorded by Hemens *et al* ([164]) in 1972, are considerably greater than those recorded by Day ([117]) in 1950. For example, where Day recorded 1,5 m at Station 3, Hemens *et al* measured 4 m. This may well be due to the scouring action of floods.
Several cross sections of the estuary between the bridge and the mouth have been plotted by NRIO ([239]), and similar profiles above the bridge have been plotted by Hemens *et al* ([164]).



Station Numbers after Hemens et al 1973(164)

Coastal Dune Forest

Coastal Riverine Forest

Reed Swamp

Mangroves

Grassland

Red Deserts

500 0 500 1000 1500 2000 metres

Fig. 120

Geomorphology

Geology. The river traverses rocks of the Ecca and Dwyka series, Table Mountain Sandstone and old granites in its catchment ([245]). The estuary is entrenched between cliffs of Table Mountain quartzitic sandstone ([257]).

A few kilometres south of the estuary are the Mzamba limestone cliffs, comprising an important site for fossilized trees, molluscs and reptiles ([125]).

Overlooking the estuary on the northern bank are the unique "red desert" areas of Natal which are sparsely vegetated, terracotta coloured areas of sandstone ([189]). They are also stone age implement sites, and are recorded as land marks on old nautical charts (Williams, pers. comm.). A Mr Rennie has attempted to gradually revegetate these areas over the years (see under Flora, Section 2.1.13.10).



A view of one of the unique "red deserts" above the Mtamvuna estuary.

Nature of bottom materials. Orme ([257]) maintains that "the estuary is largely filled with fine sand containing frequent lenses of coarser sand and boulders" (see Fig. **121**). These are fluvial materials which have become deposited in the estuary after floods. They are overlain by marine "washover" sand near the mouth. A suspension bridge had to be built over the Mtamvuna because the depth of the sediments was in excess of 80 m. Consequently conventional bridge foundations could not be contemplated.

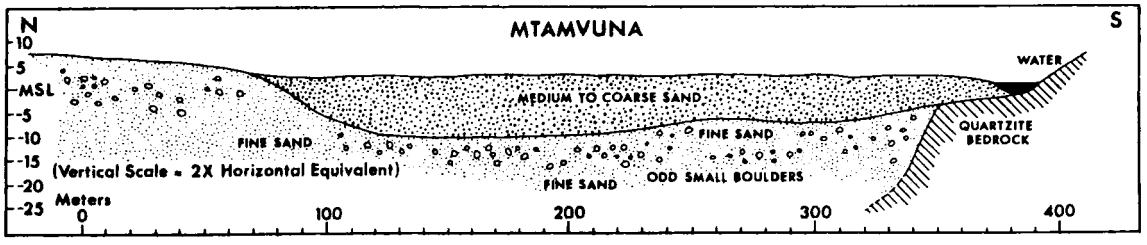


Fig. 121 Cross section through the Mtamvuna estuary at its mouth (after Orme ([257])).

Hemens *et al* ([164]) consider the sediments of the estuary to consist of "fairly homogenous silt, changing to marine sand in the immediate vicinity of the mouth".

Day ([117]) referred to intertidal banks of "very soft, slushy mud" near the old ferry site in the 1950's; and reported that these changed to "narrow mud beaches between rocky bluffs, themselves becoming progressively more sandy and wider nearer the mouth".

Sediment analysis revealed the following characteristics ([164]):—

- significant amounts of organic detritus (i.e. oxygen absorbed values of 14,4 milligrams/gram

dry weight, and 14,6% of the dry weight of the sediment was volatile at 600°C.)

- relatively high levels of phosphorus (148 micrograms/gram);
- relatively high levels of nitrogen (Kjeldahl N=1 660 micrograms/gram); and
- relatively high levels of sulphide (0,91 milligrams/gram);

Such features were attributed to the abnormal depth of the estuary and the incomplete mixing of the bottom water. Extensive bacterial degradation, and the reduction of sea water sulphate to sulphide, is said to occur under the anoxic conditions which occasionally arise.

Hemens *et al* ([164]) consider that the amount of organic detritus indicates that the Mtamvuna sediments are not subject to sorting and movement as in many other estuaries. This implies that the potential to support a rich fauna exists, were it not for periods of oxygen depletion when the mouth is closed.

Sandbar characteristics. Orme ([257]) considers the Mtamvuna sandbar to be a massive south extending feature, composed of medium to coarse sands 13 m deep.

In fact the Mtamvuna sandbar can be anything from 350 m to 700 m long depending on where the mouth is located. The channel normally lies embedded at the southern end, behind a rocky headland which protrudes into the sea. The northern part of the spit appears to be a very stable feature ([239]). Changes generally occur in the southern part where river breakouts cause the channel position to migrate from an extreme southerly position (such as throughout 1973) to a central position (such as during the floods of February 1974). Further details on such migrations, influxes of estuary sand into the surf zone, and the alternating pattern of scour and deposition are given by NRIO ([239]).

Bantu wade across the mouth and use the bar daily as a route to and from the Transkei (Williams, pers. comm.).

Breaching. There are periods when no tidal exchange occurs, i.e. when the bar is closed, isolating the estuary from the sea. An account of opening the bar by digging a channel "to study the effect of opening the mouth on the quality of water in a closed estuary" is given by Hemens *et al* ([164]). On this occasion (7 September 1972) the channel dug at low tide, had eroded to become 12 m wide and 1 m deep overnight, and was of sufficient size to produce a noticeable tidal rise and fall in the estuary.

When water levels in the estuary threaten to inundate the caravan park, the local authority is requested to open the mouth. During winter it may be necessary to do this three or four times a week because the mouth rapidly recloses (de Klerk, pers. comm.).

Configuration of adjacent shore ([132]).

Beach type — sheltered bight, suitable for bathing.

Average beach slope — 5°
Average beach width — 152 m
Average sand grain size — 349 microns
} indicative of moderate surf zone conditions.

Surf zone currents. Rip currents in the vicinity of the estuary mouth are reported as present ([132]). They are strongest at the northern end of the bar ([239]).

Physico-chemical characteristics

According to Hemens *et al* ([164]) physico-chemical conditions in the Mtamvuna estuary are similar to those from unpolluted estuaries such as the Mlalazi, Matigulu and Kosi. A sudden clear cut transition from estuary to river occurs over a 50 m stretch of rapids at Station 6 (see Fig. **120**). Both Kemp *et al* ([206]) and Hemens *et al* ([164]), have studied the physico-chemical characteristics of the Mtamvuna estuary in 1970 and 1972 respectively. The results of both surveys are presented in Table **104**.

Thermal properties. With the mouth closed, fairly well defined thermal stratification is evident 2 m to 3 m below the surface. The average surface temperatures in September 1972, were 18,1°C whilst the average bottom temperatures were 21,3°C (or 3,2°C warmer). However, after the mouth had been open for 3 days, colder water (at 20,5°C) underlay slightly warmer surface water (at 21,1°C).

The surface water temperatures of 29,8°C recorded by Day ([117]) in January 1950, provide some indication of seasonal range.

Table 104. Physico-chemical characteristics.

Mtamvuna estuary	(206) SUMMER Jan 1970	(206) WINTER July 1970	(164) Sept 1972 Surface	(164) Sept 1972 Bottom
Hydrogen ion concentration (pH)	7.33	7.93	7.8	8.2
Saturated pH value	8.60	-	-	-
Conductivity micromhos/cm	1 520	37 200	-	-
Total dissolved solids ppm (calcd.)	1 043	25 920	-	-
Dissolved oxygen mg/litre	8.8	7.8	-	-
% Saturation	101	83	-	-
Oxygen absorbed mg/litre	-	-	1.9	1.5
Biological oxygen demand mg/litre	1.0	0.2	-	-
Kjedahl nitrogen mg/litre	0.2	0.2	0.34	0.20
Ammonia mg/litre	-	-	0.14	0.02
Nitrites mg/litre	0.19	0.11	0.006	0.003
Nitrates "	-	-	0.05	0.03
Phosphates "	0.11	0.06	0.008	0.013
Total alkalinity "	43.6	106	-	-
Total hardness "	207	4 780	-	-
Calcium "	16	316	-	-
Magnesium "	40	968	-	-
Sodium "	325	7 600	-	-
Potassium "	12	300	-	-
Sulphates "	87	1 350	-	-
Chlorides "	518	15 306	-	-
Silica "	-	-	-	-
Iron "	-	-	-	-
Fluorides "	0.2	-	-	-
Free carbonic acid (as ppm carbon dioxide)	-	-	-	-
Temperature °C	-	-	-	-
Turbidity (ppm silica scale)	-	-	-	-
Colour (APHA units)	-	-	-	-
Appearance	-	-	-	-
Odour	-	-	-	-

Water transparency. Very few records are available. Day ([117]) recorded Secchi disc values in 1950 of 175 cm at the ferry site, and 225 cm nearer the mouth. The colour of the water in September 1972 was less than 5 hazen units throughout the estuary ([164]).

Salinity.

With the mouth closed: A very pronounced halocline is evident 2 m to 3 m below the surface ([164]). For example above 2 m, the average salinity was 7,7‰, whilst below 2 m it was 30‰, and below 5 m 33,5‰.

With the mouth open: Marine water passing into the estuary on each incoming tide fills the entire channel to within 1 m to 2 m of the surface. The less saline water remains at the surface and leaves the estuary on the outgoing tides.

A comparison of the 1970 rainy season/dry season results of Kemp *et al* ([206]) (see Table **104**) are of particular interest because of the markedly different salinities (as indicated by chloride, conductivity, etc.).

Dissolved oxygen.

With the mouth closed: Oxygen stratification was evident at the same depth as the halocline (i.e. 2 m to 3 m below the surface) ([164]). This is indicative of a distinct lack of mixing in the deeper, more saline waters of the estuary. Consequently the associated ecological effects of oxygen depletion on demersal biota, become apparent.

With the mouth open: A considerable increase in the amount of oxygen in the deeper water was evident. For example at Station 2, air saturation increased at 5 m from 16% to 77%, and at Station 3 at 3 m from 14% to 72% ([164]).

Public health aspects

Bacteriology. The bacteriological quality of the Mtamvuna estuary is reported to be good. From the data available ([164, 206]) (see Table **105**) evidence of faecal pollution of any consequence is slight. The only sources of faecal pollution which could affect the estuary, are soak pits and septic tanks at the camp site and caravan park opposite Station 3. Organic enrichment is occasionally evident.

Table 105. Bacteriology of the Mtamvuna estuary.

Date	Total Plate Count per ml x 10^3		*E. coli* 1 per 100 ml	*Salmonella* per 250 ml
	I 6 days @ 20°C	II 6 days @ 20°C + 24 hours @ ambient.	Confirmed	
March 1971			130	
July 1971			14	
3 Feb 1972	23	13	300	
21 Feb 1972	140	**300**	150	
3 July 1972	3	**288**		
31 July 1972	780	10		
11 Sept 1972			4	+*
8 Jan 1973	300	**3 200**		

* (Salmonellae were probably not of human origin) ([164]).
Values in bold are significant of disturbance.

Bilharzia. It is highly unlikely that bilharzia transmission occurs in the estuary because of the pronounced marine character over the whole of its length.

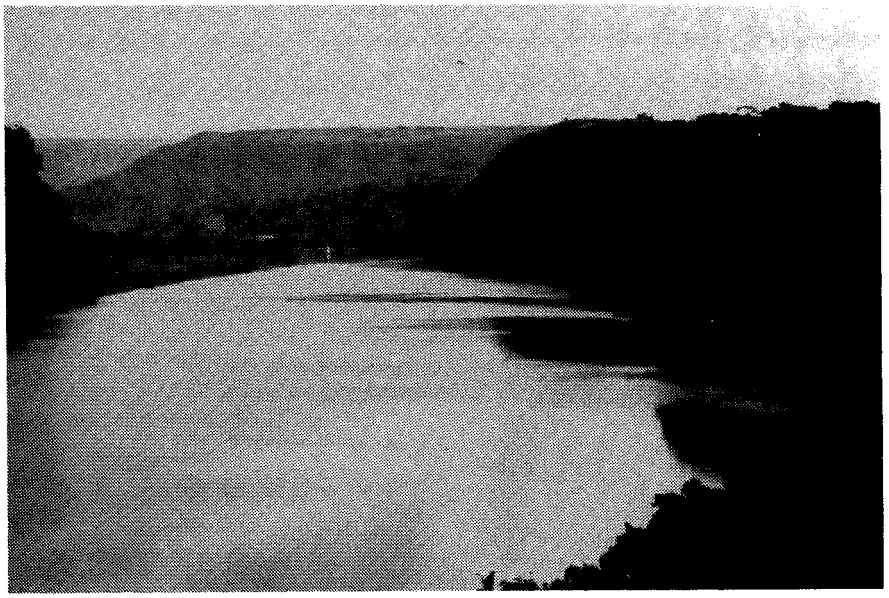
Furthermore, collections in 1972 from a small tributary which enters the estuary opposite Station 4 ([164]) and amongst marginal vegetation 43 km above the estuary at Mpunzi Drift ([206]), did not reveal the presence of bilharzia snails.

BIOTIC CHARACTERISTICS

Flora

The sides of the Mtamvuna gorge are covered in thick indigenous forest. These forests extend above the estuary where they became known as the Mtamvuna Forest Reserve. Attention has been drawn to various species characterizing these forests, such as Umzimbete (*Milletia*), *Commiphora* and *Bauhinias* ([189]).

Floristically the Mtamvuna represents a transitional area where overlap between the Cape Table Mountain Sandstone system and that of Natal occurs. Consequently the proteas amongst grassland communities on the plateau above the estuary, have an understandably wide reputation ([189]).



An impression of the thickly forested sides of the Mtamvuna estuary.

The plant communities of primary interest around the estuary are:

- The fringe of reeds (including *Phragmites* and *Juncus*) which extends along the water's edge and into the inter-tidal zone;
- a mangrove community which Hemens *et al* ([164]) consider to comprise *Avicennia* just upstream of the suspension bridge, but Cooper (pers. comm.) considers to comprise a narrow fringe of *Bruguiera* along both banks;
- the dune forest north of the Mtamvuna mouth; and the
- *Strelitzia*/palm communities amongst the indigenous forest of the northern bank.

The estuary is characterized by the absence of *Barringtonia* ([164]).

In January 1950, Day ([117]) noticed the presence of a "thin mossy algal carpet" (possibly *Chara*?) on the lower mud flats of the Mtamvuna estuary.

Fauna

Lower trophic levels.

Zooplankton: Grindley (pers. comm.) has zooplankton samples from the Mtamvuna estuary (taken in 1968) that have not yet been examined. The copepod *Pseudodiaptomus hessei* was common in 1972 ([164]).

Benthos: In January 1950, Day's attention was drawn to the absence of mudprawns (*Upogebia*), barnacles and live molluscs ([117]). However, in September 1972 (in spite of low oxygen tensions near the floor of the estuary) the average number of benthic animals/litre of sediment was 107 ([164]). In terms of numerical abundance, this figure compares favourably with other estuaries in

Natal. These numbers were made up of 10 estuarine species, the main component of which is the polychaete *Prionospio sexoculata*. This is not the case in other estuaries in Natal. At Station 1, no animal other than this occurred in the sediments. At Station 3, the tanaid crustacean, *Apseudes digitalis* made up 60% of the biomass. Freshwater species (such as gastropod molluscs) can be transported into the estuary, either passively or during floods.

Hemens *et al* ([164]) also reported the presence of 38 animal species (excluding fish), in the marginal vegetation of the Mtamvuna estuary. 80 to 90% of the numbers in September 1972 were made up of an amphipod (*Parorchestia rectipalma*), a copepod, (*Pseudodiaptomus hessei*) and another unidentified diaptomid species.

In 1950, *Parorchestia* was not common ([117]). However six species of crabs and three species of prawns (such as *Penaeus indicus*) which were reported as abundant in 1950, were few in number in 1972 ([164]).

Data on the characteristics and/or composition of the fresh water communities, either immediately above the estuary ([164]), or 43 km above the estuary (at Mpunzi Drift) ([206]) is also available.

Higher trophic levels.

Fish: The rather poorly developed fish community reported by Hemens *et al* ([164]) in 1972 (and attributed to unfavourable oxygen conditions at depth), differed markedly from Day's survey in 1950 ([117]). In the latter case 18 species of fish were revealed, only four of which were shown to be present in 1972. By the same token, nine species present in 1972, such as the flat herring (*Macrura kelee*) were not recorded as present in 1950. On the other hand, the Cape stumpnose (*Rhabdosargus holubi*) and the grunter (*Pomadasys commersoni*) were common in 1950, but absent in 1972. Of the species listed by Day four are not present in Wallace's checklist of fishes recorded in Natal estuaries ([328]). This could be related to the overlap that occurs between the Cape and Natal waters in the vicinity of the Mtamvuna estuary.

An important feature of the survey by Hemens *et al* is that prior to opening the sandbar, only six species of fishes were present in the Mtamvuna estuary. After the bar was purposely breached, contact with the sea resulted in an additional seven species being recorded as present within three days. Predators such as garrick (*Lichia amia*), shad (*Pomatomus saltatrix*) and salmon (*Argyrosomos hololepidotus*) arrived in the estuary soon after the mouth was opened. Consequently the reason for the greater species diversity recorded by Day in 1950, was probably attributable to the mouth condition at the time of sampling.

Sharks have been reported to enter the estuary by de Klerk (pers. comm.).

Birds: A survey of the Mtamvuna estuary in January 1977 by Nicholls (pers. comm.) revealed only three species of estuarine dependent birds, notable amongst which is an osprey. An element of human disturbance (such as water-skiing) does exist, but the steep edge condition is not really suitable for estuarine species of birds. Nevertheless, the forested slopes of the Mtamvuna gorge presumably provide a rich and varied habitat for many other species. The only known nesting colony of Cape vultures in southern Natal, is found on the cliffs of the Mtamvuna gorge ([189]). Fish eagles also nest in the gorge (de Klerk, pers. comm.). Associated with the proteas above the estuary Gurney's sugarbird occurs ([189]).

Mammals: The forested slopes of the Mtamvuna gorge are reported to provide a suitable habitat for mammals such as leopard and blue and grey duiker ([189]).

SYNTHESIS

By present day standards our state of knowledge of the Mtamvuna estuary is good. Further study of the system is warranted so as to maintain an understanding of the system, and to be able to detect change. This is important because by present day standards the Mtamvuna estuary is in a very satisfactory condition and has considerable resource value by virtue of its flora and fauna, and recreational potential. The Mtamvuna estuary should without doubt be protected and retained in its present environmental condition.

Although closure of the mouth has undesirable ecological effects (such as de-oxygenation) it is a relatively minor problem about which little can be done. Otherwise the system is relatively problem free.

ESTUARY/LAGOON	Year (date of information)	Reference number in Text	ABIOTIC																				BIOTIC										
			Physio-graphy	Physics				Geomor-phology			Chemistry					Bacteriology	Other						Flora			Fauna							Food Webs
MTAMVUNA ○ = denotes river survey			Catchment characteristics	Morphology	Hydrology	Density variations	Circulation and mixing	Geology	Paleoenvironment	Sediment transport and deposition	General chemistry	Eutrophication	Trace Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Epifauna	Benthic fauna	Fishes	Birds	Mammals	Reptiles	
Data Voids																						←★→		←★		★		★→			
Source of Information	Summary of available information																																
Day	1950	117		●						●												●		●			●	●				
Midgley & Pitman	1969	223	●		●																												
Kemp *et al*	1970 to 1972	206	●					●			○				○										○								
Fromme	1970 to 1972	132								●																							
Loxton, Hunting & Assoc.	1971	213	●		●																												
Ninham, Shand & Partners	1971	245	●		●			●																									
Orme	1971	257	●					●		●																							
Hemens *et al*	1972	164	●	●	●	●	●				●				●							●		●	●	●	●	●				
NTRPC	1974	236						●		●																							
NRIO	1975	239		●	●					●																							
Dunne	1976	125							●											●	●												
Cloete & Oliff	1976	85	Summary of Hemens *et al* (164)																														
Hopwood	1978	189																		●				●					●	●			
Aerial photos (Scogings)																																	
1:10 000 Job No. 261	1976	406		●																			●										
1:25 000 Job No. 262	1976	439	●	●																			●										

2.2 Present state of knowledge

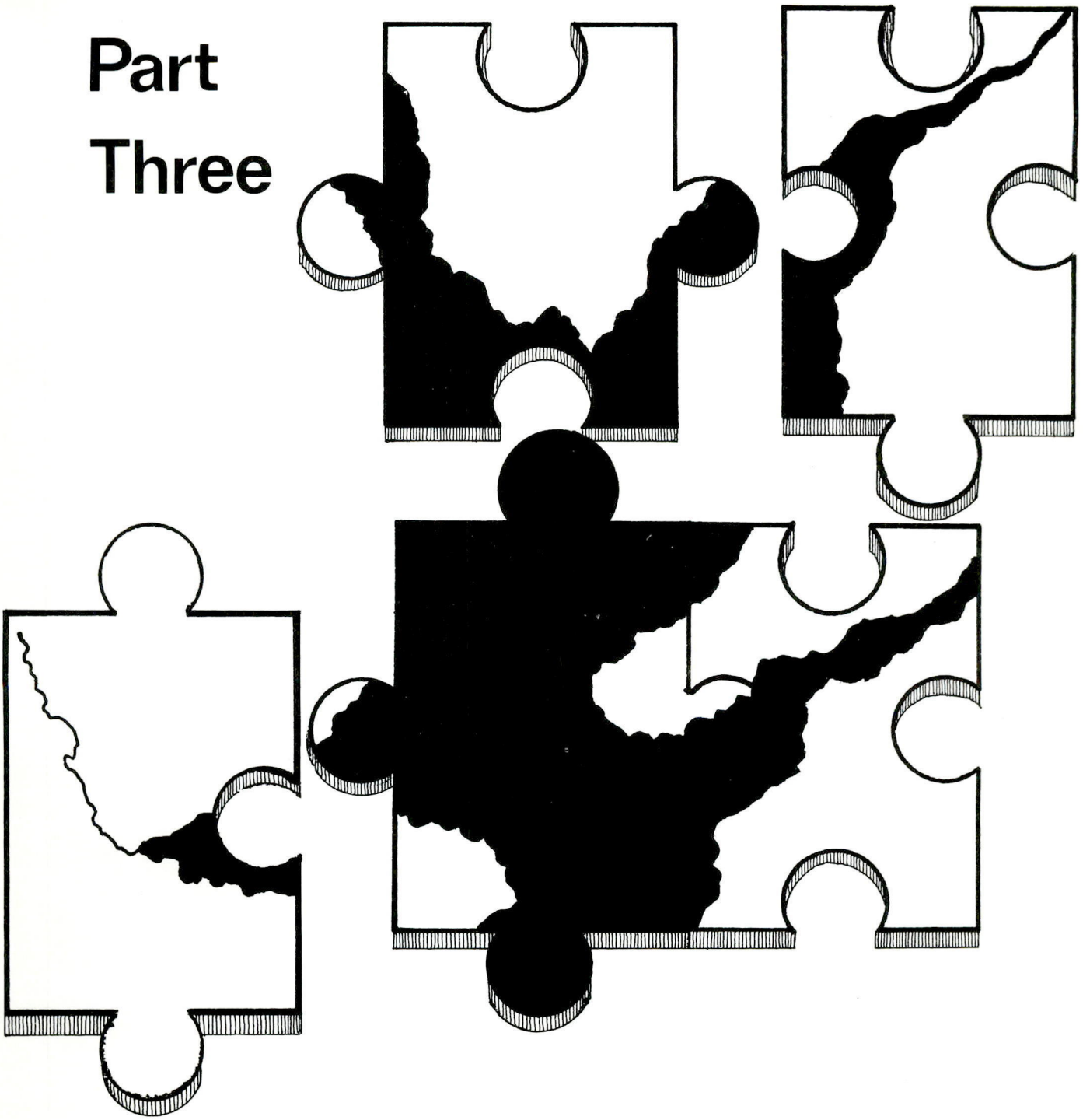
Having now examined our state of knowledge of 73 of Natal's estuaries, Schedule **4** indicates that practically no information is available on 51 of these. Amongst other things the scientist should thus accept that he has neglected Natal's estuaries as much as anyone else. When one reads that, with only two exceptions "all Natal river mouths are characterized by a rocky, south bank and a sandy, south directed spit . . ." ([135]) (when there are in fact at least 16 exceptions); or that "a total of 33 estuaries" lie between St. Lucia and the Transkei border ([328]) (when there are in fact at least 70) or realizes that the presence of some estuaries (such as the Nhlabane) was virtually unknown, one does begin to appreciate that our state of knowledge is indeed poor.

Details of the type of research that requires attention in the future are contained in Section 4.1.

Schedule 4. State of knowledge.

ESTUARY	VERY GOOD	GOOD	FAIR	FAIRLY POOR	POOR	VERY POOR	ESTUARY	VERY GOOD	GOOD	FAIR	FAIRLY POOR	POOR	VERY POOR
Kosi		●					Sezela					●	
Mgobezeleni			●				Mdesingane						●
St. Lucia	●						Fafa		●				
Mfolozi					●		Mvuzi						●
Nhlabane						●	Mtwalume					●	
Richards Bay		●					Mnamfu						●
Mlalazi			●				Kwa Makosi						●
Siyai						●	Mfazazana						●
Matigulu			●				Mhlungwa					●	
Nyoni						●	Mhlabatshane					●	
Tugela					●		Mzumbe					●	
Zinkwasi					●		iNtshambili					●	
Nonoti						●	Koshwana						●
Mdlotane						●	Damba					●	
Mvoti					●		Mhlangamkulu						●
Seteni						●	Mtentweni				●		
Mhlali					●		Mzimkulu			●			
Tongati					●		Mbango						●
Mdloti					●		Boboyi					●	
Mhlanga				●			Zotsha				●		
Mgeni		●					Mhlangeni				●		
Durban Bay				●			Vungu				●		
Sipingo			●				Kongweni						●
Mbokodweni				●			Uvuzana						●
Manzimtoti		●					Bilanhlolo					●	
Little Manzimtoti						●	Mvutshini					●	
Lovu					●		Mbizana					●	
Msimbazi			●				Kaba						●
uMgababa		●					Umhlangankulu		●				
Ngane					●		Mpenjati					●	
Mkomazi					●		Kandandhlovu						●
Mahlongwana						●	Tongazi						●
Mahlongwa					●		Ku-Boboyi						●
Mpambanyoni					●		Sandlundlu						●
Mzimayi						●	Zolwane						●
Mzinto					●		Mtamvuna		●				
Mkumbane						●	Total out of 73	1	8	6	7	25	26

Part Three



a framework of the various parameters that maintain the state of equilibrium in the estuarine environment of Natal

Part 3. A FRAMEWORK OF THE VARIOUS PARAMETERS THAT MAINTAIN A STATE OF EQUILIBRIUM IN THE ESTUARINE ENVIRONMENT OF NATAL.

3.1 The natural forces governing the existence and form of estuaries.

In trying to describe an "ideal" estuary Hedgpeth ([209]) suggested that to do so was like trying to describe a "normal" climate. This is because estuaries are complex systems ([65]), especially in populated areas, where they receive the full impact of man's increasing population and industrialization. The various types of estuaries (identified in Section 1.1) also complicate the task of attempting to describe what makes an estuary work, because each function in entirely different ways.

One generally accepted mechanism by which lagoons or estuaries are formed is through the submergence or emergence of the coastline ([184, 209, 298]). However, the factors which determine whether a particular system develops estuarine or lagoonal characteristics in Natal seem to be run-off and the nature of the drainage basin. Such characteristics are governed by rainfall, catchment size, vegetation types, slope and the erodibility of soils. This does not mean to say that gross geomorphological influences do not exist. The most obvious of these is the fact that the estuaries of southern Natal lie in close proximity to one another but become widely separated in northern Natal.

South of Port Durnford estuary mouths have the marked tendency of becoming deflected north or south at the coast. The principal factor that governs this is wave action.

In Natal the prevailing swell direction is from a south easterly direction ([250]). The net result is that sand is constantly being shifted northwards along the coast, especially in winter and spring. A southerly movement of sediments in the surf zone in summer and autumn has however been detected at certain localities ([242]).

One can scarcely separate the manner in which waves and coastal topography influence the form of estuaries, as the two are intimately associated. Thus, wherever the northward movement of sand referred to, is interfered with or resisted by rocks which protrude into the sea as promontories, an accretion of sand tends to occur to the south of such obstacles. To the north of them erosion occurs, as in the case of a groyne.

Without the protection of rocks to the south of an estuary mouth, Natal's estuaries tend to become deflected northwards behind the barrier of sand which is constantly moved into their mouths by wave action. Thus between the Tugela and Mlalazi, where the transport of sand is uninterrupted by rocky headlands, and the quantities of sand supplied by the Tugela are enormous, all estuaries assume a northerly direction ([257]). There is a marked change south of the Tugela. Estuaries between here and Durban Bay tend to be deflected southwards, but to a lesser extent, because of the much reduced input of sediments. In virtually every case the erosive forces occurring in the lee of rocky headlands, dictate the mouth position. Some headlands even protrude sufficiently far into the sea to diffract the prevailing waves into a more easterly direction (Maud, pers. comm.). Under these conditions the tendency for estuaries to be deflected south is enhanced.

On the south coast of Natal estuaries without rock protection on the southern side are forced northwards until such movement is restricted by rocks. The systems then have no option but to open to the sea at that point. Here the interesting situation can be encountered where estuaries lie within coves, and thus derive protection from rocks on both the southern and northern sides. The mouth position is nevertheless more often than not against the southern bank because of the same erosive forces described above.

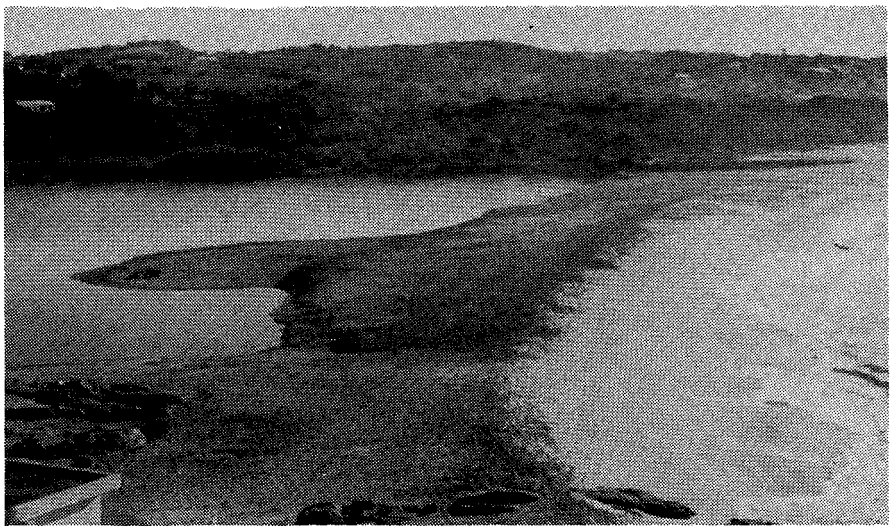
Currents generated opposite estuary mouths play the important role of transporting juvenile animals into the estuary. Currents also ensure that the mouth of the estuary does not close because of their scouring action.

Consequently structures that alter such forces (such as weirs on the Kaba, or tidal pools on the Mbizane) have adverse effects on estuaries.

Physical factors such as these are by far the most influential of processes within an estuary, because of the manner in which they dictate both chemical and biological characteristics.

One of the most important physical factors is the run-off. Run-off can be modified by man so that the quantity of water emanating from a particular drainage basin is either increased or reduced.

If reduced to the extent that flows cease or dwindle, estuarine systems become closed off from the sea. Although this can be a natural phenomenon in times of drought, closure of the mouth in the majority of Natal's estuarine systems has become an artificial norm, so that such systems may have no contact with the sea for months on end.



A closed lagoon denies marine life access into the system (Mbizana 31 August 1977).

Furthermore the lack of contact with the sea often occurs during a most critical time (May to November) when most estuarine dependent species are spawning inshore ([78, 328]). In an undisturbed condition river flows are generally perennial and estuaries either remain open or open very frequently. The converse also holds true, but in either case the implication (i.e. the inability of the estuary to perform a nursery function) is the same.



Transformation of the Mhlangeni lagoon before and after floods.

During times of flood, run-off can transform an estuary from a tranquil environment into one of turmoil. Under such conditions estuaries may become unsuitable as a refuge for juvenile organisms. Flash floods also have the tendency to alter the shape and depth of estuarine systems due to their violent scouring action. However, this is a cyclical event, which has considerable benefits as well as disadvantages. In certain estuaries scouring by floods is important in terms of maintaining its storage capacity, whilst in others scouring has the disadvantage of removing the fine, nutritive bottom materials on the floor of the system.

Run-off also governs many of the chemical characteristics of an estuary. If run-off from agricultural, urban and industrial areas is not waste free, the basic functions of an estuary can be altered. In this case the estuary becomes transformed from a nutrient trap to a pollution sink in which wastes accumulate. This situation can become particularly severe in closed systems, where, without water exchange, pollutants build up to the detriment of estuarine life.



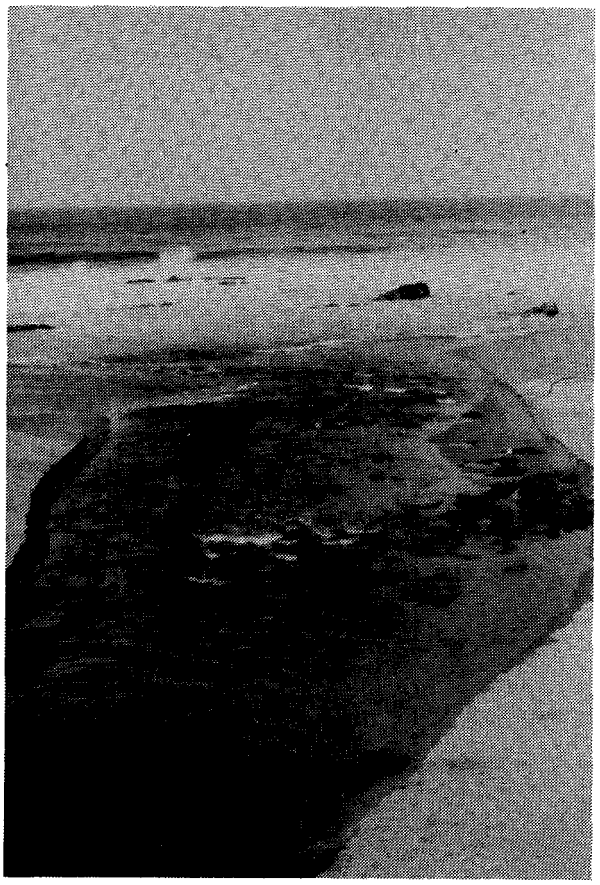
The Mdloti lagoon (on 27 October 1977) beginning to approach a high level. Notice the inundation of peripheral plant communities.

Water levels also play an important part in estuaries. When high levels occur, the extent of an estuary is maximal, the shoreline length fully developed and peripheral plant communities submerged. Under these conditions the system provides maximum opportunity for organisms to seek shelter and food. Falling levels have the important effect of shifting detritus from the periphery of the system to the centre. To be functional however, the system must be of



Many estuaries in Natal have lost their storage capacity so that when they open to the sea, they virtually drain dry. Pictured here is the Manzimtoti lagoon (on 25 March 1977) having just been drained artificially by the work gang at the mouth.

sufficient depth to ensure that even at its lowest level there is enough water to provide nursery conditions. This means that there should be sufficient storage capacity to ensure that at any one time the retention of nutrient, detritus and microbiota within the system is adequate. The retention time is affected by the quantity of inflowing water, the cross sectional area of the estuary mouth, the height of the sandbar and the magnitude of the sea tide. Water levels within an open estuary are normally cyclical in nature and fluctuate with the tide. In a closed lagoon they generally rise gradually, over a long period of time. Different water level regimes such as these dictate the type of plant and animal communities which become established.



Typical rocky sill at the mouth of an estuary (Tongati lagoon 21 May 1978).

Estuaries usually have a natural point of exit which, as described, is generally against a rocky barrier. Rocks at the mouth of an estuary not only dictate the mouth position, but also partially govern the level to which the estuary may fall. They form a sill which ensures that under natural circumstances, estuaries seldom drain themselves, that they become tide dominated, and that periods of exchange with the sea are regular, frequent events.

An estuary must be ensured of a supply of organic detritus which forms the basic ingredient upon which energy flow through the food web depends. Macrophytes within the system and wetland communities such as mangrove swamps, reed swamps, and salt marshes on the periphery are all sources of detritus ([138, 140]) (see Fig. **122**).

Decomposition of the leaf material shed by any of these plants by bacteria and fungi results in a protein rich material upon which a vast spectrum of animal life depends, either directly or indirectly. There is a continuous biochemical storage-release-restorage cycle operative within such a system. Micro-organisms break down the leaf material and primary consumers such as crabs, ingest both micro-organisms and detritus, releasing indigestible remains into the water as faecal material. These are recolonized by micro-organisms and the detritus repeats its role as a carrier of nutrients.

It is through the physical, chemical and biological interactions described above that estuaries irrespective of their type become functional from an ecological point of view. By the same token, disruption of these interactions leads to estuarine degradation in varying degrees.

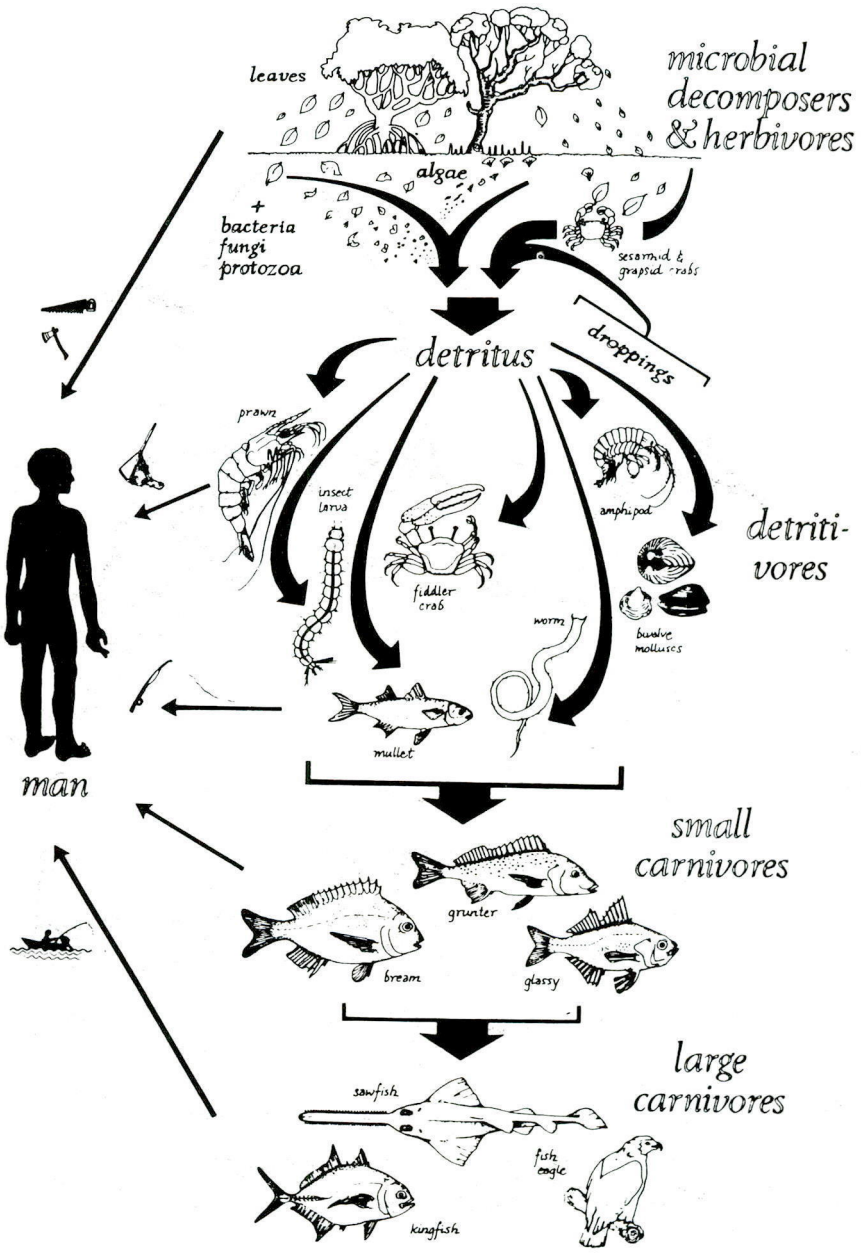


Fig. 122. Trophic interdependence within an estuary: From "In the Mangroves of South Africa" ([30]).

Each of the various components of the estuarine environment (fringing wetlands, nutritive substrates and nursery habitats) and dynamic processes (such as water circulation, nutrient inputs, light penetration, etc.) must all be safeguarded for a system to function satisfactorily as a whole. From such a concept Clark ([83]) has developed nine 'Ecosystem Management Rules'. He warns against:

- the reduction of the natural supply of nutrients by alteration of fresh water inflow;
- the excessive discharge of nitrogenous compounds;
- any significant reduction from the natural concentration of oxygen;
- any significant alteration of the natural temperature regime;
- any significant change from the natural salinity regime;
- the discharge of suspensible solids;
- any reduction or blockage of water flow;
- any discharge of pathogens or toxic substances, and
- recommends that storage components (such as marshes) be protected.

3.2. **Estuarine problems**

The insidious process of estuarine degradation has been likened by Thompson [294] to the process of going bald, in that "a few falling hairs every day go unnoticed until suddenly there is a large barren spot". Before long the question is asked "what is happening to our estuaries?", or, "how have human activities affected the natural processes operative in estuaries beyond their normal range in variation?"

Schedule 5. Estuary impacts.

ESTUARY	URBAN	AGRICULTURE	INDUSTRY	TRANSPORT	ESTUARY	URBAN	AGRICULTURE	INDUSTRY	TRANSPORT
Kosi					Sezela		●	●	
Mgobezeleni				●	Mdesingane		□		
St. Lucia		●			Fafa	□	●		
Mfolozi		●			Mvuzi		□		●
Nhlabane			●		Mtwalume		●		●
Richards Bay		●	●	●	Mnamfu		□		●
Mlalazi		●			Kwa Makosi		□		◑
Siyai		●			Mfazazana		□		
Matigulu		●			Mhlungwa		●		●
Nyoni		□			Mhlabatshane		●		
Tugela		●	●		Mzumbe		●		●
Zinkwasi		●			iNtshambili		□		
Nonoti		●	●		Koshwana	●	□		
Mdlotane		□			Damba		□		
Mvoti		●	●		Mhlangamkulu		□		
Seteni		●			Mtentweni		●		
Mhlali		●			Mzimkulu		●	●	●
Tongati		●	●		Mbango			□	
Mdloti		●	●	●	Boboyi		□		
Mhlanga		●		●	Zotsha		□		●
Mgeni	●	●	●	●	Mhlangeni	●	●		
Durban Bay	●		●	●	Vungu				
Sipingo		●	●	●	Kongweni	●			
Mbokodweni		●	●		Uvuzana		●		
Manzimtoti	●	●		●	Bilanhlolo	●	□		
Little Manzimtoti	●	□		●	Mvutshini				
Lovu		●	●	●	Mbizana		●		
Msimbazi		●		●	Kaba	□	●		
uMgababa		●		●	Umhlangankulu	●	●		
Ngane		●			Mpenjati		●		
Mkomazi		●	●	●	Kandandhlovu		□		
Mahlongwana				□	Tongazi				
Mahlongwa		●			Ku-Boboyi		●		
Mpambanyoni	●	●	●	●	Sandlundlu		●		
Mzimayi		●			Zolwane				
Mzinto		●		●	Mtamvuna				
Mkumbane		●			Total (severe):	10	45	16	23

● = Severe
□ = Less severe

Estuarine problems have been appraised in two ways: The first of these is by attempting to identify whether estuarine degradation can be attributable to one or more of four impacts — namely agriculture, industry, transportation or urbanization (see Schedule **5**).

In this manner, it can be seen that 45 out of 73 estuaries in Natal reflect the influence of agricultural impacts, despite the fact that Serfontein ([277]) considers that "farming practices do not have a very important direct effect on the coast". In 23 estuaries impacts can be attributed to the development of transportation, in the form of harbours, airports, roads and railways. In 16 of Natal's estuaries industrial impacts, and in 10 cases urban impacts were detectable.

The second of these ways is by trying to be more specific about the actual causes of estuarine degradation in each system (see Schedule **6**).

Schedules **5** and **6** are not meant to give the impression that nothing may be altered without upsetting an estuary, but they do illustrate that:

(a) Only three out of 73 estuaries in Natal are problem free. In each case these are tiny lagoons on the South coast that seem to have escaped the "balding process". However, it must be emphasized that with inadequate knowledge about 51 out of 73 estuaries (Section 2.2; see Schedule **4**, estuarine problems have remained concealed.
(b) The impoverished fauna of Natal's estuaries is principally due to INDIRECT impacts (through habitat degradation) rather than DIRECT impacts (such as overfishing, poaching, bait collection, etc.). All too often attention is given to developing means of preventing direct impacts rather than preventing indirect impacts. The latter are by far the most devastating, and most difficult to prevent.

3.2.1. **Siltation.**

Siltation has had a greater detrimental effect on Natal's estuaries than any other single factor. At least 45 out of 73 estuaries show deterioration through incoming silt and sand. This is hardly surprising as soil erosion in Natal has always been recognized as an extremely serious problem ([139, 236, 325]).

With Natal being 'tilted' in such a way that the land rises to altitudes of over 3 000 m above sea level within 130 km to 300 km of the coast ([316]), gradients are steep, and the terrain is conducive to substantial natural erosion. Water has shaped the land into its present form and rivers are still in the process of actively cutting and transporting materials to the sea ([170]). However this process has become grossly accelerated by man. Present day mechanical erosion has been estimated to average 50 to 60 tons/km^2/year ([175]).

Although attention has been drawn to the undeniably serious state of soil erosion in Bantu reserves ([236]), estuaries (such as the Mzinto, the Mhlali or Zinkwasi) with no Bantu reserves in the drainage basin, still reflect serious degrees of siltation. In each case the catchment areas are almost entirely utilized for the production of sugar cane.

In Bantu reserves the lack of contoured lands, over-stocking and veld burning have been identified as the principle causes of soil erosion ([236]). Consequently it has been argued that the reasons for siltation "are basically those of land mismanagement, not hydrological ones" ([236]). Maud (pers. comm.) is of the opinion that siltation is caused by periodic catastrophic floods such as in 1959. However a matter which seems to have received too little attention is water control ([83, 136, 276, 347]).

It has been pointed out by Scott and Fisher ([276]) that "if water can be so controlled that it takes time to reach the rivers instead of being thrown off the land as soon as possible, less silt will be removed, soil conservation will be achieved and water resources will re-develop". This statement has great implications.

Soil conservation has failed in many parts of Natal for various reasons, one of which is because water falling on the land is permitted to run-off in such a way that its velocity increases. By doubling the water velocity the soil carrying capacity of the water increases over 30 times (Gray, pers. comm.). It is important to realize that the converse is also true. If water velocities are halved, the soil carrying capacity can be decreased over 30 times.

In Gray's opinion water control "is the reverse of the normal soil conservation procedures advocated the world over in that instead of concentrating the run-off water into waterways, it is dispersed evenly over the whole landscape, both ridge and valley" ([136]). He emphasizes that it means "using rainfall where it falls, controlling surface run-off, reducing evaporation losses from water and soil, increasing both the depth and fertility of soils and maximizing production per unit of water consumed."

In Australia this lesson has been well learnt ([347, 348]) where, by concentrating run-off, the consequences have been floods, erosion and periods of drought. Cronin ([209]) also emphasizes

Schedule 6. Specific Estuarine Problems.

○ Past
● Present
* Future
? Probable

Estuary	Incoming Silt or Sand	Dredging activity	Drainage diversions	Embankments	Breaching	Impoundment	Water area losses	Cropland pollution	Industrial pollution	Pesticide pollution	Nutrient enrichment	Faecal pollution	Disruption of wetlands	Disruption of riverine vegetation
Kosi	●		?							●			?	
Mgobezeleni					●	○							●	
St. Lucia	●	●	●										●	●
Mfolozi	●		●	●				●	●				●	
Nhlabane	*					●	●							
Richards Bay	●	●	●	●			●	●	●				●	●
Mlalazi	●	○		●									●	
Siyai	●		?				●	?					●	●
Matigulu	●													
Nyoni	●													
Tugela	●								●					
Zinkwasi	●				●		●	●				●	●	●
Nonoti	●				●			●	○		●		●	
Mdlotane					●			●				?		
Mvoti	●				?			●	●				●	●
Seteni	●							?						
Mhlali	●				?								●	
Tongati	●		*	●			●	?	●			●		●
Mdloti	●			●	●		●		●				●	●
Mhlanga	●		●	●	●		●					●	●	●
Mgeni	●					○		●				●	●	
Durban Bay		●					●		●			?	●	
Sipingo	●	○	●				●	?	●		●	?	●	
Mbokodweni	●		●		●				●			●	●	●
Manzimtoti	●	○			●						●	○ ●	●	●
Little Manzimtoti	●	○	●			●						●		
Lovu	●		●	●			●	●	●			?	●	●
Msimbazi			*	●	○		*						*	●
uMgababa	○		*	●			?						*	
Ngane	●							●				?	*	
Mkomazi	●			●	?				●				* ●	
Mahlongwana													●	
Mahlongwa	●		?		●		●	?					●	●
Mpambanyoni	●			●			●		○				●	●
Mzimayi	●							?				?		
Mzinto	●			●	●		●	●	○	●			●	●
Mkumbane	●							?				?		

Estuary	Incoming Silt or Sand	Dredging activity	Drainage diversions	Embankments	Breaching	Impoundment	Water area losses	Cropland pollution	Industrial pollution	Pesticide pollution	Nutrient enrichment	Faecal pollution	Disruption of wetlands	Disruption of riverine vegetation
Sezela					●			●	●		●			
Mdesingane	*					●		?						
Fafa	●				●	●					*	●		
Mvuzi	?			●										
Mtwalume	●			●			●	?					●	
Mnamfu	?			●									●	
Kwa Makosi	?			●										
Mfazazana	?													
Mhlungwa	●			●										
Mhlabatshane	●											?		
Mzumbe	●			●			●							
iNtshambili	?													
Koshwana	?										?	●		
Damba	?			●							?			
Mhlangamkulu	?													
Mtentweni	●				○								*	
Mzimkulu	●			●	●							?	●	
Mbango														
Boboyi	?													
Zotsha	?			●										
Mhlangeni	●				●							●	●	
Vungu												?		
Kongweni					●							●	●	●
Uvuzana	●													
Bilanhlolo	?				●							?		
Mvutshini														
Mbizana	●				●									●
Kaba	●					●								
Umhlangankulu	●	●			?									
Mpenjati	●	●												
Kandandhlovu	?													
Tongazi														
Ku-Boboyi	●				?			?						●
Sandlundlu	●	*			●		●				?			
Zolwane														
Mtamvuna					●									
Total out of 73	45	5	9	21	19	5	16	11	13	2	4	11	28	18

that activities which "decrease the insoak and subsurface retention . . . increase flooding in high-flow periods and increase drought in low-flow periods".

The Commission of Enquiry into Agriculture ([284]) also concluded that it has become important ". . . to establish and develop conditions retaining the run-off of rain water as much as possible, increasing infiltration into the soil and converting floods from heavy downpours into perennial streams". Thus the concept is not new to South Africa **but does need to become implemented.** For example the South African Sugar Association may well advise and assist farmers to plan farmlands hydrologically but as a service organisation cannot insist that they do so.



At any one time there are ±35 000 ha of land in the sugar belt of Natal which are vulnerable to erosion through direct exposure to rain. ((S.A.S.A.) — pers. comm.). comm.).



The modification of flow from streams is well exemplified by this photo of a tributary above the Mdesingane lagoon (24 May 1977).

Among other ways, water is concentrated by "herring bone" and piped drainage schemes, by poorly designed waterways and roads, by exposing bare land, by not strip cropping, by burning trash, by soil compaction, and by denuding the terrain of natural vegetation. Factors such as these not only accelerate run-off but also reduce infiltration. The latter results in a cessation of winter flow, which itself can be aggravated by swamp drainage, irrigation, dam construction and afforestation schemes.

Fig. **123** has been compiled to illustrate specifically how some of the factors mentioned above interact, and bring about estuarine degradation. Sugar production is used as an example because of its predominance in the coastal lowlands and consequent proximity to estuaries, and because there is a need to illustrate that it is not the Bantu Reserves alone that are silt sources within the Province. There are other silt generating factors which can be woven into this figure such as freeway construction or overstocking and the agricultural subsistence practised in Bantu Reserves.

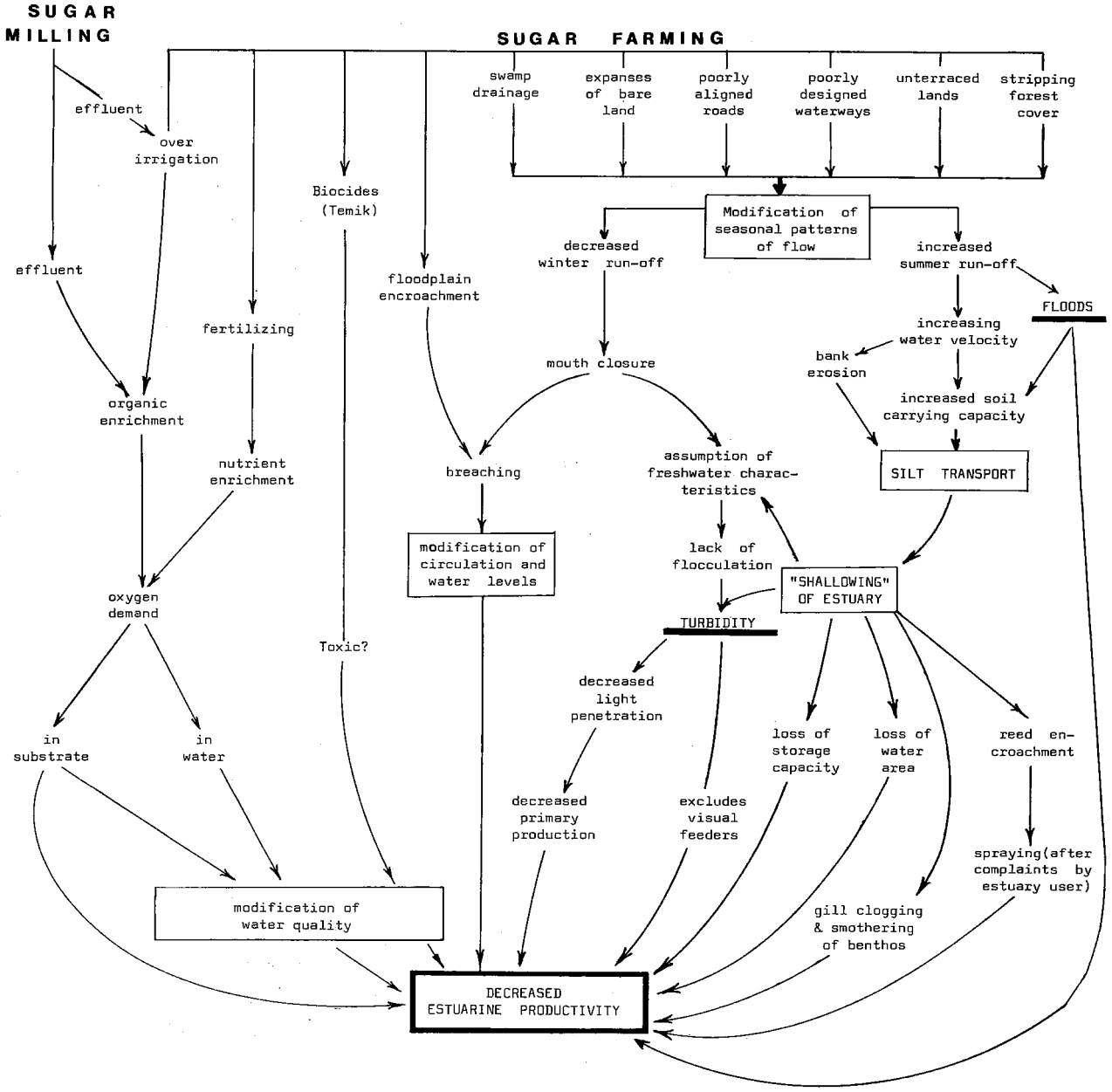


Figure 123. Impact of the Sugar Industry on Estuaries in Natal.

3.2.2 **Cessation of winter flow**

The cessation of winter flow must feature as the second most serious estuarine problem in Natal. This is because it leads to mouth closure, which means that marine life is denied the opportunity of gaining entry into the system. Furthermore fresh water is often regarded as containing a variety of clues which enable migratory organisms to find their way into estuaries ([283]). The lack of such 'clues' in the months of estuarine recruitment due to mouth closure may play an important part in accounting for the apparent scarcity of juvenile organisms in Natal's estuaries.

It is highly significant that while the alteration of drainage patterns (or an imbalance in flow) has been recognized as one of St. Lucia's problems ([35, 92, 194]), it has not been recognized as the probable common denominator behind estuarine degradation throughout Natal.

McHugh ([216]) concludes that in terms of the management of estuaries "reduced run-off could be the most crippling blow", and Clark ([83]) emphasizes that "modifying run-off patterns and thereby reducing the capabilities of land to store and regularize the release of rain water from the watershed" entails a high potential for adverse effects on estuarine systems. Water control (or lack thereof) once again features as the underlying theme on both instances.

3.2.3 **Floodplain encroachment**

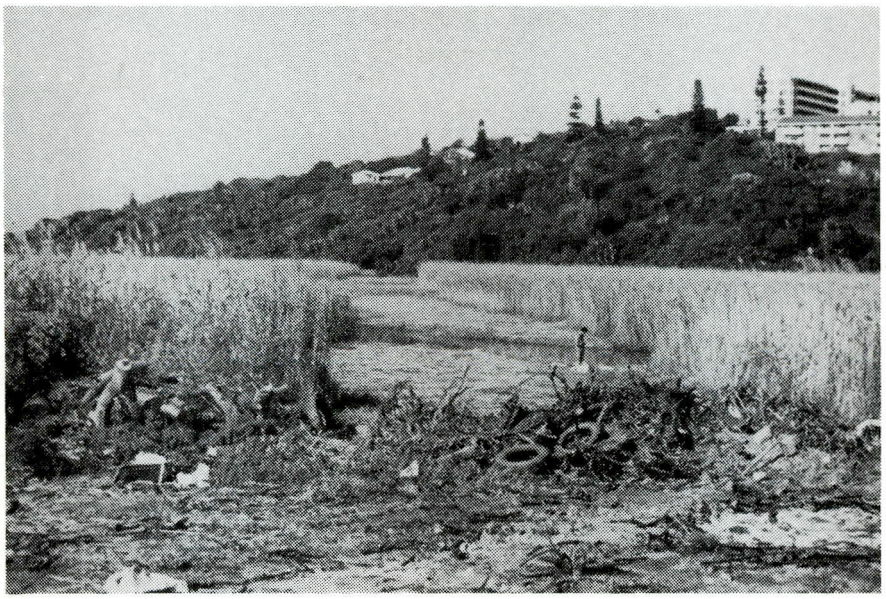
Some form of floodplain encroachment can be detected alongside at least 28 of Natal's estuaries. This encroachment generally results in silt deposition, the interruption of "marsh functions", (for significance see 3.1) and breaching (elaborated upon under 3.2.4).

Its most common form is agricultural encroachment — the floodplain having good potential because of the alluvium from which it is formed and because of the ease of mechanization. Because sugar cane comprises 93% of the agricultural products from the coastal lowlands ([122, 285]) it is this crop which, more often than not, is planted in such areas. Once a cash crop has been established on the floodplain in the vicinity of an estuary there is an economic incentive to ensure that water levels within the estuary do not flood the crop. The earliest records of lagoon breaching because of the effect lagoon levels had on sugar cane date back to 1912 ([333]).

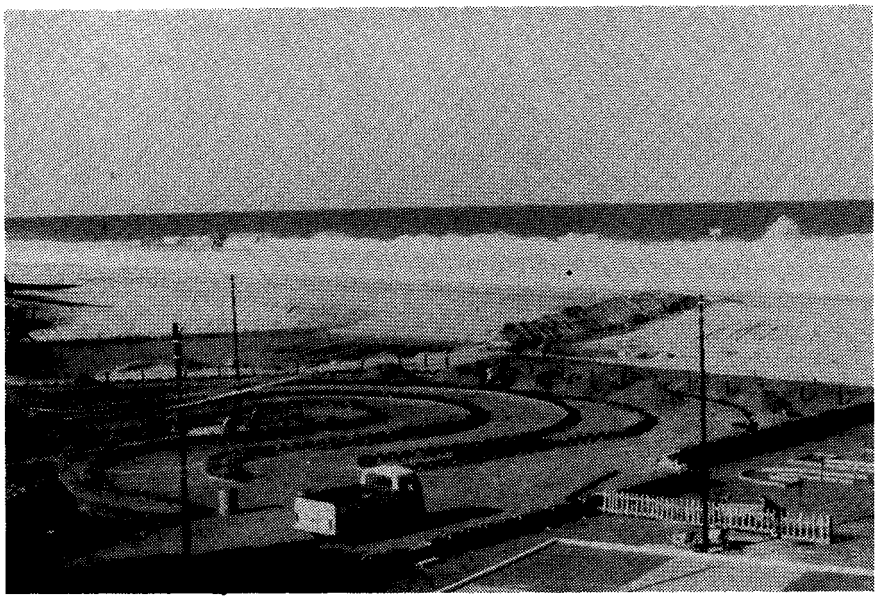
However, degradation of floodplains has not been brought about only by sugar farming. Floodplains alongside estuaries have been used for:

- sportsfields (Little Manzimtoti)
- golf courses (Mbokodweni, Mzimkulu)
- shooting ranges (Mgeni and one proposed on Lovu)
- subsistence lands (Mzimayi)
- municipal rubbish dumps (Lovu)
- amusement parks (Kongweni)
- parade grounds (proposed on Lovu)
- railways and roads (in too many instances to mention)
- spoil deposition (Mlalazi).
- township development (Sipingo)
- and caravan parks (Fafa).

Irrespective of what form it takes, flooding then becomes unacceptable in areas where this should occur naturally. The situation leads to the artificial control of water levels (see under 3.2.4).



A municipal rubbish dump on the floodplain of the Lovu estuary.

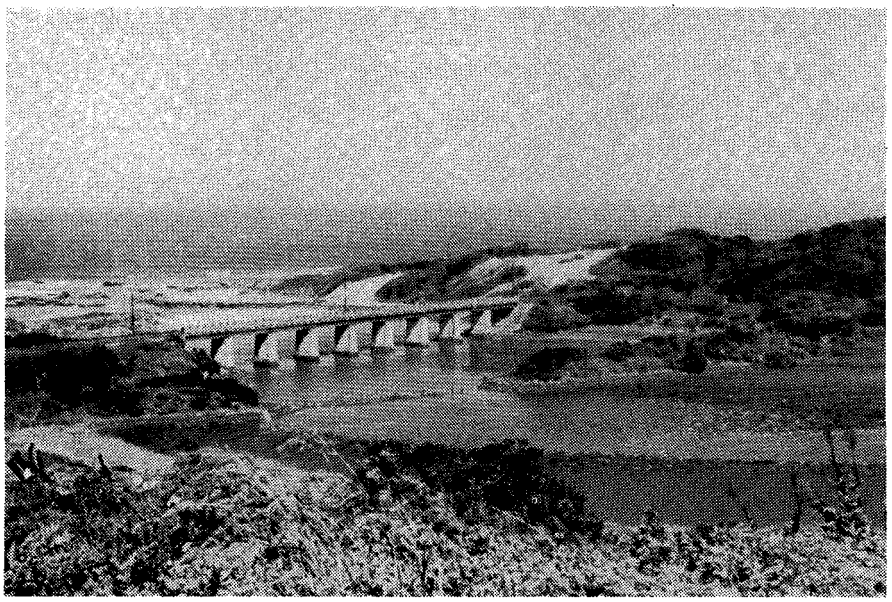


A go-cart track on the floodplain of the Kongweni lagoon at Margate. Continuing beyond the bottom right hand corner of the photograph is a putt-putt course and swimming pool.

The most serious form of floodplain encroachment is the drainage and infilling of swamps for human usage (evident on the Mfolozi, Mhlatuze and elsewhere). These fulfil the role of reducing water velocities when rivers are in flood. They trap silt, and because of their sponge properties release water during the dry season. Once by-passed (by canalization) or reclaimed for farming, very serious siltation results.

Embankments for railway and road networks across floodplains, constitute another form of floodplain encroachment, which is detectable in 21 estuaries in Natal. When embankments (or solid causeways) are built across the floodplain they can lead to:

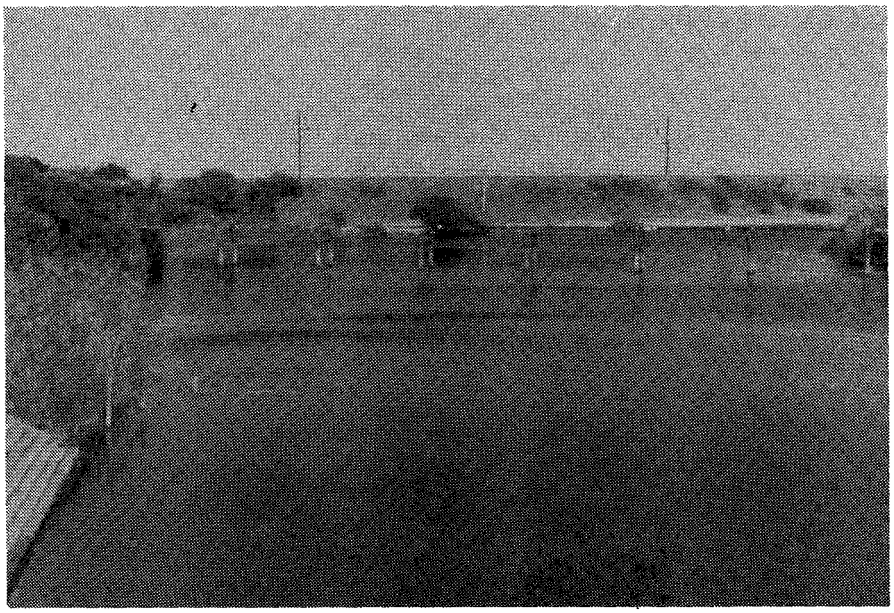
- reduced tidal exchange ([140]) (Mgobezeleni);
- a damming effect upon flood waters which leads to siltation ([141]), and in turn results in losses of storage capacity and water area (Mzumbe);
- reduced scour (i.e. a natural self deepening process associated with floods (Lovu);
- instability in the mouth position (Mtwalume).



Causeways thrown across the entrance to the uMgababa lagoon have severely throttled the system and greatly enhanced siltation.

The problem is caused by the corridors for road and rail communications being located too near to the coast because cost-benefit studies have shown this to be the only sensible corridor to use ([267]). Having become aware of this in the United States of America, 27 kms of a particular State highway was elevated upon pilings to prevent the alteration of flows from a wetland system ([83]). The need to design and construct bridges on an open span basis should become an accepted practice throughout coastal areas.

The utilization of sandbars for the purpose of carrying a railway line is not advisable, as the bars then have to become artificially stabilized. This amounts to the same thing as building embankments across floodplains.



The Mtentweni sandbar has become raised and reinforced to carry the railway line. This amounts to the same thing as building an embankment across a floodplain. Notice too, the disused remains of the old railway bridge in the foreground.

The situation worsens when, after repositioning a railway line (as implemented on the South coast in the 1940's) the unused remains of the old railway lines are left abandoned in the bed of the estuary. These structures unnecessarily add to the effects already mentioned. They should be removed once redundant.



Freeway construction throughout the coastal lowlands of Natal has considerable estuarine implications.

Increased development and population growth in coastal areas have resulted in increased traffic flows. With this has arisen the need for bigger and better communications. Both north and south of Durban, freeways are being built just inland of the existing national road. In many instances (e.g. Msimbazi, uMgababa, Mhlanga) they have estuarine implications; through silt being generated during construction, through river and estuary diversions, infilling and by constricting river courses through floodplains.

3.2.4 **Breaching**

Problems relating to the artificial control of water levels by breaching were identified in 19 of Natal's estuarine systems.

The reasons for doing so are listed below:

- to prevent the golf course from becoming swampy (Mhlangeni, Mzimkulu);
- to prevent the inundation of septic tanks (Mhlangeni, Bilanhlolo);
- to prevent the malfunctioning of storm water drains (Mhlangeni);
- to protect recreational facilities (such as a go-cart track and swimming pool alongside the Kongweni);
- to protect the dune forest (Mgobezeleni);
- to prevent the inundation of access roads (Mgobezeleni, Msimbazi, Sandlundlu);
- to prevent lawns from being inundated (Bilanhlolo);
- to prevent the inundation of sugar cane (Mdloti, Nonoti, Mhlanga, Msimbazi, etc.);
- to prevent the inundation of vegetables (Mtentweni);
- to permit the access of fish (Nhlabane);
- to prevent inundation of a footbridge (Bilanhlolo);
- to flatten the beach profile to improve bathing (Mbizane);
- to flush the lagoon after it has become smelly (Zinkwasi, Manzimtoti, Sandlundlu Mahlongwa);
- to repair pump intakes (Sezela);
- to permit more direct access to the sea for ski-boats (Mkomazi);
- to prevent the flooding of a caravan park (Mtamvuna);
- for scientific interest (Mtamvuna); and
- in the interests of good fun (Mbizane).

Breaching has become an estuarine problem in many of these instances because of floodplain encroachment (see 3.2.3). Channels are normally dug through the sandbar across the shortest point, separating the lagoon from the sea. The channel that develops becomes so deep that it virtually drains the lagoon completely. This is desirable from the point of view of the person who had gone to all the trouble of digging the channel (because it takes that much longer before it has to be done again) — but it is not desirable from an ecological point of view. The necessity of permitting water levels to rise and fall normally in estuarine systems has been discussed elsewhere (see Sect. 3.1).



A breach made by farmers on the Mdloti lagoon (March 1977) to prevent the inundation of sugar cane (photo by C. Sheppard).

Furthermore estuarine systems have a natural point of exit, and due consideration thereof should be given before artificially opening a lagoon, if for one reason or another, it is deemed essential. In principle however, the practice should not be permitted.

3.2.5 **Bank-binding riverine vegetation**

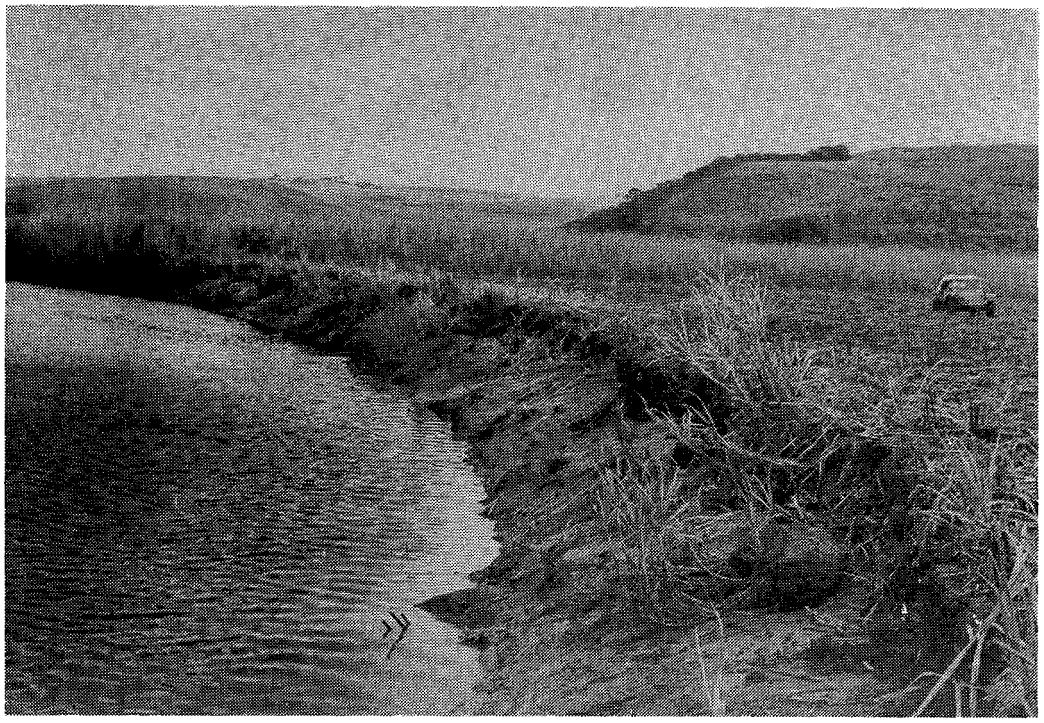
The destruction of bank-binding riverine vegetation has already been referred to as a silt generating problem. It has partly attributed to estuarine degradation in 18 of Natal's estuaries.

In the majority of cases this has occurred because of the encroachment of sugar cane onto the edges of rivers. On the coastal lowlands of Natal the Soil Conservation Act of 1969 has been ignored in many places ([178, 325, 333]). This states that:

- "Vleis, marshes, water courses, and water sponges shall not be ploughed, cultivated or drained;
- No land shall be ploughed or cultivated and no vegetation, (excepting proclaimed weeds and other noxious plants) shall be destroyed, within 10 m of the edges or banks of rivers, brooks, springs, vleis, marshes, etc. ."

Encroachment upon such places probably accelerated in 1963, when quota restrictions were lifted and the sugar industry launched a massive expansion programme. However, official complaints about "ploughing up to the edges of rivers" date back to 1948 ([301]). Despite the vulnerability of the crop itself in such situations, it is appalling to see that nothing has been done about the matter for 30 years.

The consequences of siltation (in this case through bank erosion) have already been elaborated upon (see Fig **123** in Section 3.2.1). Although the cane farmer may be reluctant to do so, sugar cane should be withdrawn from the edges of rivers, and natural vegetation re-established in its place.



Bank erosion as a result of the encroachment of sugar cane onto the edges of the Mhlanga lagoon (photo by R. van der Elst).

3.2.6 **Water area losses.**

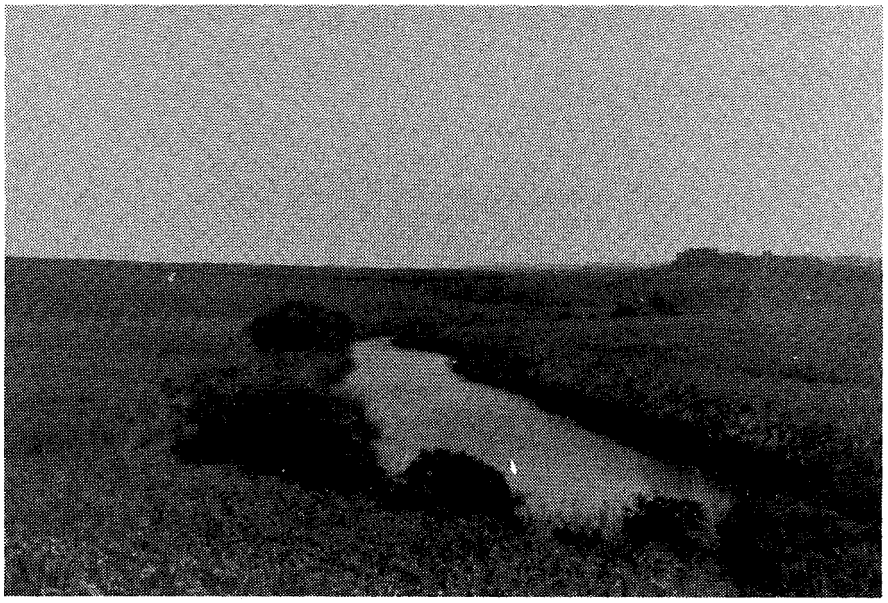
Water area losses feature as a problem which is detectable in 16 of Natal's estuaries.

Water area losses arise principally through siltation, a classical example of which is the Richards Bay sanctuary area. However, whether they are a direct result of run-off, swamp destruction or embankment construction, losses in the extent of the estuary cannot be tolerated, because without water the system loses its ecological function.

Water area losses are due to other causes. For example where the Nhlabane was formerly an estuarine system 120 ha in extent, it has become reduced to 17 ha by barrage construction.



Believe it or not, this is a photograph of the Mbati river in Zululand . . . and yet the Soil Conservation Act states that no land shall be ploughed and no vegetation destroyed within 10 m of the edge of rivers.



The Zinkwasi river has almost suffered the same fate, whilst its tributaries have already done so.

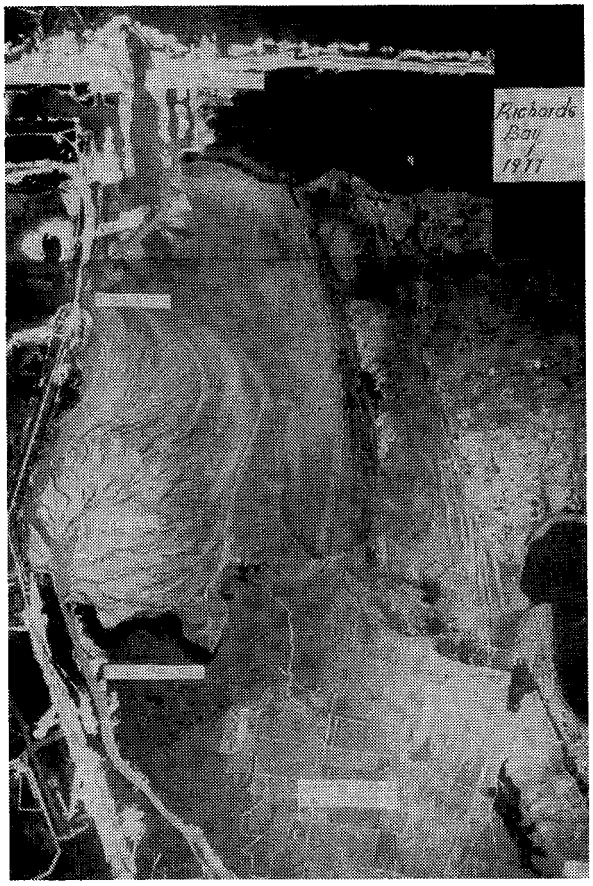
3.2.7 **Pollution**

Records of lagoon pollution date back to before 1909. One such record, (in a Mercury Pictorial dated October 28, 1909) reads as follows:

> "For years past it has been the custom of sugar mills to discharge dunder into the nearest stream. Most, if not all, of the coast streams end in a lagoon which is landlocked for part of the year. The dunder is fatal to fish and when the first rains come the stream becomes so polluted that the fish in the river and lagoon die in tens of thousands".

This situation is still occurring 70 years later.

Thus, it is surprising to find statements being made to the effect that "estuarine pollution is not common along the Natal coast, due to the lack of urban and industrial development or to the use of marine outfall sewers" ([148]).



Siltation of the Richards Bay sanctuary area has resulted in tremendous losses of water area (photo by Air Survey Company of Africa (Pty) Ltd).



The Sezela lagoon is the most polluted estuarine system in Natal.

This statement is difficult to accept because the main centres of urban and industrial development in Natal are in the coastal lowlands. One glance at Fig. 7 in the "Three Rivers Region" water quality report ([43]), will reveal that in the lower reaches of the 20 rivers surveyed:

- one was assigned to Class II — i.e. water of medium quality;
- one was assigned to Class III — i.e. water of poor quality;

- one was assigned to Class IV — i.e. water which may be faecally contaminated and hence a danger to health;
- **fourteen** were assigned to Class V — i.e. water which is either faecally contaminated or organically enriched, and with which active efforts should be made to improve its quality by lightening the pollution load it is already carrying;
- three were assigned to Class VI — i.e. foul water that is a public nuisance or is a public danger, and with which it was a matter of urgency that active efforts be made to improve the quality.

Among other things the report concluded that:

(i) "the accumulation of polluted water in the river lagoons, which are closed for most of the time, is an unsatisfactory state of affairs because of their use or potential use for recreational purposes" and
(ii) "in the 15 mile wide coastal strip, waters of all classes from III to VI occur, mainly because of pollution from sugar mills, canelands, townships, factories and municipal and industrial areas."

Many of the lagoons on the South coast appear to be in exactly the same state. The alarming thing is that the possibilities of the abatement of pollution or improvement in water quality is generally considered to be doubtful ([43]).

To conclude that "the rivers of southern Natal can all be considered as relatively clean" ([236]) is also unacceptable because readers must be aware of the fact that the survey upon which this statement is based comprised **one** rainy season sample, **one** dry season sample and only **eight** bacteriological samples (spread over a period of two years) for each station. Furthermore, rainy season samples were not taken anywhere near obvious pollution sources such as the Mzimkulu Sugar Mill ([206]).

The fact of the matter is that pollution of the water entering Natal's estuaries takes several forms:

(a) **Industrial pollution.** Of the 13 instances where industrial pollution is detectable in estuaries, deterioration in water quality can be attributed in eight cases to organic enrichment from sugar mills. This causes an abnormally high demand upon the oxygen available in water, with the result that it prevents many forms of estuarine life from becoming established (see Fig. **123** Section 3.2.1). Brand *et al* ([43]) explain that organic pollution "results in the production of anaerobic conditions in the water, unpleasant odours, and a complete transformation or even destruction of the normal aquatic fauna". Fibre disposal causes similar complications below paper mills (as on the Mvoti and Tugela for example) and board mills (as on the Mdloti and the Mgeni). In the vicinity of Durban the industries responsible for contributing to estuarine pollution (as on the Mbokodweni, Mgeni and Tongati) are more often than not associated with chemicals and the effluents are consequently toxic. In Durban one can see how industrial complexes have become built around petroleum refineries. A similar pattern can be expected to develop in the vicinity of Richards Bay. This is because embayments such as these represent water available either for transportation, processing or waste disposal ([96]).

(b) **Cropland pollution.** This term has been used to cater for the 11 or more cases where organic enrichment caused by the irrigation of sugar cane was apparent. Its significance lies once again in the oxygen demand placed upon the receiving water body (see Fig. **123** Section 3.2.1). Mineralization of the water also occurs through drainage from irrigation ([43]).

Cropland pollution is a factor that has received inadequate attention in Natal. Although pesticide pollution has been positively identified in only two estuaries (Kosi and Mzinto), it is biocides such as the nematicide "Temik" that may well have equally devastating effects upon the benthic meiofauna of estuaries as it has on soil nematodes on land. If such compounds are being transferred from canefields to water courses then evidence of them should be sought. As a matter of interest those being used by the sugar industry are as follows (Moberly, pers. comm.):

Herbicides:
Diuron
Ioxynil
2.4-D Iso-octylester
Metribuzin (Sencor)

	Paraquat
	Ametryne (Gesapax)
	Glyphosate
	Alachlor
	MCPA
	2.4-D amine
	Velpar
	Metolachlor
	Perfluidone
Insecticides:	Thiodan
	Dieldrin
Nematicides:	Aldicarb (Temik)
Non-mercurial fungicides:	Bendate
Ripeners:	Ethrel
	Embark
Fertilizers:	Urea
	Ammonium nitrate
	Superphosphate
	Potassium chloride

As criteria within which to work, the recommended maximum concentrations of many of these compounds in water has been provided by the Environmental Protection Agency in the United States of America ([83]).

(c) **Faecal pollution.** There is positive proof that 11 of Natal's estuaries are faecally contaminated. There is reason to believe that at least another dozen are in a similar condition although proof thereof would only be attained after bacteriological surveys have been conducted. The implications of inadequately treated human wastes are:

- public health hazards
- aesthetic offences
- oxygen depletion and the development of sludge communities
- eutrophication
- admixture of toxic wastes
- modification of species composition and abundance.

Although a "little domestic sewage merely adds to the fertility of the estuary" ([105]) problems develop (see Section 3.1) when mouth closure occurs, as is characteristic of so many of Natal's systems.



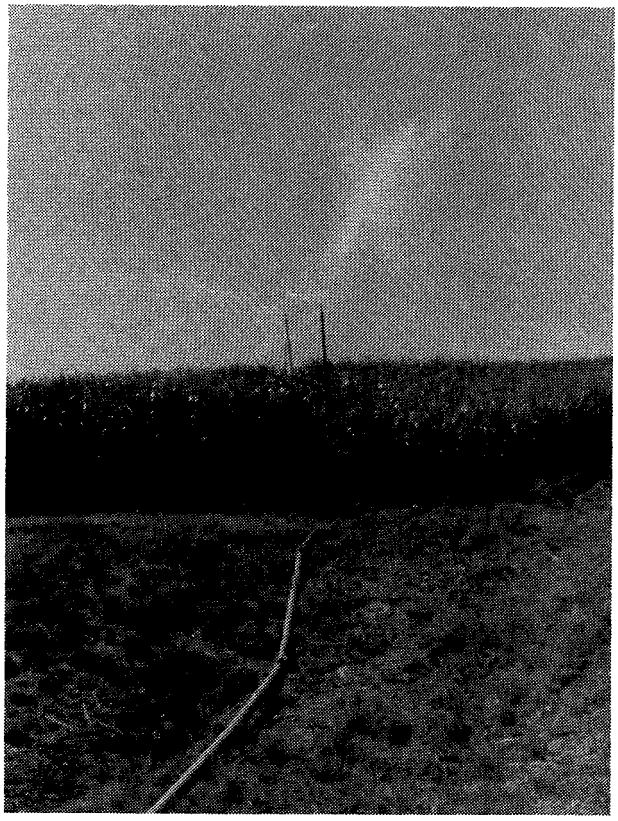
This sort of photo (taken by A. Gifford alongside the Manzimtoti lagoon in April 1970) speaks for itself.

Brand *et al* ([43]) concluded after their study of the "Three Rivers Region" that ". . . the lower reaches of most rivers of the region cannot be unreservedly recommended as fit for recreational use, although many of them are so used. Their bacterial counts are high and there is the probability that they may carry pathogenic organisms. In some cases they actually do". Whilst huts, kraals and native villages in the catchment all contribute to the sporadic faecal pollution found in so many of the smaller rivers of Natal ([43]), septic tanks ([145]) and sewage treatment plants ([212]), also contaminate Natal's estuarine waters.

(d) **Eutrophication.** Although there is very little data available upon which to base any conclusions, the problem of excessive nutrient enrichment does not appear to be a severe one in Natal's estuaries.

Where faecal contamination has been identified, nutrient enrichment presumably occurs. Water hyacinth blooms in the Nonoti, Sipingo and Sezela lagoons are also indicative of nutrient enrichment.

Primary and secondary treatment by sewage works (such as that on the Mhlanga) is generally only 50% efficient in terms of nitrate and 30% efficient in terms of phosphorus removal ([83]). Thus tertiary treatment is recommended for estuarine sewage disposal sites. The feasibility of the land application of treated sewage effluent has been demonstrated by over 500 municipalities in the United States of America ([83]). Forested areas are particularly well suited to such practices ([348]).



An attempt has been made to dispose of the dunder water from sugar mills by spray-irrigating sugar cane.

(e) **Heavy metals.** Heavy metals can enter estuaries from a wide variety of sources. These include natural weathering processes, metal industries, agro-chemical operations, storm-water from urban areas and outboard exhausts discharging below water ([216]). It is interesting to note that some workers even believe that road traffic contributes to heavy metal enrichment near bridges over some estuaries in Natal ([252]). At certain concentrations heavy metals are toxic to marine life, some species being more sensitive than others. The decreased survival of juveniles, larvae and eggs are among the effects cited.

It is highly significant that the general solution to pollution control (from any of the sources described) lies within the concept of water control ([347, 348]). This is because it is the water that acts as the medium in which pollutants are contained and transported into estuaries.

Where waste water can be distributed over a land surface it becomes cleaned by natural biological, chemical and mechanical processes. It filters into the groundwater and re-emerges into streams and water courses completely purified. Pollutants as well as waterborne pathogens are removed. This principle was applied to the disposal of "dunder water" by sugar cane mills ([25]), but seems to have failed because of over-irrigating.

There is a limit to how much water can be applied to the land before the capacity of the soil to absorb it is exceeded, and run-off results. Water applications must be tailored to suit the land. Consequently, one may find that periods of flood-flow irrigation may be more effective than sprays in coastal lowland areas ([348]), or that the capacity of the land to absorb water can be increased by soil aeration techniques (Gray, pers. comm.).

3.2.8 **Substrate disruption**

According to Cronin ([209]) bottom materials are the dominant influence in an estuary. Consequently disruption of such materials by dredging generally has adverse effects. Examples of this can be seen in Durban Bay and in the harbour side of the development at Richards Bay. In both cases the process is either on-going or liable to re-occur periodically.

In the mouth of St. Lucia the process is continuous in order to prevent it from closing. In this case the deposition of spoil along the edge of the floodplain has disrupted wetland functions, and illustrates that spoil deposition can in the long terms have a more damaging effect than disruption of the bottom materials themselves. However, at St. Lucia, the benefits of maintaining an open mouth outweigh any adverse effects being caused. It may be wise however, to cease dredging during the seasonal "runs" of migrating prawns and fish.

Very often there is no alternative but to dredge an estuary if it is to be deepened. However, without first eliminating silt sources in the catchment, the exercise becomes futile.

In several cases dredging may have taken place (as in the Manzimtoti, Little Manzimtoti and Mlalazi) but is not likely to be repeated.

In the Umhlangankulu lagoon dredging was undertaken to deepen it for recreational purposes. Excavation was purposely confined to the centre of the lagoon rather than the periphery, in the interests of the animal life established there ([48]).

In the Mpenjati sand extraction occurs at several points in the lagoon because of the suitability of such materials for construction. In this case however the ecological effects are considered to be negligible.



Excavation of the Umhlangankulu lagoon in progress (12 July 1977).

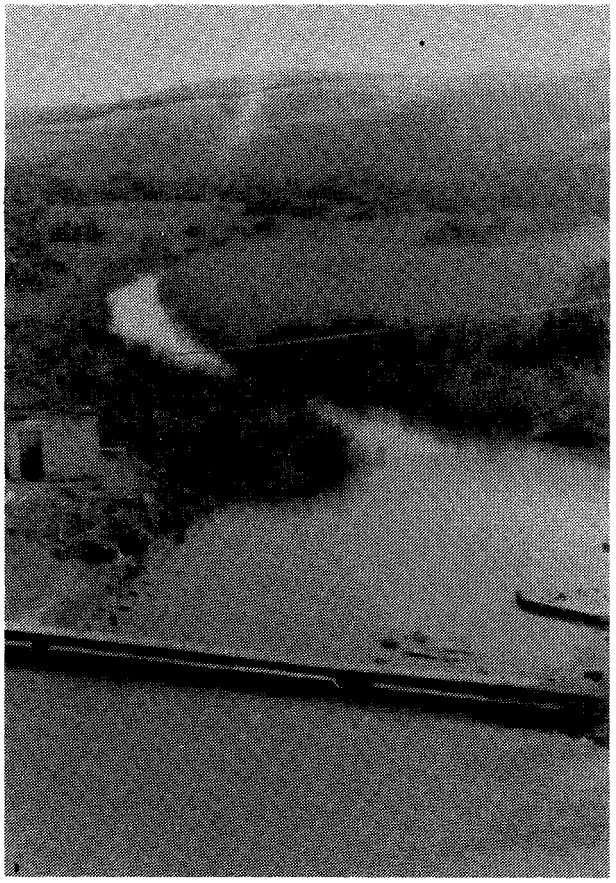
3.2.9 **Impoundment.**

In five of Natal's estuarine systems the conclusion has been reached that weir construction (particularly at the mouth of the system) has adverse estuarine effects.

Weirs are constructed to raise water levels, either to facilitate recreation (as on the Fafa and Kaba) or to store water. On the Mdesingane a weir was built to ensure that water could be supplied to the settlement of Bazley Beach, whilst on the Nhlabane a weir has been built to provide water for a massive mining venture.

Weirs interfere with the exchange of water between the sea and the estuary. They transform a brackish environment to a fresh one and act as a barrier to the movement of animal life. Where weirs occur, but have fallen into disuse (such as on the Kaba and Mdesingane) they should be removed, in the interests of restoring natural functions to the lagoons concerned.

Obstructions similar to these, were removed from both the Mgobezeleni and Beachwood systems because of their adverse effect upon mangrove communities ([62, 229]).



A photo of a disused weir across the Mdesingane lagoon (24 May 1977).

3.2.10 **Drainage diversions.**

Drainage diversions can have detrimental effects upon estuaries for two reasons. Diversions result in both the modification of river flow and the generation of silt.

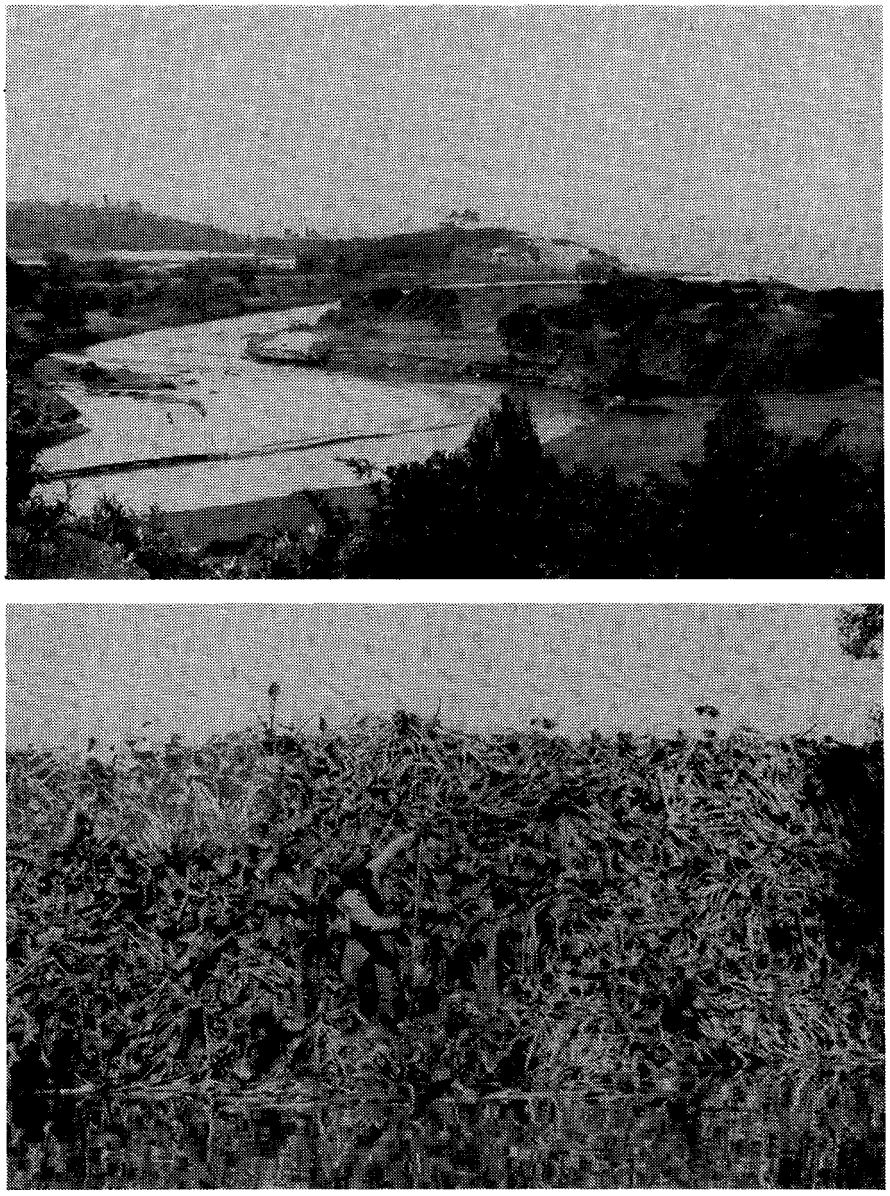
(a) **The modification of river flow.** To take two examples, diversion of the Mfolozi away from St. Lucia, and diversion of the Mlazi away from the Sipingo, in both cases led to mouth closure. The consequences have been continual dredging at St. Lucia to keep the mouth open, and the installation of two concrete pipes in the mouth of the Sipingo to prevent the system from becoming stagnant. In St. Lucia there were other inflows of fresh water to sustain the system, but in the case of the Sipingo the final blow was delivered when the Sipingo river was diverted into Mbokodweni to prevent the flooding of Prospecton. Not surprisingly the increased flow rates in the Mbokodweni have resulted in the erosion of the Manzimtoti golf course. Similarly, the reduced flow rates in the Sipingo have resulted in the proliferation of water hyacinth, the control of which is a massive on-going maintenance task.

River flow is also linked to estuarine salinity. Restriction can lead to either salinity increases (as at St. Lucia) or salinity decreases because of mouth closure (as in the Sipingo). In either case the effect is detrimental to estuarine communities ([83]).

(b) **Silt generation.** Rivers in Natal have occasionally been partially diverted or meanders short circuited. For example, this was done to facilitate road construction on the Little Manzimtoti, and rail construction and agricultural expansion on the Mhlatuze. In each case

the re-establishment of bed levels, and the increased water velocities that resulted from re-alignment of the river course, were silt generating influences from which the respective estuaries suffered.

Similar diversions are anticipated on the Msimbazi and uMgababa as construction of the new freeway proceeds and on the Tongati for industrial expansion. In each case another nail is driven into the coffin of Natal's overall estuarine environment.



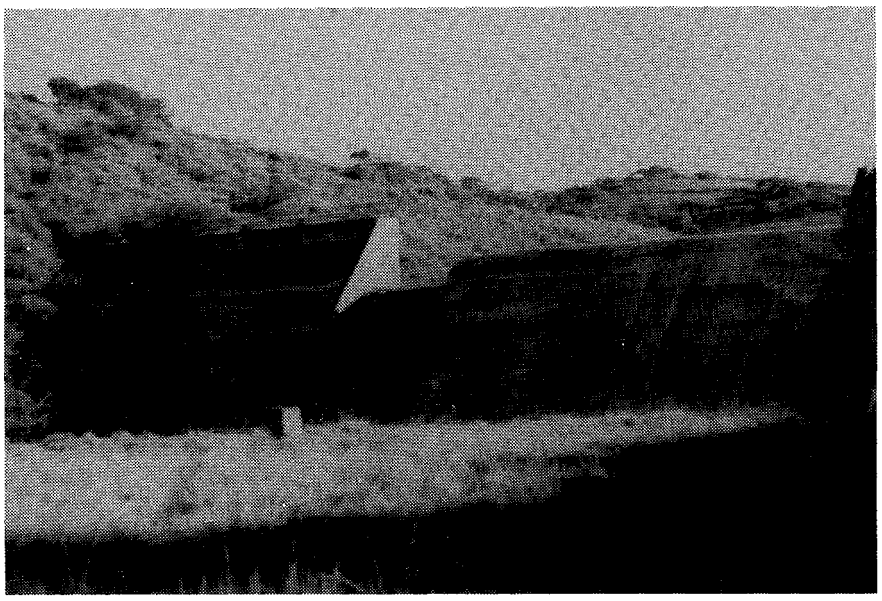
The two consequences of river diversion. Bank erosion in the Mbokodweni (above) and hyacinth blooms in the Sipingo (below).

3.2.11 **Dam construction.**

Most workers consider dam construction to have adverse estuarine effects because of the reduction in river flow ([83]). Reduced river flows affect the salinity of the system and the degree of contact between it and the sea. On the other hand, in some cases dams can moderate river flow as well as provide releases during the dry season. Dams also act as barriers to fish migrations. In Natal the principle marine species being affected is the eel (*Anguilla*), despite its ability to occasionally circumvent such obstacles.

A dam on the Mzimkulu for example, could be beneficial to the estuary because of the interception of silt. However one must recall that once depleted of its sediments a river will recharge itself below the dam, and tend to become more aggressive in its demand for such materials, particularly if the flow rate is not reduced. Furthermore, the importance of river transported sand should not be overlooked because of its role in beach nourishment. One can ill-

afford to prevent sand being supplied to the coast ([196]), because the beaches of Natal have a very real economic importance.



The Umnini dam above the uMgababa lagoon typically has both beneficial and adverse effects, on the estuary downstream.

3.2.12 **Land apportionment and politics.**

This may be a somewhat surprising subject to feature as an estuarine problem. However, if one could turn the clock back it would be important to ensure that the country was divided up in such a way, that boundaries became watersheds rather than rivers.

The question of land apportionment in Natal is complicated by rapidly changing land ownership patterns. In the near future the KwaZulu nation will assume direct control of either part or in some cases entire drainage basins, and the question of effective control within a drainage basin (for purposes of estuarine management) consequently becomes complicated by politics. In Natal the situation could arise where attempts to conserve coastal resources become jeopardised by disinterest in such matters within the catchment area.

Ideally, instead of the Mvoti river (for example) arising in the European controlled magisterial district of Umvoti, then flowing through KwaZulu, and finally re-entering the lower Tugela, it should be incorporated in **one** district, and fall under the jurisdiction of **one** authority. This principle has been widely adopted in the United Kingdom by the various regional water authorities. It places management of the entire drainage basin on an ecologically and administratively acceptable basis.

The situation where one person controls the left bank of an estuary, one person the right bank, another the upper reaches and another the lower reaches (as on the Mdloti) is also unsatisfactory. The lack of control by a single designated authority results in one party pointing accusing fingers at the other and neither party wanting to accept responsibility.

In the light of the foregoing (i.e. Sections 3.2.1 to 3.2.12), Schedule 7 attempts to summarize some of the likely consequences of man-induced modifications of the estuarine environment in Natal.

Schedule 7. Summary of the various types and likely consequences of man-induced modifications on the estuarine environment in Natal. (Concept after J. H. Kutkuhn (1966)).

FEATURE	EXAMPLE	EXPECTED ENVIRONMENTAL EFFECT	PROBABLE RESULTS IN TERMS OF ESTUARINE PRODUCTIVITY	
			ADVERSE	BENEFICIAL
Incoming silt	Mpambanyoni	Losses in storage capacity; losses of water area; increased turbidity.	Decreased production due to decreased light penetration; exclusion of visual feeders; suffocation of benthic fauna; decreased carrying capacity.	Reed encroachment; mud flat formation.
Dredging	Richards Bay	Substrate disruption; turbidity; wetland disruption; increased tidal exchange.		Deepened areas offer refuge; increased passive transport of juveniles into estuary.
Disruption of riverine vegetation	Mhlanga	Silt transport.	As above	Reed encroachment; mud flat formation.
Disruption of wetlands	Mtwalume	Silt transport, reduced winter flow; destruction of sources of detritus.	As above, with particularly severe decrease in productivity due to elimination of detritus sources.	As above
Drainage diversion	Sipingo	Reduced flow in estuary giving rise to mouth closure; or else increased water velocities giving rise to siltation.	Impeded immigration. Decreased production at all levels.	None
Dam construction	Matigulu	Modification of flow, giving rise to mouth closure.	As above, including diminished beach nourishment; barriers to movement.	Silt interception
Road and rail construction		Reduced tidal exchange; reduced scour; water area losses; decrease in depth.	Decreased production at all levels.	None
Weirs and causeways	Mgobezeleni	Altered water levels; altered salinity; altered circulation.	Lowered carrying capacity; decreased utilization; barriers to movement.	None
Breaching	Mdloti			
Cropland pollution	Zinkwasi	Deterioration in water quality; increased biological demand for oxygen; presence of toxic compounds.	Modification of species composition and abundance; development of sludge communities; poor survival.	None
Industrial pollution	Sezela			Increased birdlife (e.g. Mvoti).
Pesticide pollution	Kosi			None
Nutrient pollution	Fafa			Limited enhancement of fertility.
Faecal pollution	Mbokodweni			

3.3. **Planning guidelines.**

As the most important part of this report it would be negligent not to bring the attention of the Planning Commission to the existence of:

(a) Yeoman's concept of Keyline Planning ([347, 348]) and
(b) Clark's "Manual on the Conservation of Coastal Zone Resources" ([83]).

The latter was specifically compiled to suggest "a few simple principles and rules that can guide the use of coastal lands and waters".

Both Yeoman's principles and Clark's book make one realize that in Natal inadequate attention has been paid to the mistakes being made by others. This cannot be afforded if the estuarine environment of the Province is to retain at least a semblance of its ecological value in the future. Bearing in mind what has been said in Section 3.2, it is encouraging to find positive recommendations contained in these references, which provide guidance as to how the problems identified in Section 3.2 can be overcome.

An exceedingly brief summary of the most pertinent guidelines is presented follows:

(a) **Agriculture.**
- (i) Farming operations should be controlled to protect coastal ecosystems from damage by fertilizers, biocides, sedimentation and altered run-off.
- (ii) All vital habitat areas (wetlands) should be identified and exempted from agricultural use (as is not done in the case of sugar cane farming for example).
- (iii) Farming in coastal lowlands should be restricted to operations not requiring drainage or heavy use of chemicals.

(b) **Dams, water diversions and land drainage.**
- (i) Water management programmes should be designed to preserve existing water quality, volume, and rate of flow (this is not so on the Mkuze for example).
- (ii) Wetland areas should not be drained (as was done on the Mhlatuze or Mfolozi floodplains for example).

(c) **Estuarine flood protection.**
- (i) All structures on estuarine shores should be set back of the annual flood line (as was not done when building a go-cart track at Margate for example).
- (ii) All structures placed in estuarine floodplains areas should be elevated above the 1:100 year flood level (to lessen the flood damage that occurs in Natal).

(d) **Roadways.**
- (i) Causeways in estuarine areas should be designed to elevate the roadway on pier or piling supports and, should avoid the need for solid fill (as was not done on the Mzumbe for example).
- (ii) Bridge abutments that encroach on water courses reduce waterflow and degrade coastal ecosystems (as is the case of the old railway over the uMgababa for example).

(e) **Industry.**
- (i) Heavy industry should be located where water discharges present the least ecological threat (unlike the situation on the Sezela for example).

(f) **Septic tank location.**
- (i) Septic tanks should be set back at least 46 m from the annual high water line, for soil cleansing to be effective (as was not done alongside the Bilanhlolo for example).

(g) **Sewage treatment.**
- (i) Land application of treated sewage effluent should be used whenever possible.
- (ii) Tertiary treatment should be required for sewage effluent to be discharged into typical estuarine waters (as is not done on the Mhlanga for example).

(h) **Solid waste disposal.**
- (i) Vital habitat areas should not be used as land-fill sites (such as is being done alongside the Lovu for example).

(i) **Tract and site preparations.**

(i) Strict control on erosion should be exercised during site preparation and construction (unlike the situation during the construction of the La Mercy airport for example).

(ii) Ground surfaces should be stabilized immediately after any action that destroys the natural vegetation and leaves soils exposed to the forces of erosion (as was not done along portions of the south and north coast freeways for example).

(j) **Residential development.**

(i) Special constraints should be imposed on water-front development to preserve shoreline configuration, protect vital areas, and avoid water pollution (as is not done alongside the Manzimtoti for example).

These are only 10 of the more relevant guidelines presented. The actual ways of implementing them are provided by Clark ([83]). Our choice is a simple one. We either use them as a sound basis upon which to build or we do not.

When referring to Clark's book ([83]) or to other equally useful references ([1, 214, 255, 295]) the two messages that emerge clearer than any other are:

(a) the need to recognize the estuary as an integral part of the river basin complex and for sound management within the entire drainage basin;

(b) the need to identify and protect vital areas, these generally being defined as wetlands adjacent to estuaries.

Clark ([83]) takes the view that "management of the coastal zone has a fundamental goal — the conservation of coastal ecosystems at the highest achievable carrying capacity". This means their ability to yield resources of value to man.

His general theme is that "coastal ecosystems can be maintained at high levels of productivity even while development of the coastal zone increases, **if** there is effective planning". He believes that "each coastal ecosystem must be managed with respect for the relatedness of its parts, and the unity of its whole". The findings of this report confirm such views. What is needed is ameliorative action to arrest any further deterioration of Natal's estuarine resources. We have reason to be optimistic about such action being forthcoming, because the current attention focussed on Natal's estuaries makes their future certainly look brighter than it did a few years ago.

Part 4 **DISCUSSION.**

Decreasing estuarine productivity and the understandable conflicting demands being made on the waters of estuaries and rivers that ultimately find their way into estuaries, has by this stage been referred to repeatedly. Inevitably, the question must be asked "does the problem warrant the deep concern expressed by ecologists all over the world?" ([65, 83, 126, 268, 291, 292]).

The answer is perhaps best introduced by the following letter quoted by Ketchum ([237]), which originated from the Conservation Foundation, Washington D.C. in 1967. It reads (using local examples) as follows:

"What is an estuary? To the scientist, an estuary (such as St. Lucia) is very fertile and more productive of plant and animal life than either land or sea.

"To some an estuary is an unused space to be developed for housing projects (such as "San Lameer" on the uMhlangankulu), industrial sites (such as the Sezela), roads (such as the Manzimtoti), marinas (such as the Mhlanga), golf courses (such as the Mzimkulu), amusement parks (such as the Kongweni) and sewage treatment plants (such as the Koshwana).

"To commercial and sport fishermen estuaries are vital. Over 90% of the total harvest of seafood taken by American fishermen comes from the continental shelf, and about two-thirds of that volume are species which are in some way estuarine dependent.

"To the harbour developer seeking to dredge and fill an estuary (such as Durban Bay) it was not 'a veritable paradise' because although it did support wildlife, it also supported vermin such as rats and mosquitoes.

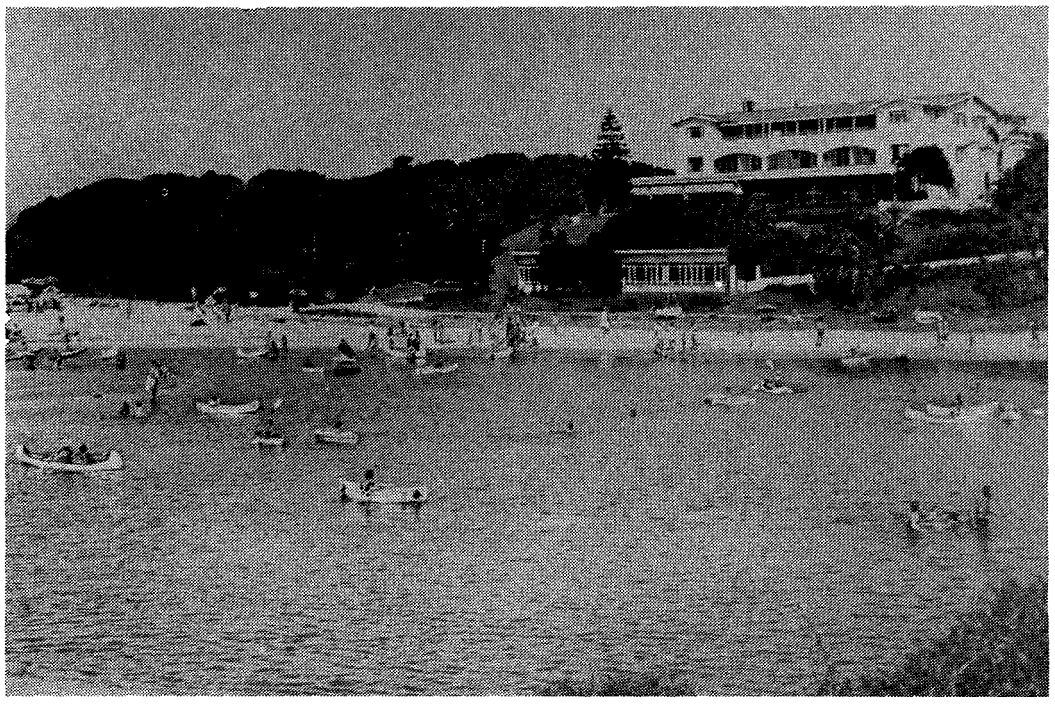
"To another developer seeking to build upon an estuary (such as Beachwood creek on the Mgeni) only concern about the 'love life of fiddler crabs' stood in his way.

"To the sand and gravel industry, estuaries (such as the Mpenjati) are a principle source of those raw materials for construction.

"To some others, estuaries (such as the Mhlanga and Kosi Bay) are to be left untouched for enjoyment and relaxation, for recreation without development, and for a closeness to nature".

Clearly therefore, a country needs estuaries. In Natal they are essential for the growth and well being of the Province, not only for the fisheries they sustain, or for their recreational or aesthetic value, but also for industrial and urban development. The problem is that in Natal, and elsewhere throughout the world, urban, agricultural and industrial development has proceeded too fast. Man has not been able to devise ways and means of permitting this rapid development without jeopardising the natural values of a resource such as an estuary ([282]). All too often attempts to do so are over-ruled by economics or are implemented far too late.

However among other things, the estuaries of Natal fulfil a distinct social function in that they provide opportunity for outdoor recreational activities. St Lucia is a good example of a



Estuaries fulfil a distinct social function in Natal. (A postcard of the Mhlangeni lagoon reproduced with permission of Art Publishers (Pty) Ltd).

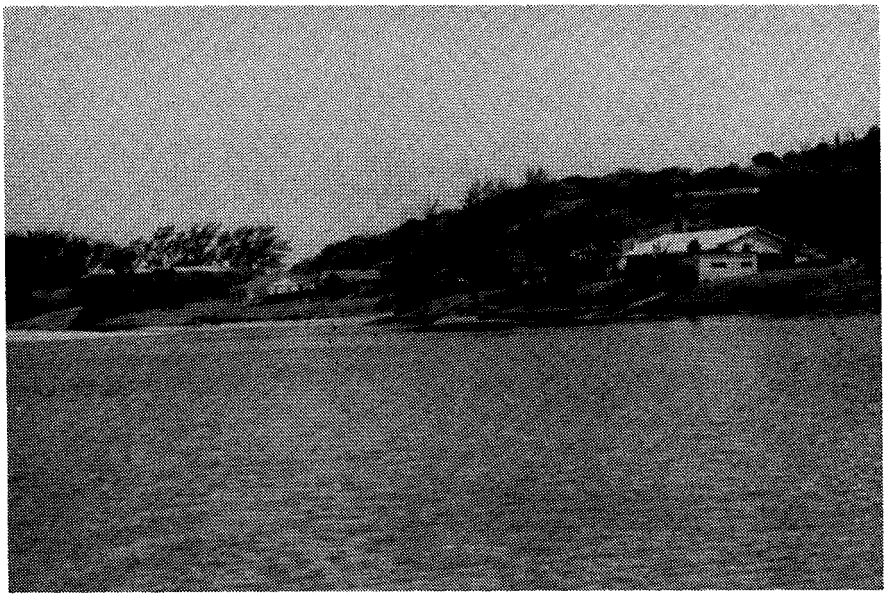
multiple use estuary — but estuary uses elsewhere (in an approximate order of priority) include boating (Zinkwasi), angling (Mtamvuna), picnicking and camping (Mlalazi), sea bathing at the estuary mouth (Vungu), water ski-ing (Fafa), walking (Mzimkulu), bird watching (Mvoti), ski-boat bases (Mkomazi) and swimming (Mhlangeni). Swimming features last because it is either prohibited or disagreeable because of poor water quality.



Bilharzia is also one of the reasons why swimming in Natal's estuaries (from the point of view of recreation) does not feature as a popular activity (Ku-Boboyi lagoon 10 June 1977).

In the United States of America, surveys have revealed that "the most rapidly increasing use of estuaries appears to be for personal satisfaction (such as recreation) . . ." [290]. The development of marinas in the United States of America serves as an example. A survey in Durban by Schlemmer (in press) has also showed that the primary demand amongst 88% to 98% of the population is for social recreational facilities [88].

Consequently the intensity of recreational use of estuaries is expected to increase in Natal as the population continues to grow in the coastal lowlands [129]. Numerically speaking the Bantu predominate but the coastal lowlands also contain about three-quarters of the European, nine-tenths of the Indian and three-quarters of the Coloured populations of the region [122, 285]. The coastal areas of Natal also represent the environment to which visitors from the whole of South Africa, and elsewhere, descend in their thousands each year.



Waterfront property development alongside the Zinkwasi lagoon.

Development on the south coast of Natal adequately illustrates the manner in which lagoons have become the focal point of holiday resorts, residential areas and amenities such as golf courses. Waterfront properties are generally far more valuable than properties without such frontage, because of the aesthetic value that an estuary bestows upon the property (138).

Conflicts can arise because of the competitive usage of estuaries and their shorelines. A case example is the Zinkwasi lagoon where conflicts have developed over water level control. The yachtsman requires the lagoon level to be high, whilst the waterfront property owner requires it to be no higher than a certain point at the foot of his garden. The situation becomes more complicated when the water skier requests that the lagoon be emptied because of its poor water quality and the conservationist resists it on the grounds that the lagoon must be permitted to empty naturally. The local authority has the unfortunate task of deciding on the matter.

Economics also play an important part in estuaries (282), yet no-one has ever attempted to attach a monetary value to the estuaries of Natal. Consequently this is one of the data voids identified (see Section 4.1) that requires to be filled. Although estuaries have an indirect value, to which no rand value can really be ascribed, when undertaking the exercise the following points may be worth bearing in mind:

(a) Understandable concern about estuarine degradation reducing the food producing potential of the sea has been expressed (174). However the food producing potential of the sea in Natal waters has itself yet to be evaluated. Until that has been done it would be prudent not to overlook the importance of marine/estuarine interactions.
(b) At present there is no large scale commercial fishery operating in the coastal waters of Natal. However, should such a fishery develop on the continental shelf it is highly probable that it would be estuarine dependent. One should be aware of the fact that between the commercial and the sport fishery in the United States of America, the direct value derived from the estuarine fishery was estimated to be worth $600 million (123, 290). de Sylva (123) stated that "the key to the future of marine sport fisheries resources is in the survival and management of estuaries".
(c) Sport angling is a popular recreational activity involving 50 000 people in Natal alone (308). In 1976 there were 47 048 people fishing with rod and line, 2 636 fishing from ski-boats and 245 from paddle-skis. (A further 10 000 were involved in spearfishing, crayfishing and shell or aquarium specimen collecting). The value of a sport fishery should be assessed **by the cost of each kilogram caught**, because economists are quick to point out that the product in sport fishing is recreation, not fish (123).
(d) A small estuarine dependent bait fishery worth R60 000 in 1975 (313) exists at St. Lucia.
(e) The recreational value of Natal's estuaries (just discussed) contributes significantly to the economic value of the region as a whole.
(f) Estuaries have been regarded by Heydorn (181) and others (96) as "areas in which protein suitable for human consumption is available in an easily accessible form, particularly with regard to fish". However having by this time become conscious of the state of the estuarine environment in Natal, one should bear in mind that in their **present day condition** the potential of many estuaries in this respect has become greatly reduced. Certain systems (such as St. Lucia) do, however, have considerable potential for aqua-culture ventures — using species such as mullet (*Mugil cephalus*), prawns (*Penaeidae*) and crabs (such as *Scylla serrata*).

From an ecological point of view, estuaries provide refuge and feeding grounds for a very wide spectrum of animals. In an undisturbed state estuaries are one of the richest and most diverse of habitats (see Table **107**).

A multitude of forms of life ranging from higher plants, to bacteria and fungi, to plankton, crabs, worms, molluscs, insects, crustaceans, fish and birds all occupy different trophic levels within an estuary (292). *In toto* they form an intricate food web, with each 'thread' in the web feeding on or obtaining energy from the one preceding it. At the base of the web are plants as producers. These are followed by primary and secondary consumers. Bacteria and fungi are consumers that operate in decomposition at all levels (see Section 3.1).

Fish and prawns are two components of the food web that have received the most attention in Natal. It is important to appreciate however, that the true ramifications of marine/estuarine interdependence are far wider and extremely complicated. Sweet (290) points out that the term includes a vast spectrum of biological relationships so that "even some continental shelf species and most marine predators can be considered dependent on the estuary as the ultimate source of their food".

Table 107. Primary productivity of important habitat types in terms of annual production (according to Clark ([83])).

Habitat type	Primary production in kilocalories/m^2
Deserts	< 0,5
Grassland; Deep lakes; Mountain forest; some agriculture	0,5-3
Most forests and secondary plant communities; shallow lakes; moist grasslands; most agriculture.	3-10
Some **estuaries**; coral reefs; plant communities on floodplains; intensively fertilized agriculture.	10-25
Continental shelf waters	0,5-3
Deep oceans	< 1

In Natal the inference has been drawn that the life cycles of 54 species of fish are closely associated with the estuarine environment ([329]). However, it is important to realize that 25 of these 54 species are either rare themselves, or, are rarely found in Natal's estuaries. This means it may be more realistic to accept that there are 29 important, or common species which are truly estuarine dependent in the coastal waters of Natal. The fact that 82 species of fish have been recorded from St. Lucia ([314]) and 133 species from Kosi ([33]) simply means that within this assemblage are freshwater, euryhaline and stenohaline forms. According to Wallace ([328, 331]), the occurrence of juveniles of numerous species of fish in estuaries "suggests that it is the early phase in the life cycle for which estuaries hold the greatest adaptive significance and survival value." He also emphasized that "the abundance of juvenile fish in estuaries, and the absence of positive evidence of their widespread occurrence at sea, leads to the conclusion that the most important function of estuaries in the biology of these species is **the provision of a nursery habitat for juveniles**".

Although the adults of many fish enter estuaries for feeding purposes ([170]) they spawn at sea because of the more stable environment. Very few species actually spawn in estuaries and many people ([236]) are under a misapprehension as far as this is concerned. The spawning grounds of the dominant estuarine species are located inshore and in the vicinity of estuary mouths ([331]). Recruits are thought to originate from areas where the continental shelf is relatively wide (i.e. 40 km) such as opposite the Tugela and opposite Delagoa Bay in Mozambique. Wallace ([329]) considers that the inshore spawning habit developed to ensure that juveniles were not transported by the south going Agulhas current to the "less favourable south coast region" (i.e. the Cape). If this is the case, the predominantly north going, wave generated water movements, within the surf zone (see Section 3.1) must be significant in terms of juvenile survival.

One interesting point stressed by workers in this field (whether relating to fish ([328]) or prawns ([76])) is the question of the **seasonality of spawning**. The spawning season of the dominant estuarine species is from May to November. This enables juveniles to migrate into estuaries before the summer rainfall season of strong river flow ([329]). Wallace's statement that "in order to support a juvenile population it is essential that the access route from the sea is open during the winter and spring months of major estuarine recruitment" ([331]) is clear enough.

However, arising from this is the important point that in their present condition virtually all of Natal's estuarine systems are closed at this time of the year (see Section 3.2.2). Furthermore, when they are open, they are generally in flood and in the latter condition they are unsuitable for juvenile recruitment ([331]). Added to this, the storage capacity of many systems has been lost through siltation (see Section 3.1). Consequently, even if they do open in winter or spring (naturally or artifically), they are so shallow that they virtually drain dry.

These facts point to the necessity for embayments such as Durban Bay and Richards Bay to continue fulfilling an estuarine role despite their disturbed condition. They also suggest that there seems to be reason for expressing caution before attributing a nursery function to Natal's estuaries *in toto*, when in actual fact many of them may no longer do so. Furthermore, because of the degraded condition of Natal's estuaries, recruitment of the marine stocks in Natal may be becoming more and more dependent upon the transport of juveniles by currents from regions

such as the East coast of Madagascar and unspoilt estuarine areas on the Mozambique coast. Nevertheless Natal's estuaries are still important for the survival of these juveniles, because of their dependence upon locating suitable nursery areas (de Freitas, pers. comm.). The continued degradation of these areas consequently has enormous ecological implications. One of the most obvious, is that it has probably contributed substantially to the declining trends in the availability of adult fish in Natal's coastal waters (van der Elst, pers. comm.). If nothing is done about the situation, then the point of no return may well approach very rapidly.

4.1 Proposals for future research

Possible Contributors

The following programme of research is proposed; and listed in order of priority. The duration, anticipated costs; and level of expertise required for each have yet to be determined.

(a) **An immediate examination of existing legislation** should be made in order to establish whether it is adequate to prevent the further degradation of Natal's estuarine resources. Where found to be adequate it should be enforced; and where found to be inadequate the necessary amendments should be made.

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(b) That the principles and practices of Key-line development ([347], [348]) or "**water control**" be critically examined as the possible direction for catchment planning, soil conservation and pollution abatement.

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AGRICULTURAL TECHNICAL SERVICES

(c) **That one lagoon be selected as a pilot study in catchment restoration.** It is suggested that the Siyai lagoon be selected as a lagoon upon which attention be concentrated for a co-ordinated, multi-disciplinary exercise in catchment restoration. This should involve scientists, engineers and sugar cane farmers. Financial and other resources should be pooled to achieve the aim of re-establishing a harmonious relationship between man, the Siyai lagoon and its catchment. Public attention should be focussed on its venture.

The Siyai lagoon has been selected as a system with a sufficiently small catchment to bring the project within the bounds of economic and practical means. It has also been selected because of the knowledge acquired by Mr Garland (the farmer whose land surrounds the lagoon) in terms of moderating river flow, and restoring natural vegetation along the water courses, in sponge areas and marshes. With the co-operation of the few farmers higher in the catchment, and that of the South African Sugar Association much could be learnt from the project. Hopefully it would demonstrate that the damage done is not irreversible, that such a system can recover, and that the technique used could be applied elsewhere in Natal. It is suggested that the Zinkwasi would be the next most suitable catchment in which, whatever techniques are developed are applied on a larger scale.

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(d) That a greater understanding of the **hydrological** forces at work in both a disturbed and undisturbed estuarine system be assessed. Attention should be given to rates of siltation, water levels, discharges and variations in the mouth position. Amongst other things, this would enable the precise impact of lagoon breaching and the influence of 'water control' (or lack thereof) to be assessed.

NRIO

(e) Where this report has indicated that no records of certain characteristics are available, this information should, if possible be acquired to **fill such gaps with facts rather than opinions.**

In most cases this will mean carrying out standard ecological surveys of the lagoons identified (see Schedule 8). Survey methods and the expression of results must be standardized. Participants could give consideration to forming a team which could examine each lagoon simultaneously so that the information collected relates as a whole. Computerization of the data would be important to facilitate efficient processing and accessibility. Sampling frequency should be determined by the state of the system (i.e. open, closed, in flood, polluted, etc.), rather than the season. One

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of the fundamental objectives of such surveys would be to assess whether in their **present condition** the system being examined contributes to the nursery function of Natal's estuarine environment.

In some cases specialist attention may be required, where by the virtue of the use to which certain estuaries are put, bacteriological surveys are needed in the interest of public health. It is suggested that local authorities could be persuaded to finance these particular surveys.

In other cases a more detailed chemical understanding of the system appears warranted — either because of the pollution potential identified in the vicinity of certain systems, or to support ecological investigations.

LOCAL AUTHORITIES

PRIVATE CONSULTANTS

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Schedule 8. Basic Research Needs

ESTUARY	PHYSICAL	CHEMICAL	BIOLOGICAL	BACTERIOLOGICAL	ESTUARY	PHYSICAL	CHEMICAL	BIOLOGICAL	BACTERIOLOGICAL
Kosi	●	●			Sezela		●	●	●
Mgobezeleni	●		●	●	Mdesingane				
St.Lucia	Complete review				Fafa		●	●	●
Mfolozi		●	●		Mvuzi				
Nhlabane	●		●		Mtwalume			●	
Richards Bay		●	●		Mnamfu				
Mlalazi	●		●		Kwa Makosi				
Siyai	●	●	●		Mfazazana				
Matigulu	●				Mhlungwa				
Nyoni			●		Mhlabatshane				●
Tugela	●				Mzumbe				
Zinkwasi	●			●	iNtshambili			●	
Nonoti		●	●		Koshwana				●
Mdlotane			●		Damba			●	●
Mvoti			●		Mhlangamkulu			●	
Seteni					Mtentweni			●	
Mhlali			●		Mzimkulu	●	●	●	
Tongati		●			Mbango				
Mdloti			●		Boboyi				
Mhlanga			●		Zotsha		●	●	
Mgeni		●	●		Mhlangeni				●
Durban Bay			●		Vungu		●	●	●
Sipingo	●	●	●		Kongweni				●
Mbokodweni	●				Uvuzana				
Manzimtoti				●	Bilanhlolo				●
Little Manzimtoti				●	Mvutshini				
Lovu	●		●		Mbizana			●	
Msimbazi			●		Kaba				●
uMgababa		●	●		Umhlangankulu	●			●
Ngane				●	Mpenjati			●	
Mkomazi		●	●		Kandandhlovu				
Mahlongwana			●		Tongazi			●	
Mahlongwa			●		Ku-Boboyi		●	●	●
Mpambanyoni					Sandlundlu		●		●
Mzimayi				●	Zolwane				
Mzinto		●	●		Mtamvuna			●	
Mkumbane					Total:	13	18	38	19

	Possible Contributors
(f) That this report become augmented by:—	
(i) an effort to **acquire every available aerial photograph** (going back to 1937 or beyond) **of the estuaries of Natal.** This would mean locating such photographs amongst the relevant institutions involved in aerial photography and building up a reference collection. Accurate interpretation of changes in the estuarine environment of Natal could then be made. This step is as important as having done a bibliographical review of Natal's estuaries;	ORI NTRPC NRIO
(ii) a calculation of the extent of **estuarine areas** (whether submerged or submersible) in Natal. Peripheral areas (generally wetlands) are as much part of the estuary as the water itself, because of the marked degree of interdependence between the two. As part of this exercise a special attempt should be made to show how water levels alter the extent and shoreline length of estuarine areas.	
(iii) the collation of more **hydrological information** from each drainage basin because of the direct bearing of such data on development, water resource management and estuarine productivity. It should be noted that this should even include an accurate determination of the size of each catchment, because the information presently available (see Part 2) is at complete variance in this respect.	NRIO DEPARTMENT OF WATER AFFAIRS
(g) That a **wetland study** be commenced in one particular system such as the Mhlanga lagoon. This suggestion is made because throughout this report the importance of protecting such areas has been stressed, because of their vital role in the production of organic detritus. More needs to be known about the sources of detritus in a typical lagoon system. Being the commonest wetland community in Natal, there is a need to know about the "marsh function" of a *Phragmites* reed swamp. How does it supply detritus, how does it act as a buffer strip and in what manner does it function as a habitat for certain estuarine animals? How efficient are reed swamps in retaining sediments? The answers to such questions are important, if policies proposed for the conservation of wetlands and floodplains, are to be adopted.	ORI UNIVERSITY NPB
(h) That detailed **on-going research** programmes are maintained on at least one **of each type of estuary** identified in Natal, these being:	
(i) Richards Bay (both harbour and sanctuary) as an embayment;	
(ii) St. Lucia as a lake associated system;	NIWR
(iii) Mhlanga and Fafa as lagoons;	ORI
(iv) Mtamvuma and Mlalazi as estuaries;	NPB
(v) Mzimkulu as an estuary-cum-river mouth.	UNIVERSITIES
The knowledge already acquired about those systems should be steadily added to, even if the opinion is expressed that the time has come when we cannot learn anything more about them.	
(i) That the severity of and effects of **cropland pollution** (biocides, herbicides, fertilizers) be assessed as a matter of urgency (see Section 3.2.7.b).	NIWR
(j) That **impact** surveys are conducted wherever possible because there is a need to be more accurate in making	

	Possible Contributors
predictions about the effects of certain actions. Thus where engineering actions such as freeway construction are anticipated — (such as on the uMgababa or Msimbazi) — that **prior** to, **during** and **after** such actions, intensive efforts are made to assess the precise environmental impact of such actions upon the system in question. For example, an opportunity was lost in the case of the Nonoti where, in the interests of pollution abatement, various suggestions were made for adoption by sugar mills as a code of practice ([25]). However, no surveys were conducted to assess the environmental response of the system to the practice adopted.	ORI NIWR NRIO
(k) That **Natal's estuarine resources be evaluated.** A "price tag" needs to be affixed to estuaries, to serve as a basis upon which the economic benefits of these resources can be determined. Sykes ([291]) has emphasized that . . ." by the dictates of our economic society, estuarine values must be expressed in (rands) since estuaries are frequently in competition with profit making industrial enterprises". However, one should become accustomed to the fact that, because of "the self-centredness of man and his apparently natural desire to promote those activities that are in his own best interest" ([136]), estuarine problems will never be solved until due regard is given to developing ways and means of simultaneously protecting vested interests.	DEPARTMENT OF PLANNING AND THE ENVIRONMENT
(l) That a thorough study of **currents in the surf zone** be undertaken (despite the inherent difficulties) because of the part played by wave driven water movements in estuarine morphology and the transport of marine organisms. A beach evaluation study along the north coast of Natal could be incorporated simultaneously.	NRIO

Provision must naturally be made for those scientists who are reluctant to relinquish their specific interests in estuaries (whether these be taxonomic, physiological, life history studies, population dynamics, productivity etc.) because of any co-ordinated programme. However, such people should be encouraged to pursue their interests upon those estuaries selected for detailed study (see (h) above). One should also heed the advice of Smith ([282]) who stressed that "all too often scientific information is either not the sort required, or if it is, it has not been presented in a form readily assimilated by planning and government. . ." He warned of the danger of clear perspectives becoming drowned in data and suggested that "we can afford to abandon at least occasionally, the heights of our ivory towers, and contribute our talents in the most effective manner possible to the resolutions of problems inherent in coastal lagoon management".

Part 5 ACKNOWLEDGEMENTS

The compilation of a report of this nature has been very much a team effort, and has purposely involved the assistance of innumerable people. It is with pleasure and gratitude that I acknowledge my indebtedness to them all.

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Wildlife Society of S.A.
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Finally, I would like to thank my much neglected wife and children for their tolerance over the past two years.

Part 6. **GLOSSARY OF TECHNICAL TERMS**

ABIOTIC	Non-living (characteristics).
AEOLIANITE	Wind deposited sediments.
ALGOLOGICAL	Observations based upon the study of algae.
ALLOCTHONOUS	(Species) or (materials) originating from outside of the area where they are found and subsequently become introduced into (the estuary).
ALLUVIUM	Silt or fine sedimentary materials from which floodplains are formed.
AMBIENT	As the word stands it means 'the surroundings'. In this report it is used in a context meaning room temperature.
ANAEROBIC	Lacking, or devoid of oxygen.
ANOXIC	As above.
AUTOCHTHONOUS	(Species) or (materials) originating where they are found (within the estuary).
AVIFAUNA	Bird life.
BARRAGE	A dam wall.
BATHYMETRY	Depth measurement(s).
BENTHOS	Animals (or plants) living on the bottom (of an estuary).
BIOACCUMULATION	The stepwise accumulation of substances in living organisms.
BIOMASS	A quantitative estimation of the total weight of living material found in a particular area or volume.
BIOTIC	Living (characteristics).
"BORROW PIT"	A deep hole formed by dredgers adjacent to the Richards Bay sanctuary area, from which material was "borrowed" for fill and construction purposes.
CARBON ASSIMILATION	See under Photosynthesis.
CARRYING CAPACITY	The point or limit at which population growth naturally stabilizes within any particular environment, such as an estuary. The level at which equilibrium is reached, is then referred to as the carrying capacity of the system.
CHIRONOMIDS	A group of insects which include mosquitoes and midges.
CHLOROPHYTA	A very diverse group of green algae.
COLIFORMS	Members of a particularly large, widespread group of bacteria normally present in the gastro-intestinal tract.
COPEPODA	A group of small shrimp like crustaceans, many of which are very important as food for fishes.
CYANOPHYTA	A group of algae with distinct blue-green pigments, some of which produce toxins.

DENDRITIC	Tree like, or branched (appearance).
DETRITUS	Organic debris from decomposing plants and animals.
DIATOMS	A class of algae with distinct (brown) pigments and siliceous cell walls. They are important components of phytoplankton.
DOLOSSE	Special concrete blocks used in the building of protective walls such as breakwaters.
DUNDER	Water borne wastes from sugar mills which comprise the washings from the mill evaporators. They are generally contaminated by sugar from syrup spillages in the mill, as well as oil. The admixture of sewage from the factory may also occur. The dunder is piped to collecting ponds or dams outside the mill, and sometimes disposed of by irrigating sugar cane.
E. COLI	Actually *Escherichia coli*, which are a specific type of non-pathogenic coliform bacteria, ordinarily occurring in the intestinal tract of man and animals. The presence of these organisms is consequently indicative of faecal contamination.
ECOSYSTEM	An ecological system formed by the interaction of co-acting organisms and their environment.
ECTOGENIC (MEROMIXIS)	A mixing process in a lake brought about by water of external origin (such as the sea).
ENDEMIC	Normally confined to a given region.
EPIFAUNA	Animal life found on the surface of any substrate — such as plants, rocks or even other animals.
EPILIMNION	The water layer (in a lake) above the thermocline.
EPIPELIC	Animals or plants found on the surface of a mud substrate.
EPIPHYTE	Non-parasitic plants living on the surface of any substrate (such as diatoms upon the leaves of "eel-grass").
EURYHALINE	Organisms able to tolerate a wide variation of salinity and subsequently osmotic pressure.
EUTROPHICATION	The process by which a body of water is greatly enriched by the natural or artificial addition of nutrients. They may result in both beneficial (increased productivity) and adverse effects.
"EVERGLADES SCHEME"	A proposal by the Natal Parks Board to create waterways and walk-ways into swamp areas at St. Lucia for recreational/educational purposes.
FAUNA	Animal components of a particular area.
FILAMENTOUS	Thread-like.
FLOCCULATION	A term used to describe the settlement or coagulation of river borne silt particles when they come into contact with sea water.
FLORA	Plant components of a particular area.
FLUVIAL	(Deposits) originating from rivers.

FOOD CHAIN or FOOD WEB	A 'chain' of organisms through which energy is transferred. Each 'link' feeds on and obtains energy from the one preceding it. The various components of one link collectively form a **trophic level**. The lowest levels are primary producers. Above these are consumer levels.
GASTROPOD	Class of mollusc, often single shelled.
GEOMORPHOLOGY	The study of landform or topography.
GILL NET	A vertically placed net left in the water into which fish blunder and become enmeshed.
GRAVID	A condition when the ovaries of animals become ripe and ready for egg laying (or spawning).
HABITAT	A place (or niche) with a particular kind of environment.
HALOCLINE	A layer of water exhibiting a steep salinity gradient separating freshwater above from salt water below.
HALOPHILOUS	A type of plant that can tolerate very salty conditions being typical of those alongside estuaries (i.e. salt loving).
"HERRING-BONE DRAINAGE"	A means of drainage (commonly installed in waterlogged areas), which, from an aerial view resembles a fish skeleton.
HOMOTHERMAL	Temperatures which are distributed evenly throughout the water body.
HYDROGRAPHIC	The descriptive study of water masses (flow, floods, tides, etc.).
HYDROSTATIC HEAD	The pressure exerted by water (or any liquid for that matter) where movement is not involved.
HYGROPHILOUS	A type of plant which can live where there is an abundant supply of water.
HYPOLIMNION	The water layer (in a lake) below the thermocline.
HYPSOGRAPHIC CURVE	A graphical means of depicting the relationship between volume and depth.
INTERSTITIAL	Substances or organisms occurring in the spaces between sediment particles.
INVERTEBRATES	Collective term for animals without backbones.
LARVA	The pre-adult form of many invertebrates, which is normally very different from the adult in structure and habits.
LITTORAL DRIFT	Wave generated movements of water or sand along the coastline — often in the direction of the prevailing swell.
MACROPHYTES	Any large plant as opposed to small ones (or microphytes). Aquatic macrophytes may float at the surface (such as hyacinth, *(Eichornia)*) or be submerged and rooted in the mud (such as pondweed, *(Potamogeton)*).
MANGAL	A littoral plant community of mangroves and associated species growing below the high water mark in waterlogged soils.
MEGALOPA	A larval stage of certain crustacea such as crabs, conspicuous by large stalked eyes.

MEIOFAUNA	Microscopic or semi-microscopic animals that inhabit sediments (often interstitial) but live quite independently of the macrofauna (or benthos).
MEROPLANKTON	Seasonal or temporary plankton.
MESOTROPHIC	A moderately nourished system (neither eutrophic or oligotrophic).
MICROBIOTA	Flora and fauna composed of microscopic organisms.
MICRON	One thousandth of a millimetre, abbreviated to μ.
MORPHOMETRY	Physical dimensions such as shape, depth, width, length, etc.
NEMATODES	Small cylindrical worms (called round worms) with tapered ends, and a cuticle (or skin) made from a substance called chitin. They move with a whip-like thrashing of the body. They are tremendously abundant wherever organic substances are present.
NERITIC	Inhabiting the sea above the continental shelf.
OLIGOCHAETES	A group of aquatic worms which are similar to earth worms. They are generally very abundant in organically rich substrates, and are tolerant of low oxygen concentrations.
OLIGOTROPHIC	A poorly nourished system, being the opposite to eutrophic.
OSMOREGULATION	The control of water/salts balance (i.e. osmotic processes) within an organism.
PATHOGENIC	Disease producing.
PETASMA	Male genital organs of a penaeid prawn.
PHOTOSYNTHESIS	The process by which living plant cells (by means of their chlorophyll) form organic nutriments (in the form of carbohydrates) by the utilization of the **energy** from sunlight, **water** from the cell and **carbon dioxide** from the air. The process may also be referred to as **carbon assimilation.**
PHYTOPLANKTON	Plant components of plankton.
PISCIVOROUS	Fish eating.
PLANKTON	Microscopic animals and plants which float or drift passively in the water. They are of great ecological importance in the food web of an ecosystem such as an estuary.
PLATE COUNT	A bacterial count of all the micro-organisms cultured in a dish (or plate) containing a solid nutrient medium upon which they can grow.
PODSOLIZED	Leached.
PPM	Parts per million (≡milligrams per litre).
PRIMARY PRODUCTIVITY	The rate of photosynthesis.
RIPARIAN	Living on the banks of rivers or streams.
SALMONELLA	A type of coliform bacterium of particular significance to man because of its role in producing sudden gastro-intestinal disturbances. These organisms may also produce typhoid.

SAPROBIOLOGICAL	Organisms (such as bacteria and fungi) which live on dead or decaying organic matter.
SCUBA	Self contained underwater breathing apparatus.
SECCHI DISC	A simple instrument to measure the transparency of water. It consists of a circular disc which is slowly lowered on a graduated line into the water until it disappears from sight. The depth at which this happens is an indication of water turbidity. Thus, in turbid waters the readings are low, and in clear waters they are high.
SEICHE	A difference in water levels which arises from water movements caused by strong winds blowing for long periods of time from one particular direction across a water surface.
SLED NET	A very fine mesh net, with a D-shaped opening, which is pulled slowly **across** the current, along the bottom of an estuary in order to sample the zooplankton occurring at that depth. The D is maintained in a horizontal position to the ground, but just off the bottom by three sleds.
STENOHALINE	Organisms unable to tolerate a wide variation of salinity, and consequently normally restricted to sea water.
STRAND LINE	A line of debris which becomes stranded along the high water mark.
STRATIFICATION	A term used to describe a layered water body — whether such layers be temperature, oxygen or salinity.
TELEOST	Modern day bony fishes (as distinct from cartilaginous).
TERRIGENOUS	Derived from land.
THERMOCLINE	A relatively narrow layer of water with a steep temperature gradient which, in a lake separates the epilimnion and the hypolimnion.
TIDAL BASIN	That area of an estuarine system (such as Kosi) where a tidal influence is noticeable.
TIDAL PRISM	The difference between the volume of water (in an estuary) at high tide and that at low tide.
TROPHIC LEVEL	See under 'Food web'.
TURNOVER	An event which normally occurs in winter when the bottom water becomes replaced by surface water due to the latter having become colder (and hence heavier) during the winter.
VECTOR	A carrier of pathogenic organisms, and any agent (such as a mosquito) transferring a parasite (such as malaria) to a host (such as man).
VOLATILE	Substances which evaporate rapidly.
WATERSHED	The line along a ridge which separates waters flowing to different rivers or drainage basins.
ZOOPLANKTON	Animal components of plankton.

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