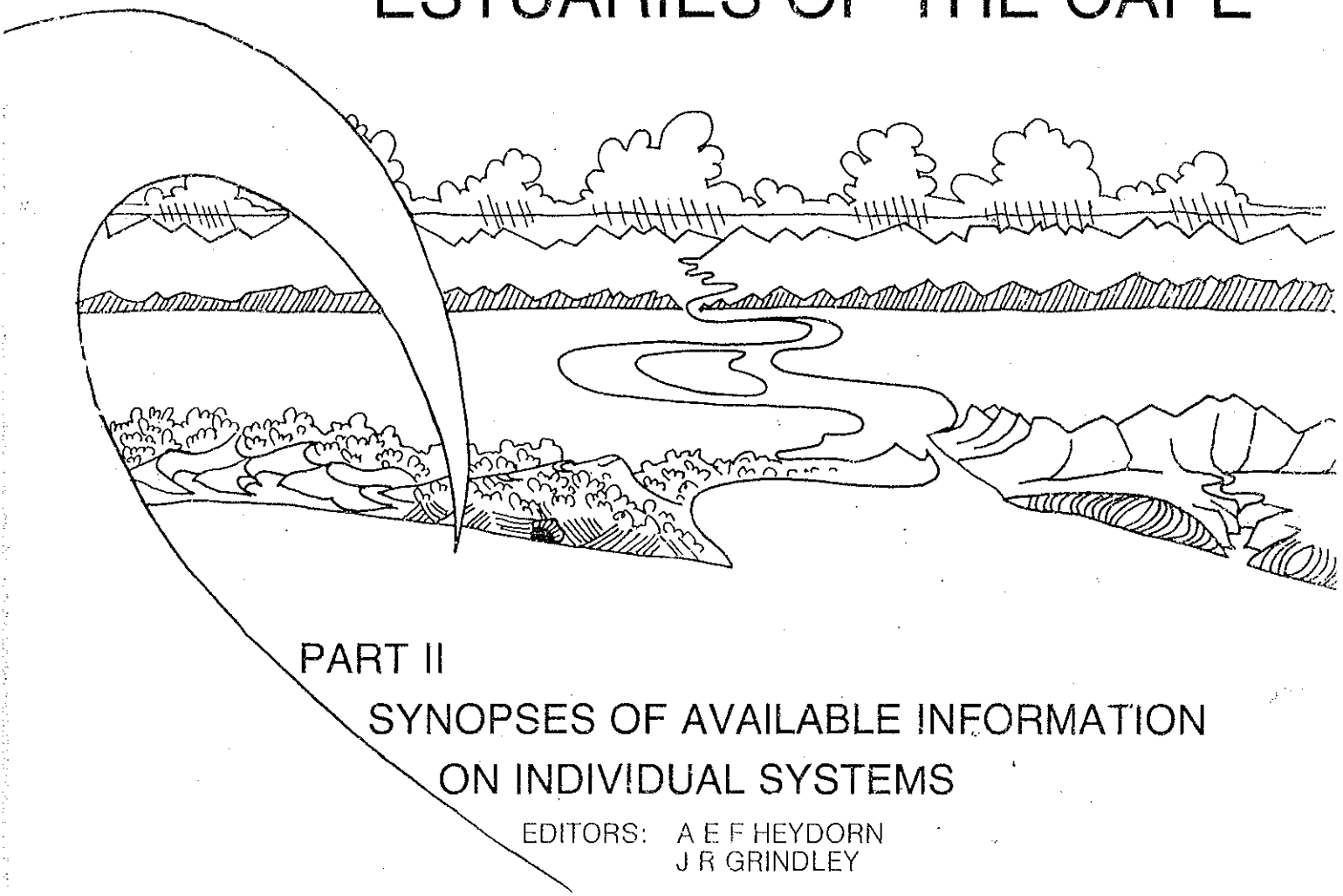
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT – ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS: A E F HEYDORN
J R GRINDLEY

REPORT NO. 18

BOT/KLEINMOND SYSTEM (CSW 13)

CSIR RESEARCH REPORT 417

Stellenbosch, South Africa
September 1982

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PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 18: BOT/KLEINMOND SYSTEM (CSW 13)

(CSW 13 — CSIR Estuary Index Number)

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PREFACE

The Estuarine and Coastal Research Unit (ECRU) was established by the National Research Institute for Oceanology (NRIO) of the CSIR in 1979 with the following aims:

- to contribute information relevant to the development of a cohesive management policy for the South African coastline;

- to compile syntheses of all available knowledge on the 167 estuaries of the Cape between the Kei and the Orange rivers;

- to identify gaps in information, to conduct research to fill these and to stimulate Universities, Museums and other institutions to become involved in this kind of work;

- to contribute to *ad hoc* investigations carried out by NRIO on the impacts of proposed developments in the coastal environment, and especially in estuaries.

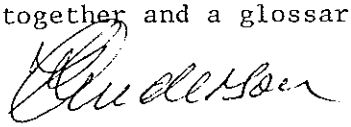
The Unit was established at the request of the Government, and the Department of Environment Affairs contributes substantially to the running costs.

In 1980 the Unit published its first report under the title "The Estuaries of the Cape, Part I - Synopsis of the Cape Coast. Natural Features, Dynamics and Utilization" (by Heydorn and Tinley)+. As the name of the report implies, it is an overview of the Cape Coast dealing with aspects such as climate, geology, soils, catchments, run-off, vegetation, oceanography, and of course, estuaries. At the specific request of the Government, the report includes preliminary management recommendations.

The present report is one of a series on Cape Estuaries being published under the general title "The Estuaries of the Cape, Part II". In these reports all available information on individual estuaries is summarized and presented in a format similar to that used in a report on Natal estuaries which was published by the Natal Town and Regional Planning Commission in 1978. It was found however, that much information is dated or inadequate and that the compilation of Part II reports is therefore not possible without brief prior surveys by the ECRU. These surveys are usually carried out in collaboration with the Botanical Research Institute and frequently with individual scientists who have special interest in the systems concerned. One of these is Prof JR Grindley of the University of Cape Town who is co-editor of the Part II series.

These surveys are, however, not adequate to provide complete understanding of the functioning of estuarine systems under the variable conditions prevalent along the South African coastline. The ECRU therefore liaises closely with Universities and other research institutes and encourages them to carry out longer-term research on selected estuarine systems. In this way a far greater range of expertise is involved in the programme and it is hoped that the needs of those responsible for coastal zone management at Local-, Provincial and Central Government levels can be met within a reasonable period of time.

Finally, the attempt has been made to write the Part II reports in language understandable to the layman. However it has been impossible to avoid technical terms altogether and a glossary explaining these is therefore included in each report.



FP Anderson
DIRECTOR

National Research Institute for Oceanology
CSIR

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APPENDICES

PLATES

BOT/KLEINMOND SYSTEM

In this report an attempt is made to synthesise available information on the Botriviervlei and Kleinmond estuary. Research has increasingly shown that the two have close links and must be regarded as one system. This has not always been recognised and consequently more information is available on the Bot vlei than on the Kleinmond estuary. Whenever only one of the two lagoons is mentioned below it should be assumed that no information exists for the other.

1. HISTORICAL BACKGROUND

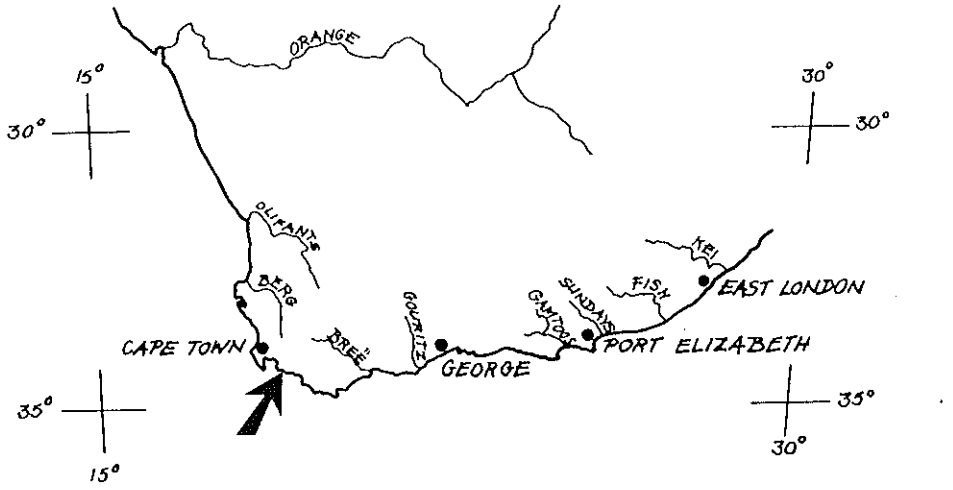
The name Bot River is probably a direct reference to the slow-flowing nature of the river and is derived from *bot*, the Afrikaans word for sluggish. The Kleinmond estuary derives its name from the fact that it used to be the mouth of the Little Bot River which had its origins in the Botriviervlei (Topographical Sheet, 1903). Unfortunately little is known of the history of the Botriviervlei and few documents are available. It seems that the mouth of the Bot River was used as a "natural port of a large and most productive portion of the Swellendam District, as the mouth of the Breede River is of its more eastern region" and that it served as a place where farmers from surrounding areas could send their produce, particularly wheat, for shipping to far-away markets (South African Commercial Advertiser : 3 August 1833 and 27 June 1938). There is some doubt, however, about whether the vlei itself was ever used as a harbour or whether the articles refer to the nearby bay at Hawston now called Harry's Bay. Certainly the Royal Navy chart "Table Bay to Cape Agulhas" (Sheet 1) surveyed between 1853 and 1869 shows the Bot estuary to be closed to the sea and it also clearly shows the Little Bot River with a mouth at what is now Kleinmond.

More recently, within living memory, the mouth of the Botriviervlei has been closed more or less permanently. There is some evidence that the vlei occasionally overflowed into the sea without actually cutting a channel and thus establishing a true mouth (R Bally, Univ. of Cape Town, pers. comm.) and water from the vlei can also overflow into the sea via the Kleinmond estuary some 5 km to the northwest which is also historically the mouth of the Bot River. There is, however, a history of artificial breaching of the dune barrier carried out mainly by local fisherfolk from nearby Hawston, sometimes much against the wishes of farmers around the vlei (see Caledon Divisional Council, Memorandum no. VB 26/1, 1975). This controversy was revived again recently when the question of artificial breaching was discussed by various interested parties. The intensity of the discussion made it clear that an urgent need exists for the development of a management strategy for the system and its implementation by one responsible body.

2. LOCATION

The Botriviervlei lies between $34^{\circ}18\frac{1}{2}'$ - $34^{\circ}22\frac{1}{2}'$S and $19^{\circ}04'$ - $19^{\circ}09'$E between the towns of Kleinmond and Hermanus on the south

west coast of the Cape Province. It is about 110 km from Cape Town.



2.1 Accessibility

The Bot vlei lies on the main coastal road which skirts the eastern shore of False Bay and then proceeds via Betty's Bay and Kleinmond (R44) to Hermanus and beyond (R43). The newly constructed section of road branching off the national road no. 2 (N2) near the town of Bot River, passes over a modern bridge which bisects the floodplains at the head of the estuary and proceeds on to Hermanus. The vlei itself is accessible in three places; the remaining areas are private land. On the western shoreline there is an untarred public road branching off the R44 at Lamloch and leading to the water's edge. On the opposite shoreline there is access to two developments, the Lake Marina development and Yacht Club near the mouth of the Afdaks River, and the Sonesta holiday resort for coloured persons near the coast. The former is reached via a tarred road branching off the R43, the latter via the township of Hawston (Figure 1).

2.2 Local authorities

The Botriviervlei and its entire catchment fall within the jurisdiction of the Caledon Divisional Council with head offices at Caledon. There are Municipal Offices at Kleinmond and Local Area representations at Hawston and Bot River. The state land on the Houhoek and Groenland mountains is administered by the Directorate of Forestry.

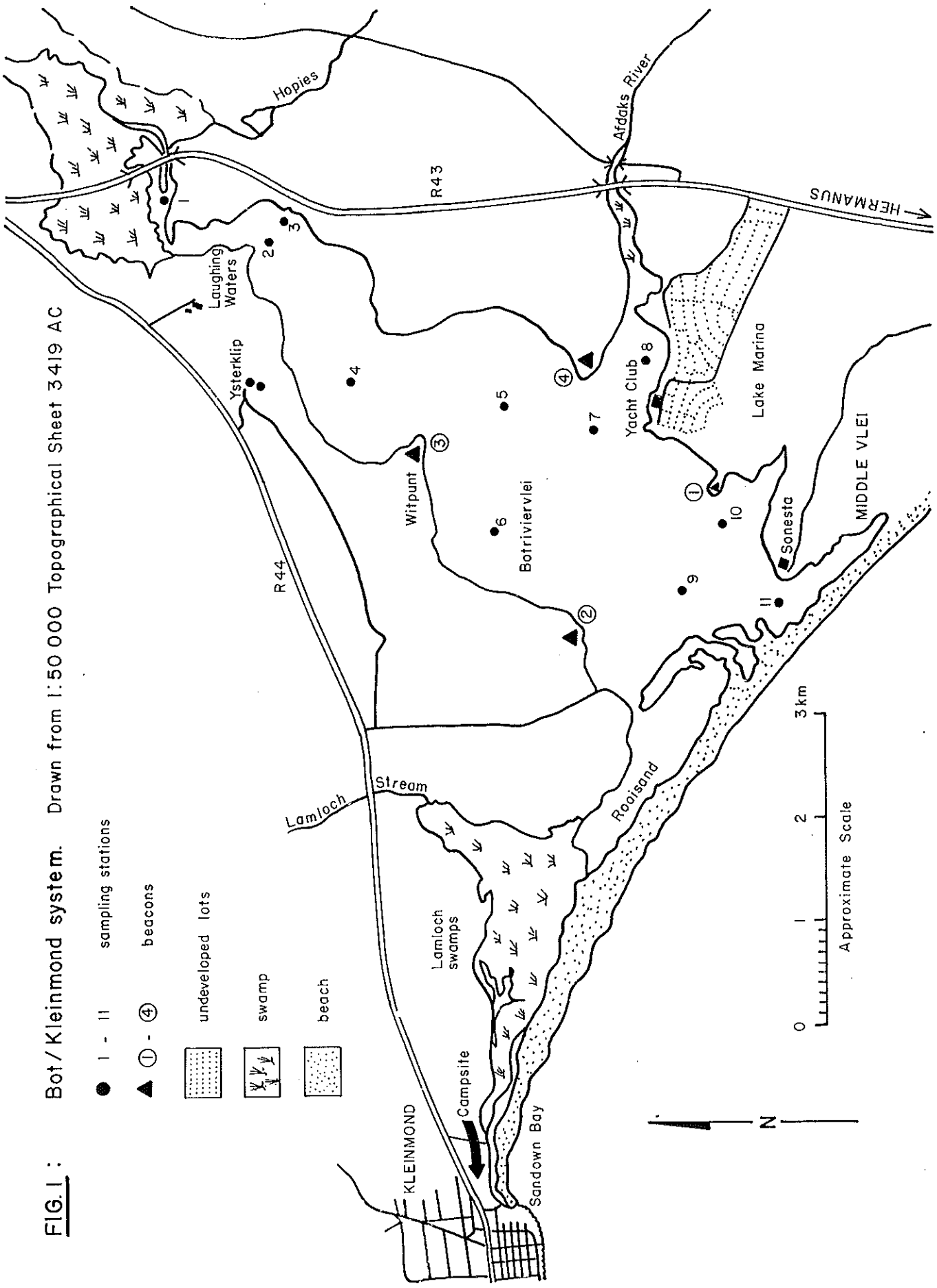


FIG. 1 : Bot / Kleinmond system. Drawn from 1:50 000 Topographical Sheet 3419 AC

The Caledon Divisional Council has recently abolished its estuaries committee ("vleiekomitee") and further decided that all duties and functions with regard to the Bot and Klein estuaries will be carried out only on instructions from the Department of Nature and Environmental Conservation (JW Lambrechts, Caledon Divisional Council, pers. comm.).

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Catchment characteristics

Area

813 km^2	(Heydorn and Tinley, 1980)
927 km^2	(Noble and Hemens, 1978)
1000 km^2	(Caledon Divisional Council, Memo. no. VB 26/1, 1975)

The Bot River and its tributaries drain the Houhoek, Groenland, Swart, Shaw's and Babilonstoring Mountains.

River length

The total length of the river from the dunes at the seaward side of the Botriviervlei to the source of the Bot River is approximately 42 km while the source of the Swart River, a major tributary of the Bot, is about 48 km from the sea (1:250 000 Topographical Sheet 3319).

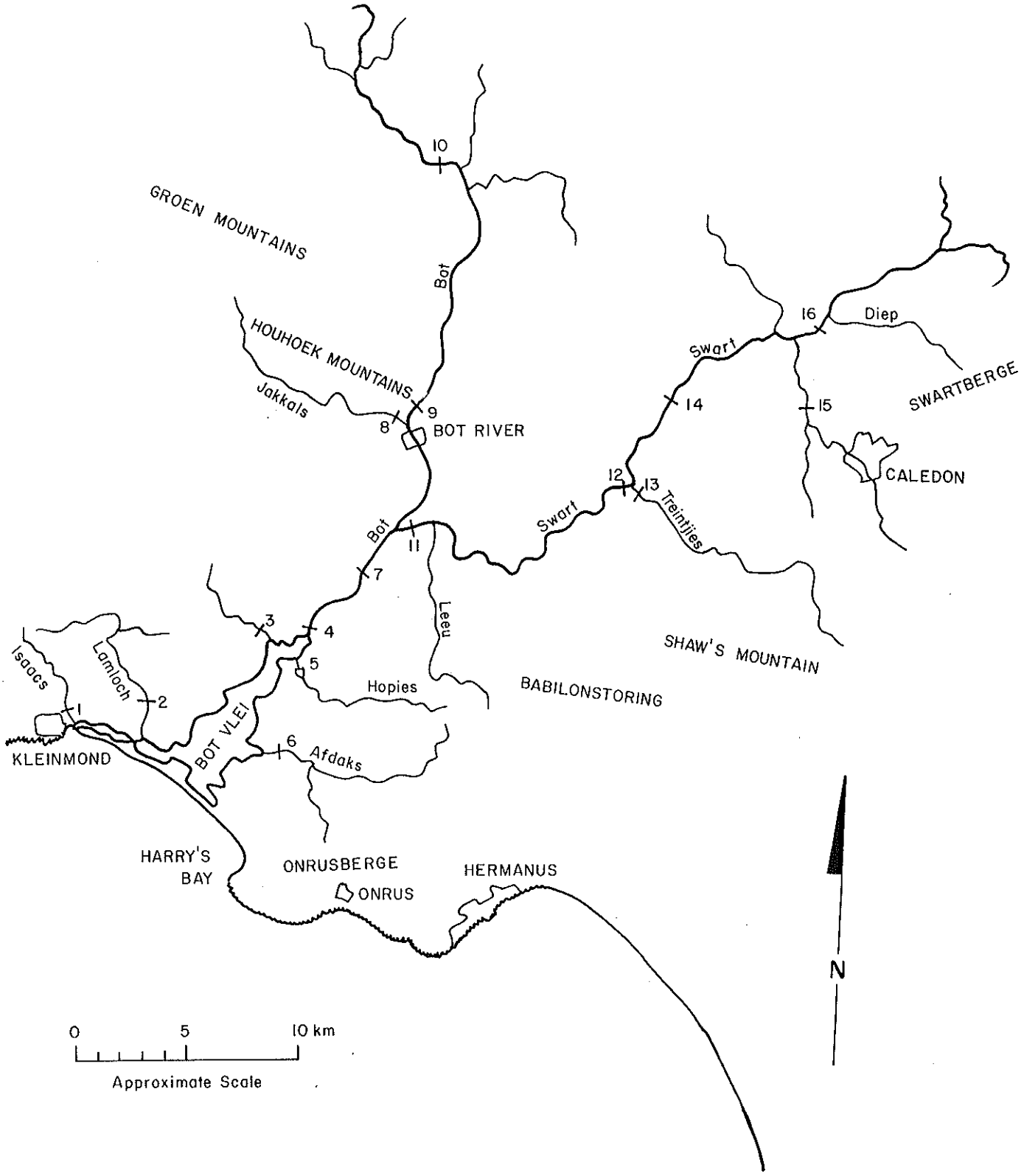
Tributaries

Apart from a number of small tributaries two larger rivers drain into the Bot River. About 20 km from the sea the Bot is joined by the Jakkals River and about 5 km downstream of this junction the major tributary, the Swart River, flows into the Bot. This river also collects the waters of the smaller Treintjies River. Several small rivers drain directly into the Botriviervlei. The Hopies River flows into the head of the estuary on the southeastern side while the Afdaks River drains into the same side about halfway between the head of the vlei and the sea. The Lamloch Stream flows both into the shallow western extension of the vlei known as Rooisand and into the Kleinmond swamps. The small Isaacs River enters the Kleinmond estuary near its mouth (Figure 2).

Rainfall and run-off

The run-off is 116 x 10^6 m^3 (Noble and Hemens, 1978).
The Botriviervlei and catchment lie within the Winter Rainfall Region with highest precipitation in June/July. The mean annual rainfall varies between 500 and 600 mm (Heydorn and Tinley, 1980) although this figure may be "1200 mm and higher" (Caledon Divisional Council, Memo. no. VB 26/1, 1975).

FIG. 2: Catchment of the Botriviervlei showing sixteen stations sampled in the major rivers of the area. Drawn from 1:50 000 Topographical Sheet 3319.



Geology and water quality

The catchment area of the Botriviervlei is dominated by sedimentary rocks of the Bokkeveld Group although on both its western and eastern borders some Table Mountain Sandstone (TMS) is present

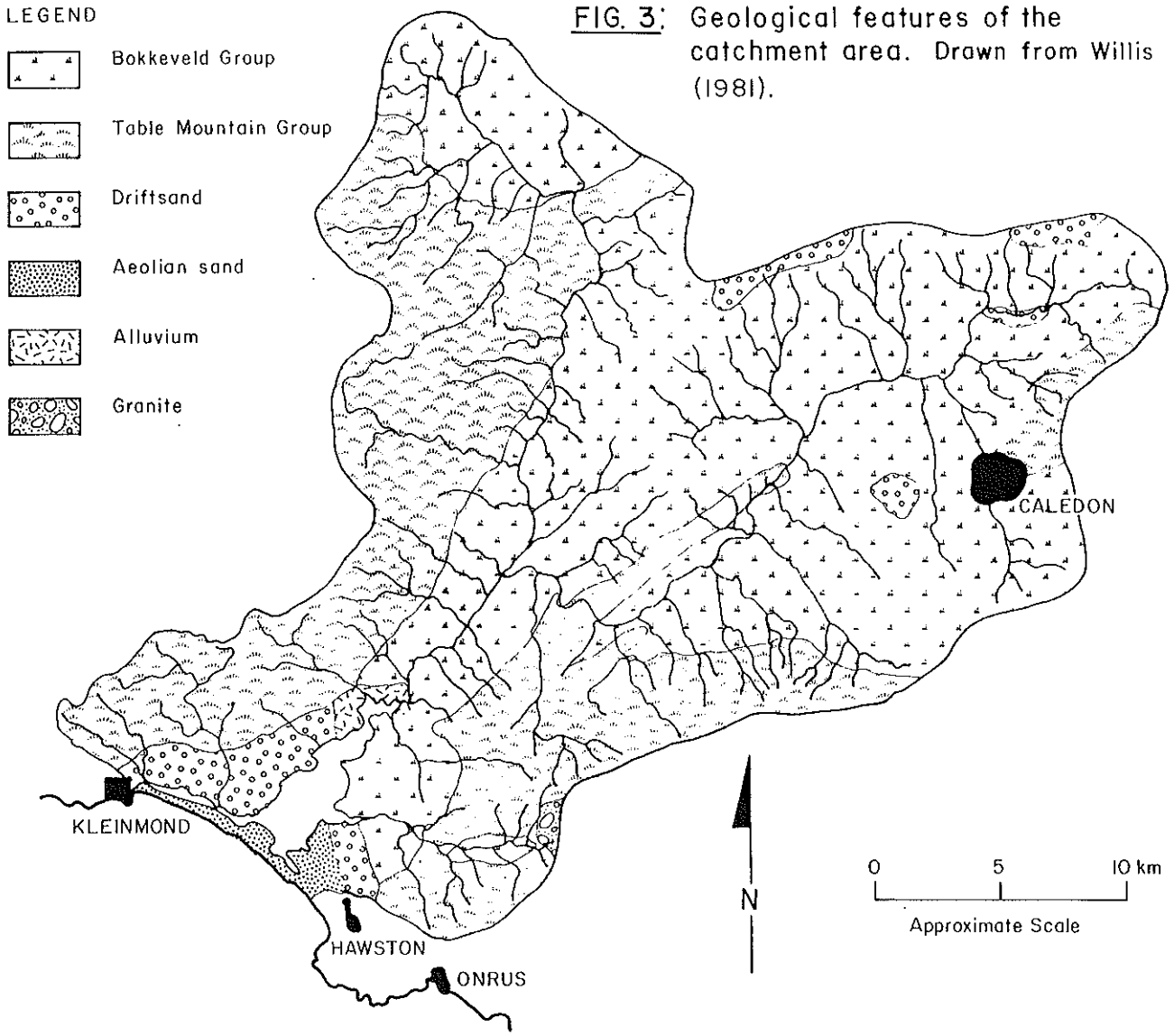


FIG. 3: Geological features of the catchment area. Drawn from Willis (1981).

(Willis, 1981; see also Figure 3). These geological features produce waters unstained by humic acids and the vlei has "white" or "turbid" waters (Heydorn and Tinley, 1980).

The ECRU survey on 19 August 1982 recorded pH and salinities at 16 stations in the Bot River catchment (Figure 2). The results are shown in Table 1. It can be seen that the pH in the Bot and Swart Rivers and its tributaries varied between 7,4 and 9,4

confirming that the river system carries turbid waters which are characteristically alkaline (Heydorn and Tinley, 1980).

In contrast, neighbouring estuaries, for example the Palmiet, which are fed by TMS-dominated catchments, are all deeply stained with humic acids to the colour of strong tea. This is also true of the Kleinmond estuary which is fed principally by the Lamloch Stream and the Isaacs River, both of which drain TMS areas. Table 1 confirms this, showing acid, black waters in those two rivers.

All the rivers in the Bot River catchment were found to be either fresh or only very faintly saline ; it appears, thus, that the catchment does not contribute to the salinity of the estuary although it can be seen that the Swart River and its tributaries had brackish waters of two to three parts per thousand while the Bot River waters were completely fresh. It should be noted, however, that this may depend on the flow rate of the rivers. During summer, when less water drains from the catchment, salinities in the rivers may be much higher. Thus a value of 10 parts per thousand was measured in one of the Swart River tributaries in summer 1981 (AEF Heydorn, pers. comm.). (The saline waters of the vlei extended as far as the old road bridge over the Bot River, about seventeen kilometres from the sea.)

3.1.2 Land Ownership / Uses

Apart from some forestry land on the Houhoek and Groen mountains, the catchment of the Botriviervlei is dominated by privately owned farmland. This summary is based on information obtained from Mr C Baker, Agriculture Extension Officer at Caledon.

About 60 percent of the drainage basin is used for agriculture. The average size of farms in the area is about 750 - 800 ha and as much as 70 percent of the farmland may be used for wheat farming. The remaining area is used mainly for sheep pasturage. In the rather steep-sided valley of the Bot River, the trend is for farmers to move increasingly away from the traditional wheat farming to pasturage, but there are also deciduous fruit orchards and vineyards. This is because of erosion problems in the valley which are aggravated by regular ploughing. Erosion is similarly problematic in the remainder of the catchment because the soil layer is rather shallow and unstable and farmers generally alternate between wheat and pasturage as a soil conservation measure.

The soil in the area is rather poor, being particularly low in phosphorus, and fertilizers are used extensively. Inevitably there is some run-off of fertilizers into the rivers. This is not regarded as a problem (C Baker, pers. comm.) and the water is not analysed on a regular basis. Nutrient levels in the Bot estuary (Tables 3 and 4) confirm this since the values are not particularly high.

TABLE 1: Salinity and pH measurements in the rivers of the catchment of the Bot/Kleinmond system (ECRU survey 82-08-19). Stations are shown in Figure 2.

Station No		Salinity parts per thousand	pH
1	lower Isaacs River	0,0	3,6
2	lower Lamloch Stream	1,0	4,1
3	small river entering Bot vlei above Laughing Waters	0,0	6,1
4	Bot River at new road bridge	11,0	7,4
5	Hopies River below dam	2,0	9,4
6	Afdaks River at old road bridge	2,0	8,6
7	Bot River at old road bridge	2,0	8,6
8	Jakkals River just above junction with Bot River	0,0	8,7
9	Bot River above town	0,5	8,7
10	upper Bot River	0,0	8,9
11	Swart River just before junction with Bot River	3,0	8,3
12	Swart River at confluence with Treintjies River	2,0	7,4
13	Treintjies River just above station 12 (stagnant)	3,0	7,7
14	Swart River at N2 bridge	2,0	8,5
15	Tributary of Swart at N2 bridge near Caledon	2,0	8,5
16	Swart River just below confluence with Diep River	3,0	8,1

3.1.3 Obstructions

There are no State-constructed dams in the catchment although many farmers have their own earth dams which collect rainwater for irrigation purposes. Occasionally water is pumped from the rivers in the drainage basin into the farm dams in order to stock up for the summer months (Caledon Divisional Council, Memo. no. VB 26/1, 1975). The only dam built across a river course is at the northeastern end of the Botriviervlei where the Hopies River has been dammed up by a large earthen dam shortly before it enters the vlei.

3.1.4 Siltation

Rooseboom (1980) estimates that as much as 150 tons of sediment per square kilometre of catchment area may be eroded annually, although no direct measurements are available. Erosion of the steeper sides of the upper Bot River valley is evident and run-off from ploughed farmland is inevitable.

3.1.5 River flow patterns

The Directorate of Water Affairs has maintained a river flow gauging station on the Bot River since April 1967 (Station no. G4M14 "Roode Heuvel"). The annual records until the 1978/79 season clearly show the seasonal nature of the flow regime in the Bot River. Maximum flow rates are usually recorded in July or August when the maximum daily average flow may be as high as 65,91 m^3/s (August 1974) although much lower rates may also be recorded, for example in September 1969 the maximum daily average flow was only 1,33 m^3/s. The average maximum daily flow for the whole period 1967 - 1979 is 2,52 m^3/s.

3.2 Estuary

Sections 3.2.1 and 3.2.2 contributed by Dr G A W Fromme, CEHD/NRIO, Stellenbosch.

3.2.1 Estuary Characteristics

Estuary type and area

The lagoon is of the closed estuary type with sporadical, natural breachings of the coastal dune belt and periodical, artificial openings every two or three years, mostly at Sonesta (Figure 4). When full, i.e. when the water level is approximately 2 m above mean sea level (MSL), the main lagoon has an area of 13,6 km^2 and the western side arm, or Rooisand, an area of 1,28 km^2.

Geomorphology and geology

Although the Bot River drains only a small catchment (813 - 1000 km^2) it forms one of the largest lagoons in the southwestern Cape. The Botriviervlei is a relatively shallow triangular coastal lake, 7 km long and up to 2 km wide, situated in a broad valley flanked by the mountains of Kleinmond in the NW and Hawston-Onrust-Hermanus in the SW, both about 450 metres high. The geological features of the area are shown in Figure 3.

The lagoon is separated from the sea by a 100 - 200 metres wide coastal dune belt consisting of a steep, narrow barrier dune ridge, 3 - 6 m high, and a hinterland of low hummock dunes, both partially vegetated by coastal grasses and shrubs (see Section 4.1.5).

At the seaward, northwestern end of the main lagoon there is a shallow side arm, Rooisand (bottom level MSL + 1,7 m), which is connected to the main vlei by a narrow, 80 m wide bottleneck called Die Keel. During periods of low water levels in the main lagoon, Rooisand is usually dry, but when the water level rises above MSL + 1,7 m, the vlei overflows through this area into the adjacent Kleinmond estuary via the Lamloch swamp area. There is also a distinct overflow channel in the dune hinterland which links the western end of Rooisand with the swamps (Figure 4, see also Plate I).

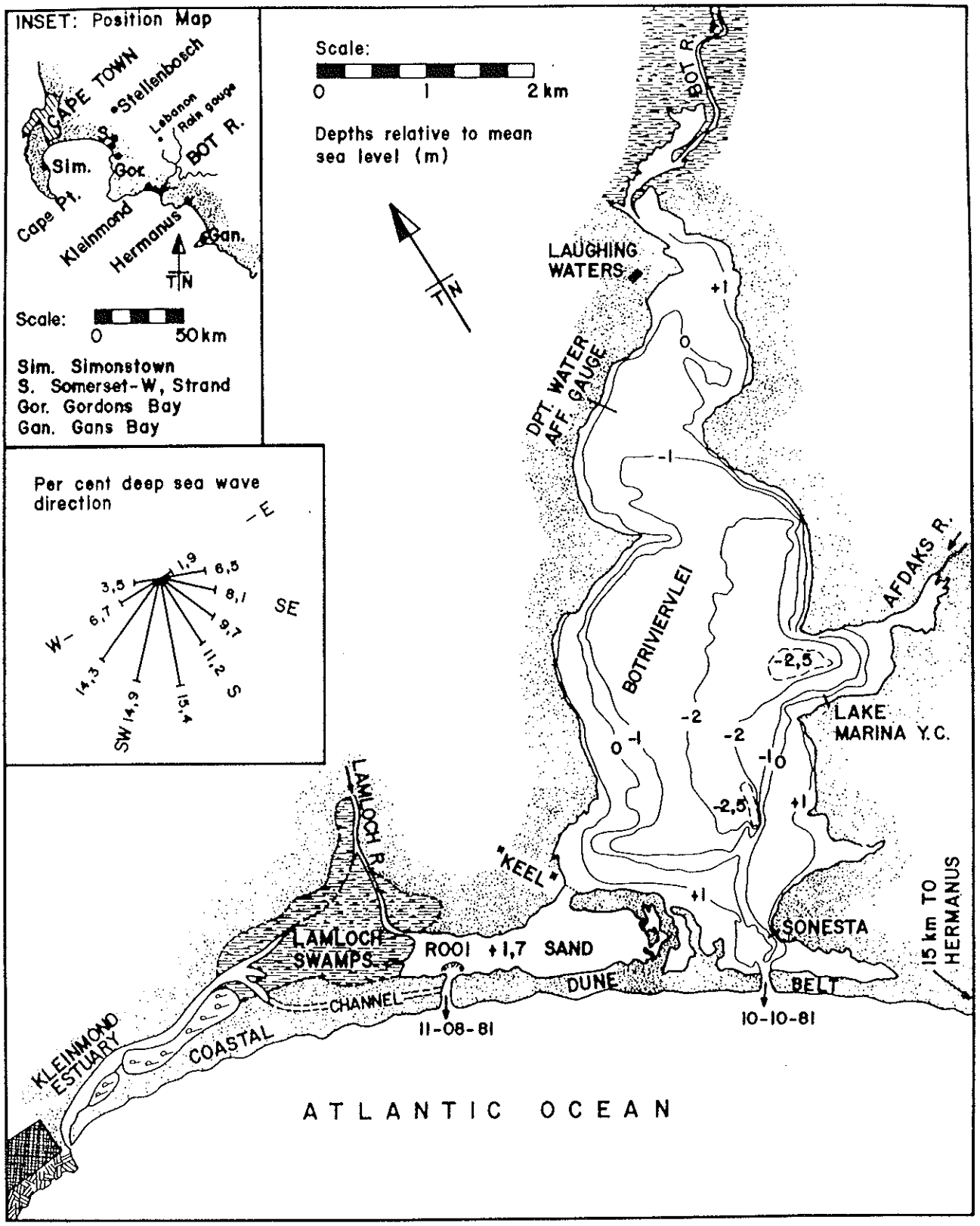


FIG. 4: BOTRIVIERVLEI SYSTEM (Bathymetry after J. Willis, 1981)

Sandbar characteristics

The Botriviervlei is effectively dammed up by a coastal dune belt. The dune ridge is, however, interrupted by a number of natural gaps through which wash-over from the sea occurs occasionally. Between Sonesta and the western end of Rooisand, 22 such gaps, measuring from a few metres to over 100 m in width, were mapped. Observations have shown that four conditions must coincide in order for wash-over from the sea to the vlei to occur: 1. Equinox spring high tides. 2. High waves. 3. Onshore winds. 4. High water level in the vlei inundating the dune hinterland so that wash-over can reach the vlei water.

Besides the natural wash-over fans there are two major artificial synclines in the dune ridge. The one, 250 - 300 m wide, situated at Sonesta, is caused by continuous breachings, mostly artificial, but is closed most of the time by a massive sand bar built up by wave and current action. A side effect of the Sonesta breachings is that conspicuously high (8 - 10 m), bare, transverse sand dunes are formed by strong southeasterly summer winds blowing across the large zone of unconsolidated sand produced by the breachings. In August 1981 another artificial opening was cut in the Bot dune ridge at the western end of Rooisand (Figure 4). This mouth, which was about 50 m wide, was closed naturally by a sand bar three months after the breaching.

Bathymetry

A bathymetric survey of the Botriviervlei was completed at the end of 1980 (Willis, 1981). The bathymetric chart (Figure 4) shows shallow water over most areas of the vlei (bed level 1 - 2 m below MSL) and confined deeper areas with bed level of 2 - 2,5 m below MSL. The water level usually fluctuates between about MSL + 1,4 m and MSL + 2,7 m, although when the vlei is opened to the sea it drops to approximately MSL. It can also be seen that the vlei is generally deeper along the eastern banks and that the deep water areas are congruent with the ancient Bot River valley. The slope of the bed across the centre of the vlei from the western bank to the Afdaks River bay is very flat, approximately 1 : 60, or less than one degree.

There are some marginal low-lying areas which are flooded during periods of high water levels. These are the arm SE of Sonesta, and the Rooisand area which serves as a link between the main vlei and the Kleinmond estuary.

Bottom material

Geoseismic profiling and drilling by the Geological Survey (Theron et al., 1980) revealed two facies of deposition:
a) Fine fluviatile sediments infilling the bedrock topography of the drowning river valley during the onset of the rise in sea level (beginning of the Flandrian Transgression) 18 000 years ago. b) Subsequent marine sedimentation with marine mud in the upper reaches of the ancient bay and clean marine sand in the nearshore region.

Analyses by the Geochemistry Department, UCT (Willis, 1982) show that the deeper portions of the vlei contain 95 percent mud, while the shallower regions are covered chiefly by fine to medium sand. Where the bed is formed by Bokkeveld shales, clay-rich sediments with high mud content are found, e.g. at the Lake Marina Yacht Club (see Figure 5).

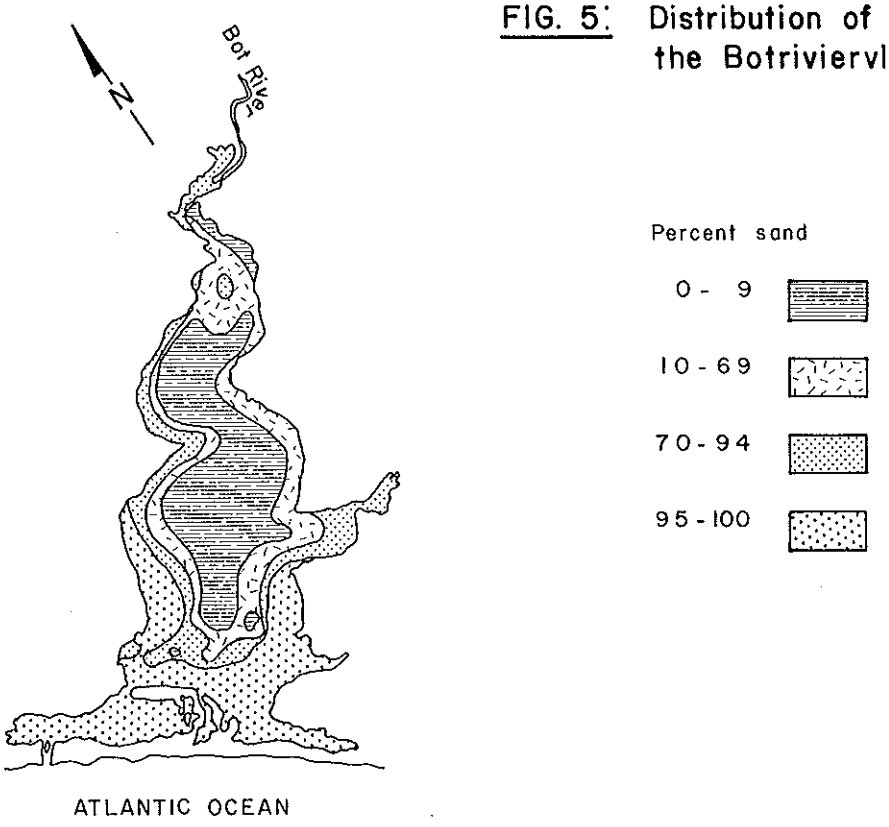


FIG. 5: Distribution of sand fraction in the Botriviervlei. (From Willis, 1982).

Siltation

As in most South African estuaries and lagoons, siltation is a problem in the Bot River. Agriculture and forestry activity causes soil erosion, and irrigation leads to a reduction in run-off resulting in increasing siltation at the bottom of the catchment, that is, in the estuaries and lagoons. Obstructions of sediment-filtering floodplains near the head of an estuary by bridges and causeways can sometimes accelerate siltation in estuaries, although this does not appear to be the case in the Bot River which has a well-defined river bed. Since it can be shown that in such systems the greatest flow, and particularly the transport of the vast majority of suspended sediment, takes place in the donga-like river bed, it appears that the new road bridge between Bot River and Hermanus has little effect on the siltation rates in the Botriviervlei.

During the construction of this bridge, however, the flow of the river was severely impeded. An earthen service dam was built across the river course. Although this contained two culverts designed to allow water to continue flowing into the vlei, these were always found to be blocked on numerous visits since February 1980, and no flow was measured. This dam was breached for the first time by floodwaters in winter 1980 after which it was repaired. During the untimely floods in January 1981 and further

in the winter of that year, a large portion of this dam was washed away and this contributed to some of the sediment which entered the Botriviervlei during those floods. More importantly, some of the sediment accumulated above the service dam during the time that the culverts were blocked, probably also entered the vlei at this time, further increasing the sediment load of the water.

Willis (1981) describes a "very sharp sediment front" in the upper reaches of the Botriviervlei after the strong floods in January 1981. This front is a result of the settling effect of the flocculation of mud suspended in fresh water when it meets saline water. From Willis' data a total deposition of some 35 000 tons of mud over an area of 1,2 km^2 at the top of the vlei can be estimated. In addition, 1 - 2 cm thick fresh mud was also found in the vlei south of the front. According to Rooseboom (1980) an annual sediment load of 122 000 tons can be expected to reach the vlei from the catchment, which means that a substantial deposition of about 35 000 tons during a single flood is possible. It should be noted, however, that this high figure appears to be partly due to the additional sediment introduced by the obstruction in the river course during construction of the bridge across the upper floodplains.

3.2.2 Mouth Dynamics

History of estuary

Maps

Table 2 lists the information gathered from various maps dating back to 1840. It can be seen that the Botriviervlei probably had an open mouth early in the 19th Century, but there is no evidence that since the turn of the century there has been any permanent or semi-permanent inlet.

Aerial photographs

Aerial photographs taken in 1938, 1961, 1972, 1973, 1977, 1979, 1980, and 1981 show that the water surface area was highly variable, with very low levels leaving all side arms dry and massive sand bars obstructing possible outlets at Sonesta or Rooisand-west, as well as very high levels with flooding of the entire dune hinterland and all low lying areas around the lagoon; in this situation active overflow to the Kleinmond estuary through the Lamloch swamps is evident.

Other evidence and summary

It has been noted in the section on Historical Background and in an article by Bally (1982) that the Botriviervlei has been opened to the sea artificially every two or three years in the recent past. According to Mr J Delport (Ysterklip farm, pers. comm.) dune stabilisation along the Hawston coastline after World War II, has resulted in a higher buildup of the coastal dune at Sonesta. This might have contributed to preventing natural breachings of the vlei in the past decades.

It should be mentioned that under certain conditions natural breachings may occur. This could happen when both the Botriviervlei and Kleinmond estuary are closed to the sea and water levels are high. The position for the breaching would then depend on where the lowest point in the coastal dunes is. In the past this has often been at Kleinmond where the water has broken through although this mouth has also often been opened artificially.

It can thus be concluded that since the mid 1800's, there has been a distinct tendency for the Botriviervlei to change from an open estuary to a coastal nearly freshwater lake with only a tentative link with the sea via the Lamloch swamp area and the overflow channel in the dune slack. This development has been retarded in the past by artificial openings aimed at re-establishing estuarine conditions.

Inshore oceanography

Hydraulics of the coast

The characteristics and dynamics of a river mouth are closely related to the topography and geomorphology of the coast and to the wave and current regime of the nearshore and offshore zone. Data from Voluntary Observing Ships, (Swart and Serdyn, 1982) and data from the Slangkop Waverider (Rossouw and Coetzee, 1982) for the area of the southwestern Cape coast, were used to find the various factors which affect this coastline.

The distribution of deep-sea wave directions is given in the wave rose in Figure 6 which shows that the highest proportion of these waves strike the coast from the SSW (15,4 percent). The dominant wave heights for the three main groups of wave periods and their association with wave direction according to VOS is given below:

Period (sec)	Wave height (m)	Direction
<10	2,65	SSW/SW
10 - 14	2,65	SSW/SW
>14	3,20	SW/WSW

VOS record extreme maximum deep sea wave heights of 7,5 to 10,5 m from any direction affecting the Botriviervlei coastline. The Slangkop Waverider records an average significant wave height of 4,5 m and a maximum significant wave height of 9 m which is in agreement with the VOS data.

Using VOS data, the average energy wave height along the Bot River coast was calculated as 2,1 m, which classifies it as a high energy coastline. Comparison with the False Bay coast showed that the Botriviervlei coast receives twice as much wave energy.

TABLE 2: Maps and charts showing Bot/Kleinmond system

Map/Chart	Year	Condition of Botriviervlei
Western Cape	1840	Wide open, funnel-shaped mouth
Coastline Table Bay to Cape Agulhas	1853-1869	Closed estuary with outflow in the form of a river meandering through present marshland to the present Kleinmond estuary mouth
Colony of the Cape of Good Hope	1880	Lagoon mouth slightly open at present Sonesta ("Bot River Mouth"). "Little Bot River" flows westwards into a lake situated at present Lamloch swamps and then to the sea at present Kleinmond estuary mouth ("Little Bot River mouth").
Palmiet to Quoin Point	1880	
Cape of Good Hope South Western	1903	
Cape of Good Hope and Neighbourhood	1899	Sketchy map showing Botriviervlei closed; same river outflow via lake to sea as in 1880 map
1:50 000 Sheet 3319AC	1976	All maps are based on aerial surveys flown in 1938, 1961/62 and 1973. They invariably show large mouth openings, either west or east of Rooisand. Checking these modern maps against the aerial photographs they are based on, no open tidal inlets can be discerned. According to Mr K Lester (Head of Surveys and Mapping, Mowbray, Cape Town) this can be explained by the practice that "everything below the HWOST mark was drawn in blue".
1:50 000 Topographic Sheet SE35/17½	1967	
1:125 000 Geological Map 3419A	1966	
1:250 000 Topographic Sheet 3319	1975	
1:50 000 Sheet 3419 AC	1976	
World Aeronautical Chart 3422 1:1 000 000	1976	

The wave rose in Figure 6 shows that 53 percent of the incident waves arrive at the coast from the south-east. This suggests a northwesterly longshore drift at the coast. A number of visual observations of the movement of turbid waters, flushed out of the Botriviervlei after the artificial openings in 1981, substantiate this. Observations of NW-orientated patterns of sand shoals forming at these inlets, as well as beach erosion SW of Hawston as opposed to accretion at the central and northwesterly beaches of the bay, also indicate a predominantly north-westerly littoral drift.

It can be concluded that:

1. The predominance of high wave energy from the southeast, generates northwesterly longshore currents and sediment transport and causes erosion of the southeasterly beaches and accretion at the northwesterly ones.

2. The loss of sand at the southwesterly beaches is, however, slow and the Bot River coastline is either in sedimentary equilibrium or there is an external source of supply of sand to the system. This might be provided either by sand transported from the SE within the surf zone or from off-shore.

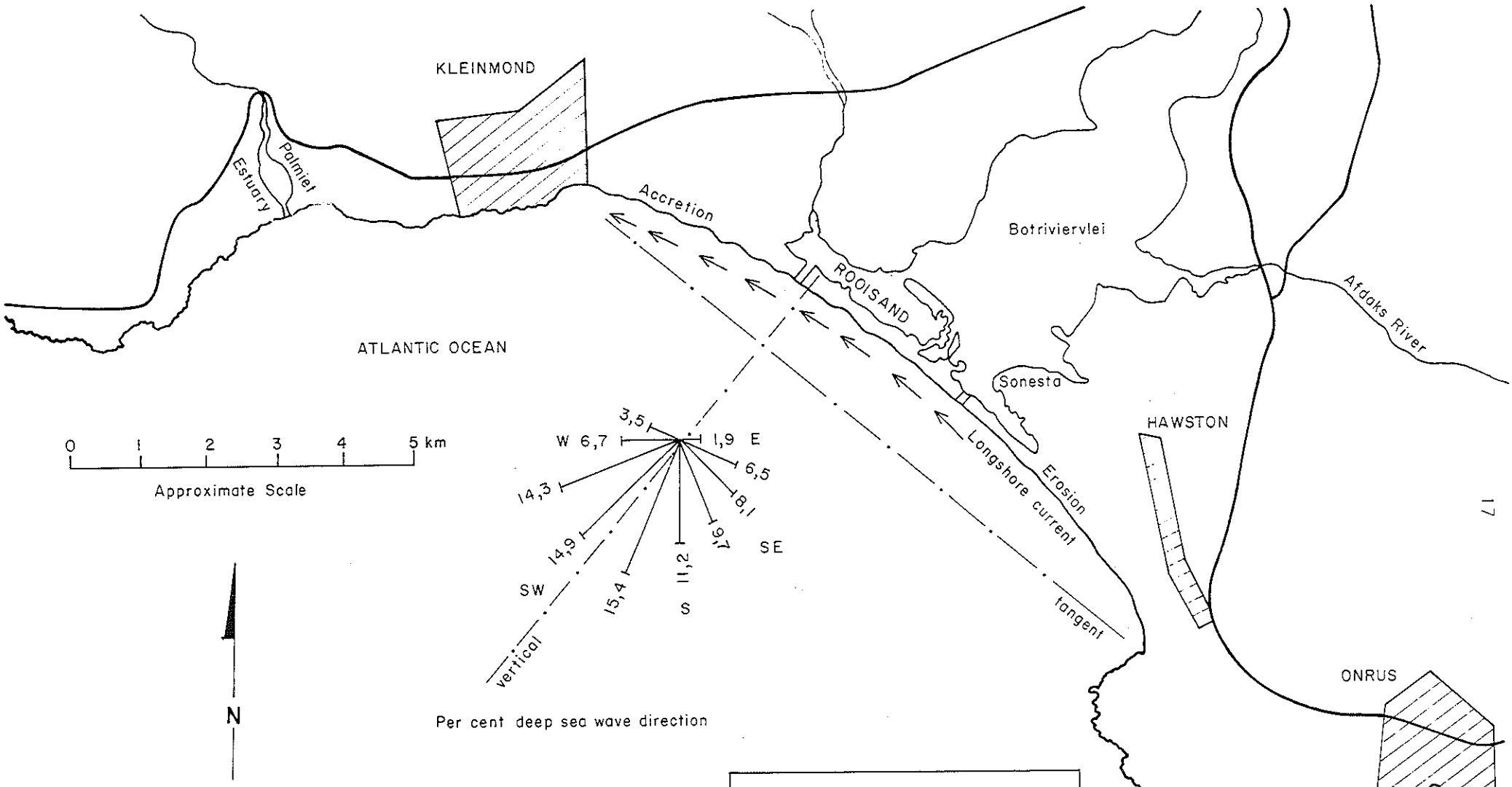
3. The high wave energy which the coast receives causes massive sand bars to build up at temporary openings of estuary mouths. This results in the relatively fast closing of such inlets as soon as the freshwater flow from within the system decreases, usually during the dry summer months.

Hydraulics of the Botriviervlei

The hydraulic behaviour of the Botriviervlei is governed by the seasonal character of the feeder-rivers and by the overflow from the main vlei to the Kleinmond estuary via Die Keel, Rooisand and the Lamloch swamps or the dune hinterland channel (Figure 4). During the winter floods the vlei is filled up to a very high water level (about MSL + 2,7 m) which causes a freshening of the water, reduction in the flocculating effect of saline water on mud-laden fresh water, a high silt load, and a change from a saline to a brackish or even freshwater lake. Flooding of low-lying properties and erosion of banks are other effects of high water levels.

The overflow into the Kleinmond estuary (see "Geomorphology and geology") provides only a very restricted contact with the sea with the disadvantage that the vlei cannot discharge its suspended mud load or obtain seawater by means of tidal exchange. The recruitment of marine fishes is also impeded by this limited connection.

Hydraulically, the overflow system acts as a one-way safety valve which allows excess floodwaters to escape from the Botriviervlei via the Kleinmond system, but prevents the vlei from breaking open to the sea by natural means. This situation is aggravated



Per cent deep sea wave directions	
Right of vertical	Left of vertical
52,8	39,4

FIG. 6: Coastal hydraulics: Bot River Bay.

by the extraction of water in the catchment for agriculture and forestry and by dune consolidation close to the potential breaching site at Sonesta.

Artificial breachings

The sand bar at Sonesta has been breached frequently and regularly in the recent past with the aim of maintaining estuarine conditions in the vlei, particularly with regard to angling fish. From the sedimentological and hydrological points of view the breachings were beneficial although the short-term ecological effects were negative; the recovery of the system is still being studied. During the flood year of 1981 conditions in the Botriviervlei had become critical with respect to high water levels, high silt load of the water and lowered salinities. Two artificial breachings were therefore carried out. The first, on 11 August at the western end of Rooisand, caused a lowering of the water level from MSL + 2,69 m to MSL + 1,96 m (i.e. by 0,73 m), but failed to establish a tidal contact between the main vlei and the sea. Because of extensive fish mortality in the vlei, the dune barrier was again breached on 10 October at the traditional site at Sonesta where a deep-water channel from previous breachings lends itself to a more effective opening. This breaching caused a lowering of the water level in the Botriviervlei from MSL + 1,88 m to MSL + 0,70 m, within one day. The vlei became tidal immediately after the opening of the mouth with a tidal range of about 0,15 m.

The radical lowering of the water level caused a complete drying out of Rooisand and other low-lying wetlands, associated with a loss of 40 percent of the water surface which had an immediate impact on the ecology of the system (see below). The breachings did, however, achieve the aim of removing the suspended mud and the dead fish, and of causing a strong influx of seawater which temporarily re-established estuarine conditions in the Botriviervlei. Both breachings remained open for only a few months (Rooisand: 3 months, Sonesta: 2 months) until they were closed by wave driven sand movements. The untimely Sonesta breaching at the beginning of the dry season caused this mouth to be particularly short-lived.

A hydrograph given in Figure 7 illustrates the variations in water level, rainfall and salinity for the Botriviervlei during the critical year 1981.

Concluding remarks

During the present century the Botriviervlei, which appears to have been an open estuary in the past, has changed character tending to become a coastal lake without an open connection to the sea. In the long term this will, apart from a significant change in its ecology, result in increasing accretion of terrestrial sediment in the vlei bed, eventually leading to shoaling and a conversion into a marshland similar to the upper regions of the Kleinmond and Onrus River estuaries. (Theron *et al.*, 1981).

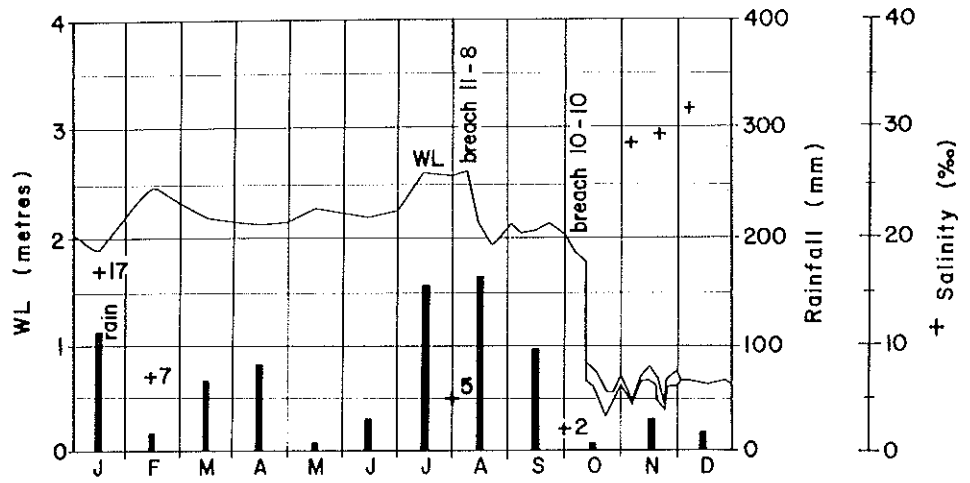


FIG. 7: WATER LEVELS, RAINFALL AND SALINITIES BOTRIVIERVLEI, 1981 (From Fromme, 1982)

Measuring Stations { Water levels: Dpt. Water Affairs Gauging Station; Rainfall : Lebanon Forestry Station; Salinity : Lake Marina Yacht Club

The only possible measure which can be taken to maintain optimum contact of the Botriviervlei with the sea is artificial breaching of the dune barrier at Sonesta, preferably at the peak of the winter rains. This can be achieved only at the expense of discharging large volumes of water and with highly detrimental short term consequences for the general ecology of the system, as was the case after the October 1981 breaching (see also below). This would retard the process of conversion from a closed estuary into a coastal marshland but would, in the long term, not be able to halt it completely.

It should be emphasised in this context, that while there is an open mouth at Sonesta, considerable amounts of marine sediment are carried into the vlei (Theron *et al.* 1981). It is likely that this deposit could block the Middle Vlei arm of the Bot Lagoon and create a sandbank between Sonesta and the coastal dunes. This may also contribute to progressive widening of the dune belt at Sonesta.

3.2.3 Land Ownership/Uses

A large proportion of the land around the vlei is private property. On the western shore only a small area is accessible to the public via a dirt track from Lamloch although the 1:250 000 Topographical Sheet 3319 Worcester shows a large area at Witpunt, about halfway down the western shore, to be a "public resort". According to a Department of Planning report (1968) an area of 321,25 morgen stretching from the Kleinmond lagoon to the North of Witpunt has been set aside for recreational development and is controlled by the Cape Provincial Administration. All the rest of that shoreline is private farmland and mainly Proteas are farmed there. On all the land on the eastern shoreline between the head of the vlei and the mouth of the Afdaks River, grain is grown almost down to the water's edge. South of the bay formed at the mouth of the Afdaks River is the Lake Marina development

established in 1955 and consisting of 776 erven for residential use (Cape Provincial Administration, 1973), although the Department of Planning report (1968) mentions 758 erven of about 0,4 acres (17 000 square ft.) belonging to the private company Fisherhaven Townships (Pty) Ltd. The whole area is earmarked for residential development. Only a few of the sites have actually been occupied and the major development in this area is the Lake Marina Yacht Club which has a clubhouse, boathouses and a slipway and jetty on the southern shore of the bay. Further south, on the tip of the Middle Vlei peninsula, is the Sonesta holiday resort, previously owned by the Department of Community development but now managed by the Cape Department of Nature and Environmental Conservation. This resort is reserved for use by coloured persons. The whole Middle Vlei peninsula is marked as "Demarcated Forest Reserve" (Cape Provincial Administration, 1973) and belongs to the Directorate of Forestry (Dept of Planning report, 1968).

The whole of the Kleinmond swamps as well as the upper reaches of the estuary are classified as "Primitive Areas"; the northern shore of the lower reaches of the estuary has a municipal caravan park and is classified as a "Natural Environment Area" (Cape Provincial Administration, 1973).

Because of the limited access to the Botriviervlei, the area is at present not heavily used for recreational purposes. Activities are mainly angling and boating. Both sailing dinghies and power boats are used. Existing legislation allows power boating above 11,25 km/h (7 mph) in the central deep areas of the vlei marked by beacons 1 - 4 only (Figure 1). The area between beacons 1 and 2 and the sea is closed to power boats. The remainder of the vlei may be used by power boats at low speed and rowing boats may use all three zones (Department of Planning report, 1968). The Kleinmond estuary is too small for boating, although rubber dinghies and canoes are sometimes used during the holiday season.

In the past, coloured fishermen conducted a commercial fishery in the Botriviervlei using mainly gill nets. Overfishing was suspected when catches showed a steady decline and fewer permits were issued. Between 1966 and 1971 the number of permits dropped from 19 to 7 and only two commercial permits were issued in that year. Since 1972 commercial exploitation has been completely stopped and only riparian licences were issued. According to the Department of Nature and Environmental Conservation about 10 licences have been issued in 1982 of which five are for riparian fishermen from Hawston, the remainder being for local farmers.

3.2.4 Obstructions

The major obstruction to the Bot River over the last seven years has occurred during the construction of the road bridge which cuts across the extensive *Phragmites* floodplains at the head of the estuary where the river enters the vlei. The effects of this obstruction have been discussed in Section 3.2.1 (Siltation) above.

The road bridge spans only the central channel of the Bot River at the head of the vlei. The large floodplains, particularly on the northwestern side are bisected by a 300 m long causeway leading up to the bridge. The one culvert in the causeway, is considered to be wholly inadequate for allowing sufficient water to pass between the two sections of the floodplains. During the ECRU survey of 19 August 1982 no water flowed through this culvert although much water was present above the bridge and none below. This situation is aggravated by the presence under the bridge itself of the remains of the service dam some 0,5 m above the surface of the surrounding floodplains. Water flow is thus restricted to a narrow 18 metres of the potential 126 m (i.e. the total span of the bridge). The new road bridge over the Afdaks River appears to have had no detrimental impact because it crosses the river above the floodplains.

Two small wooden footbridges also exist, the first linking the Sonesta resort with the coastal dunes, and the second crossing the Kleinmond estuary near its mouth. They appear to have no impact on the functioning of the system.

3.2.5 Physico-chemical characteristics

pH

Measurements of pH have been made sporadically in the Botriviervlei since 1967 and the values range from 6,8 and 8,5. This is in accordance with the characterisation of the Bot River water as "turbid water" with a pH "slightly acid to alkaline" (Heydorn and Tinley, 1980). Coetzee (1982) has recently published an extensive set of physico-chemical measurements from the Botriviervlei which are reproduced in Table 3. Apart from one record from January 1975, (pH 8,4) no data are available for the Kleinmond estuary, although the ECRU survey on 19 August 1982 found a range of 5,5 - 6,6 while the mouth was closed.

Temperature

Temperature records for the Bot estuary reported by Coetzee (1982; see Table 3) show a distinct annual pattern with highest temperatures in December/January and lowest records in July. The range was 11,9^{o}C in winter to 23,6^{o}C in summer.

Turbidity

Few measurements of turbidity are available although Koop *et al.* (in press) reported that the clarity of the water in the Botriviervlei followed a daily pattern during their study conducted in 1980. In the early mornings, before the onset of winds, underwater visibility of 3 metres or more was recorded (Secchi disc). By the afternoon, however, turbulence caused by winds usually reduced visibility to about 10 - 20 cm and led to the suspension of fine sediment, particularly in the more exposed lower reaches.

TABLE 3: Physico-chemical measurements taken at five stations in the Botriviervlei between July 1980 and December 1981 (from Coetzee, 1982). Stations are shown in Figure 1.

		1980			1981								
	Station Number	Jul.	Sept.	Oct.	Dec.	Jan.	Feb.	March	May	Jul.	Aug.	Sept.	Nov.	Dec.
Temperature °C	3	14,5	15,0	20,0	23,0	24,5	23,0	20,5	16,0	12,0	11,5	17,0	dry	dry
	4	13,5	15,0	19,5	21,5	24,0	23,0	20,0	14,0	12,0	12,0	16,0	21,0	23,5
	5	13,5	15,0	18,0	21,5	23,5	22,5	21,0	15,5	12,0	12,5	16,0	20,5	23,5
	6	13,5	15,0	18,0	22,0	22,5	23,0	20,5	15,5	11,5	12,5	16,0	20,5	23,0
	9	13,0	15,0	18,0	21,0	23,5	22,0	20,0	15,5	12,0	12,5	15,0	20,0	23,0
	mean	13,6	15,0	18,7	21,8	23,6	22,7	20,4	15,3	11,9	12,2	16,0	20,5	23,3
Salinity °/oo	3	11,0	10,0	10,0	9,5	11,0	7,0	7,0	7,0	4,0	1,0	1,0	dry	dry
	4	13,0	11,0	11,0	11,0	11,0	7,5	8,0	8,0	5,0	3,0	2,0	28,5	31,0
	5	14,5	12,5	12,0	11,5	11,5	8,5	8,0	8,0	5,5	4,0	2,5	29,0	31,0
	6	14,0	12,5	12,0	11,5	11,5	8,5	8,5	8,0	6,0	4,5	3,0	29,0	30,5
	9	15,0	12,5	12,0	11,5	12,0	8,5	8,5	8,0	6,0	4,5	3,0	29,0	30,5
	mean	13,5	11,7	11,4	11,0	11,4	8,0	8,0	7,8	5,3	3,4	2,3	28,9	30,8
Dissolved O_2 mg/ℓ	3	9,2	10,1	10,4	9,8	9,2	7,8	8,5	9,4	10,2	9,6	8,0	dry	dry
	4	10,8	9,7	9,7	8,1	8,8	9,2	9,4	9,4	10,4	9,8	8,9	5,8	6,4
	5	10,5	9,6	9,6	8,5	7,3	8,5	9,0	9,0	10,4	10,0	9,4	5,8	6,8
	6	10,5	9,1	9,7	9,0	7,3	6,8	9,5	9,0	11,0	9,6	9,0	5,5	5,4
	9	10,5	9,2	9,5	8,4	7,7	8,0	9,0	8,8	10,6	9,6	9,2	6,0	6,3
	mean	10,3	9,5	9,8	8,8	8,1	8,1	9,1	9,1	10,5	9,7	8,9	5,8	6,2
pH	3	7,9	8,4	8,4	8,7	9,3	7,8	7,9	7,6	7,6	6,6	6,5	dry	dry
	4	8,1	8,2	8,2	8,4	8,2	8,2	8,1	7,8	7,9	7,4	7,1	-	7,4
	5	7,9	8,2	8,2	8,3	7,4	8,1	8,2	7,8	8,1	7,8	7,3	-	7,6
	6	7,9	8,3	8,4	8,4	7,4	8,0	8,1	7,9	8,1	7,8	7,5	-	7,6
	9	7,9	8,3	8,4	8,3	7,5	8,0	8,1	7,6	8,1	7,8	7,5	-	7,6
	mean	7,9	8,3	8,3	8,4	8,0	8,0	8,1	7,7	8,0	7,5	7,2	-	7,6

TABLE 4: Salinity and nutrient values recorded in surface (s) and bottom (b) water samples from the Botriviervlei on 26 March 1980 (from Koop *et al.*, 1982). Stations are shown in Figure 1.

Station no.	Salinity parts per thousand	Nutrients (µg at . ℓ^{-1}) NH_4	NO_3	PO_4	SiO_3
1 s	12	1,29	0,28	0,58	26,19
b	12	5,14	0,83	0,35	22,62
2 s	10	2,14	0,51	0,54	20,24
b	11	8,05	0,55	0,62	17,26
3 s	10	9,71	0,37	0,85	15,48
b	10	8,48	0,78	0,58	17,26
4 s	8	1,90	0,97	0,54	25,00
b	9	5,19	0,66	0,66	16,67
5 s	10	6,24	0,37	0,73	14,29
b	8	6,67	0,37	0,35	11,31
6 s	8	3,56	1,15	0,33	16,27
b	11	1,20	0,51	0,37	18,67
7 s	7	5,77	1,06	0,57	16,27
b	10	1,97	5,54	0,41	15,66
8 s	7	10,67	0,32	0,33	12,65
b	9	2,16	0,32	0,57	19,28
9 s	8	7,93	0,74	0,49	21,08
b	8	6,54	0,69	0,33	12,65
10 s	8	5,91	0,51	0,78	17,47
b	8	1,49	0,51	0,94	19,28
11 s	7	2,60	4,06	0,36	7,06
b	8	6,87	0,46	2,62	9,04

Salinity

Records of salinity dating back to 1967, are available for the Botriviervlei although regular measurements have been taken only since 1980 (Table 3). For results from a survey on 26 March 1980, see Table 4. Apart from the fact that there may be very rapid and drastic changes in salinity due, for example, to such events as sudden floods or the opening of the vlei to the sea after a lengthy period of isolation, there appears to be an annual pattern of fluctuations in salinity. This is linked to the annual rainfall regime. Generally, salinities in summer tend to be rather high with peak values of around 40 parts per thousand being recorded in January to March. The extent to which the vlei becomes saline, approaching or even exceeding the salinity of seawater, will depend on the amount of water that has entered the vlei the previous winter and the amount of evaporation in the following months. With the onset of winter rains, large volumes of fresh water flow into the vlei and salinity drops, reaching its lowest values between September and November. During this time salinities as low as 3 - 5 parts per thousand have been recorded.

Only one record, from January 1975, is available for the Kleinmond estuary. At that time a salinity of 21,1 parts per thousand was noted. The ECRU survey on 19 August 1982, recorded salinities between 0,0 parts per thousand in the upper reaches of the estuary down to the footbridge and 1,0 parts per thousand close to the sandbank which had closed off the estuary. The Kleinmond estuary seems to open to the sea every year (B Bennett, pers. comm.) and the pattern appears to be one of very low salinities while the estuary is closed and salinities of seawater when it is open to the sea and becomes tidal. Overtopping of the dune barrier by seawater while the estuary is closed, appears to have little effect on the salinity in the estuary. At the time of the ECRU survey (19 August 1982) waves frequently washed into the estuary and much kelp was observed floating in the shallows, yet the salinity measured was almost that of freshwater.

Nutrients

Nutrient levels recorded from the Botriviervlei during a survey on 26 March 1980 (Koop *et al.*, in press) are shown in Table 4. The values may be regarded as normal for this type of system. No evidence of stratification was found although in the case of ammonia, values were generally higher in bottom water samples than in samples from the surface, indicating reducing conditions in the sediments. Silicates are probably of riverine origin indicated by the fact that much higher values were recorded at the head of the estuary than near the coastal dunes.

Samples of water from the Bot estuary have been taken systematically since the beginning of 1980 by Dr R Bally of the Zoology Department, University of Cape Town in order to determine nutrient levels on a regular basis. The data are being analysed at the moment.

No data are available for the Kleinmond estuary.

Dissolved oxygen

The dissolved oxygen content of surface waters in the Botriviervlei is shown in Table 3 for 1980 and 1981. The water was always well oxygenated, the values ranging between 5,4 and 10,8 mg per litre. Anoxic conditions were never encountered.

4. BIOTIC CHARACTERISTICS

4.1 Flora

This section was contributed by M O'Callaghan of the Botanical Research Unit, University of Stellenbosch.

4.1.1 Phytoplankton/Diatoms

Koop *et al.* (in press) have reported that the phytoplankton biomass of the Botriviervlei consists mainly of flagellates. The standing stock of phytoplankton is, however, relatively low, their growth possibly being limited by wind-induced turbidity.

Measurements of diatoms in the sediment (Koop *et al.*, in press) also give low values and show that they are restricted to the top 5 cm, predominating in finer sediments.

4.1.2 Algae

Fairly substantial amounts of large algae are often deposited on the sandy beach in front of the Botriviervlei and Kleinmond estuary. Frequently these algae are also washed into the estuary by waves overtopping the dune barrier, or when the estuary is open to the sea. These driftline algae are mainly the giant kelps *Ecklonia maxima* and *Laminaria pallida* as well as smaller amounts of *Macrocystis angustifolia*.

Koop *et al.* (in press) mention the presence of the alga *Chara* sp. throughout the vlei, but particularly dense near the head. Dense beds of *Chara* were also found in the Lamloch swamps (82.08.23). The epiphytic alga *Cladophora* sp. has been reported to grow on submerged plants (Koop *et al.*, in press). This alga can break loose and form dense mats which float and are often deposited on the vegetation along the shoreline. It does not appear to have a definite growth cycle and its occurrence is unpredictable. It oftens grows rapidly for several months followed by an equally rapid decline.

4.1.3 Aquatic vegetation

Ruppia maritima is reported to be the most important aquatic plant in terms of biomass (Koop *et al.*, in press). This aquatic grass was found throughout the vlei in water shallower than 2,9 m. A similar plant, *Potamogeton pectinatus*, was found in dense isolated patches in the upper reaches of the vlei. *Sporobolus virginicus* might also be classified as an aquatic plant. Although it grows predominantly in areas which are periodically inundated (see below), it can withstand long periods of complete submergence and even support epiphytic algae (AEF Heydorn, pers. comm.). It is found submerged mainly in the shallow waters along the southern parts of the Lamloch swamps.

4.1.4 Terrestrial, semi-aquatic and emergent vegetation

Acocks (1975) describes the vegetation of this area, in general, as 'coastal macchia', although both true macchia and coastal renosterveld veldtypes may occur here. For the sake of convenience, the vegetation around this vlei was classified into four basic types, as shown in Figure 8. These are:

(a) Semi-aquatic vegetation (reed swamps and marshes)
(b) Dune vegetation (including aliens)
(c) Coastal renosterveld/fynbos (including aliens)
(d) Farmed areas

A list of species and physical features is given in Appendix I.

(a) *Semi-aquatic vegetation*

There are a number of communities which make up the semi-aquatic vegetation of this system. Possibly the most important of these are the *Phragmites australis* and *Scirpus littoralis* reed swamps. These form dense patches in very wet and/or submerged areas. They are found mainly near the bridge at the head of the Botriviervlei and in the Lamloch swamp area. Small patches are also found along the banks of the vlei, especially at the Afdaks River inlet.

At the time of sampling (August 1982), the Lamloch swamp area was totally flooded. Many land plants were found growing submerged or partly so. The most common of these was the marsh grass *Chondropetalum tectorum* with other restioids. Where the water levels are lower, *Juncus kraussii* is an important constituent of the vegetation. This role is taken over by *Scirpus nodosus* in the sandier dune areas and *Juncus acutis* nearer the head of the vlei.

The other semi-aquatic vegetation type, broadly defined as 'marshes' was found in areas which are periodically inundated. In the lower sandy parts of the vlei, these marshes consist mainly of the brakkweek *(Sporobolus virginicus)* with *Sarcocornia natalensis* in restricted areas. *S. decumbens* was found in the Lamloch area while pure stands of *S. natalensis* are to be found near the head of the vlei.

(b) *Dune vegetation*

The hummock dunes have a sparse covering of marram grass *(Ammophila arenaria)*, sea wheat *(Agropyron distichum)*, klappiesbrak *(Tetragonia decumbens)*, bietou *(Chrysanthemoides monolifera)*, blombos *(Metalasia muricata)*, and numerous other herbs and shrubs. As one leaves the fore-dune area, the vegetation becomes dominated by rooikrans *(Acacia cyclops)* and only small isolated patches of the natural hind dune vegetation remain in the form of bietou, taaibos *(Rhus glauca)*, slangbos *(Stoebe plumosa)* and pipe grass *(Ehrharta villosa)*. Nearer Kleinmond, an area of dense patches of natural dune scrub endangered by encroaching rooikrans, are to be found. Species in this area include the milkwood *(Sideroxylon inerme)*, taaibos (*Rhus* spp.) bruinsalie *(Salvia aurea)*, kinkelbossie *(Tetragonia fruticosa)* and others.

(c) *Coastal renosterveld/fynbos*

The area around the marina development is dominated by Port Jackson willow *(Acacia saligna)* with Australian myrtle *(Leptospermum laevigatum)*, that is, alien vegetation. However, remnants of the natural flora include species such as *Leucodendron modestum, Erica cordifolia, Spiloxene* sp. and numerous Mesembryanthenaceae. This indicates that the vegetation of this area might previously have constituted a diverse mosaic of wet coastal renosterveld and coastal fynbos.

(d) *Farmed areas*

The land around the Botriviervlei is used for two main types of agriculture. On the shale-derived soils to the east of the vlei, grain farming predominates with some sheep grazing. Small restricted patches of renosterveld, dominated by *Elytropappus rhinocerotis*, are found in some areas.

To the west of the vlei, natural flower farming is practised on the sandstone derived soils with some grazing by cattle and horses. Although disturbed, much of this area is still covered by wet coastal fynbos.

Large areas around this vlei are dominated by aliens. Although the introduction of these shrubs and trees might initially have been thought beneficial (e.g. for controlling sand movement), they have since become a major problem. For example, the area between Sonesta and Onrus is totally dominated by rooikrans with very few of the natural shrubs left. Rooikrans is also encroaching into the Lamloch swamp area and onto the dunes between the Botriviervlei and Kleinmond. As these plants have the ability to suppress and eventually destroy the natural vegetation, this enroachment is likely to have undesirable consequences. Not only will the destruction of the natural vegetation result in a decrease in the water bird diversity, but any beneficial effect the vegetation has on the regulation of ground and surface water flow and nutrient content of the water will be inhibited.

Port Jackson willow has all but brought about the demise of an interesting vegetation complex around the marina, while aliens are found along the water's edge throughout most of the vlei. They also occur along roads, tracks and waterways on privately owned land.

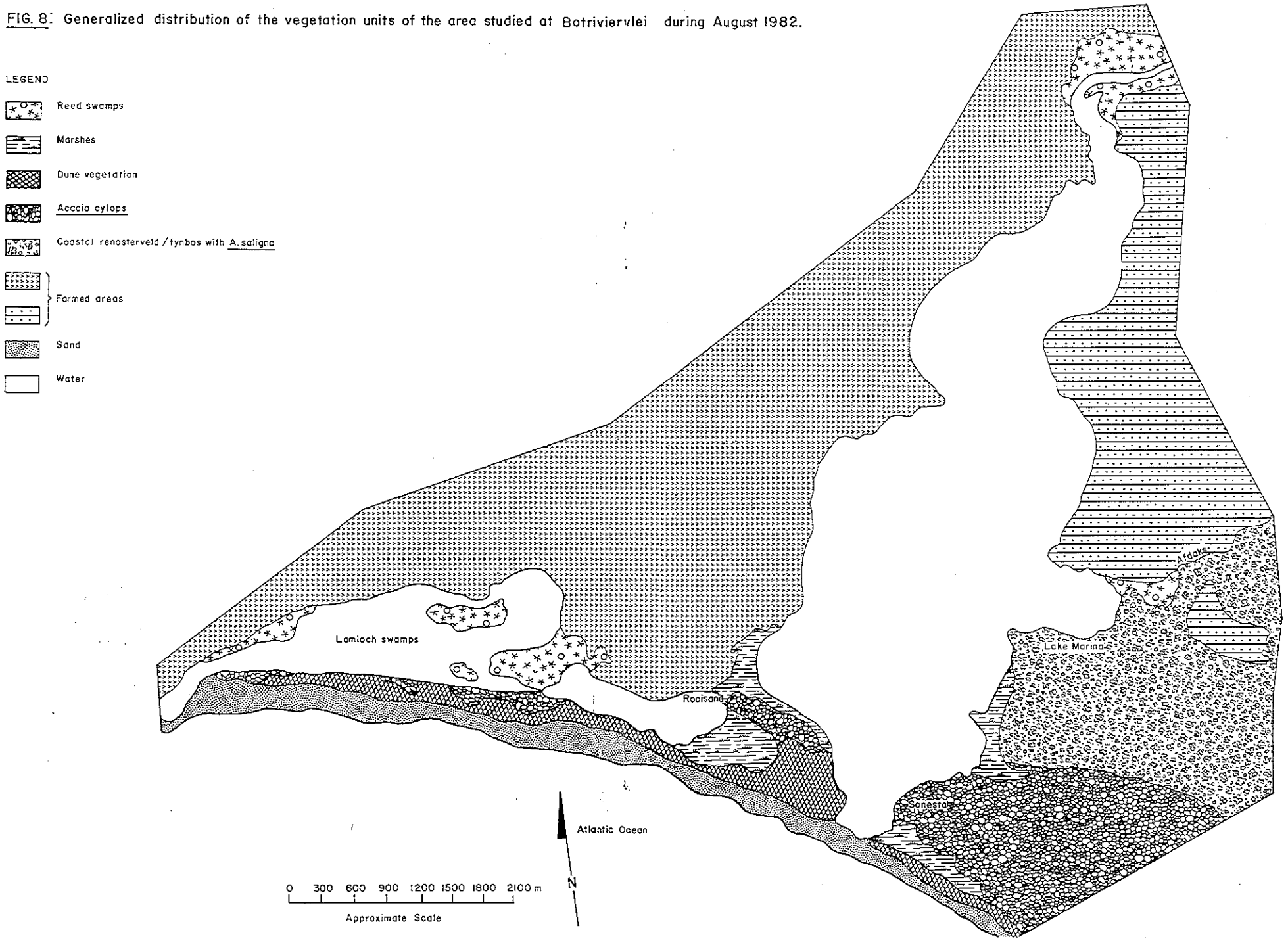
An effort should be made to control these aliens. This would entail their gradual removal and the re-establishment of the natural vegetation, followed by the continued control of the spread and regrowth of the aliens. This would be a long-term project and funding might be difficult. However, it would result in the reinstatement of a natural area with high aesthetic, scientific and educational value.

4.2 Fauna

4.2.1 Zooplankton

Coetzee (1982) has recently published an extensive survey of the zooplankton of the Botriviervlei undertaken during 1980 and 1981. He obtained a range of values of 8 - 298 mg dry mass per m^3 of vlei water which appears to be within the range recorded from other South African estuaries. More than 99 percent of the zooplankton was made up of the copepods *Pseudodiaptomus hessei*, *Halicyclops* spp. as well as copepod nauplius larvae and various harpacticoid copepods. Of these four groups, *P. hessei* and its larvae constituted about 90 percent and was thus clearly the most abundant zooplankton organism in the vlei.

FIG. 8: Generalized distribution of the vegetation units of the area studied at Botriviervlei during August 1982.



During the survey, the mouth of the vlei was opened in October 1981. An interesting addition to the zooplankton in the estuary after it was opened to the sea was the appearance of larvae and post-larvae of the burrowing sandprawn *Callianassa kraussi*. Sandprawns have been shown to be unable to breed at salinities below about 17 parts per thousand (Forbes, 1978) and Coetzee (1982) concludes that the population in the Bot vlei had probably been unable to breed at least since the start of his study in July 1980 because salinities were never higher than 15 parts per thousand.

A checklist of all organisms found in the zooplankton by Coetzee is given in Appendix II.

4.2.2 Aquatic Invertebrates

There are no extensive rocky areas within the system and an invertebrate fauna typically associated with rocks, e.g. limpets, barnacles and periwinkles is absent. Some rocks do occur around Witpunt as well as on the opposite shore of the Botriviervlei, north of the Afdaks mouth. These are small areas and appear to support mainly mobile forms, particularly isopods and amphipods which are found throughout the system. The largest proportion of the invertebrate fauna from both the Bot and Kleinmond estuaries are either benthic, living on or in the bottom sediments, or associated with the aquatic vegetation. No data are available for the Kleinmond estuary but the results of a survey of the Botriviervlei has recently been submitted for publication (Koop *et al.*, in press). Further work on the invertebrate fauna is being conducted by H de Decker of the Zoology Department, University of Cape Town, who is studying the seasonal distribution, abundance and biomass as well as the feeding relationships of some selected species.

The most striking feature of the results presented by Koop *et al.* (in press) is the paucity of the fauna. A total of only 18 species of invertebrates was recorded. Clearly some species may reach rather high densities, up to 4 000 individuals of the small snail *Hydrobia* per square metre being recorded, although this is still far short of the figure of up to 100 000 individuals per square metre found in other estuaries, for example, the nearby Palmiet (Branch and Day, 1981). The nature of the estuary, with its closed mouth and lack of tidal exchange and its relatively uniform physical and chemical conditions throughout, leads to a fairly even distribution of invertebrates. Thus the major species occur at all locations.

There appears to be clear driftline fauna consisting of a staphylinid beetle, the amphipod *Orchestia ancheidos*, the sea louse or isopod *Exosphaeroma hylecoetes* and the polychaete worms *Nephtys* and *Ceratonereis* as well as a few individuals of the tiny snail *Hydrobia*. The remaining species are fairly evenly distributed although the sandprawn *Callianassa kraussi* and the prawn *Palaemon pacificus* exhibit a rather patchy distribution with the sandprawns avoiding the muddier regions. The invertebrate species recorded from the Botriviervlei are:

Polychaete worms	-	*Nephtys zeylanica*
		Ceratonereis erythraeensis
Sea lice (isopods)	-	*Exosphaeroma hylecoetes*
		Cyathura carinata
Amphipods	-	*Melita zeylanica*
		Corophium triaenomix
		Orchestia ancheidos
Tanaeid	-	*Apseudes digitalis*
Prawn	-	*Palaemon pacificus*
Burrowing prawn	-	*Callianassa kraussi*
Insects	-	mayfly larvae (Ephemeroptera)
	-	midge larvae (Chironomidae)
	-	fly pupae (Diptera)
	-	beetle (Staphylinidae)
Mussel	-	*Lamya capensis*
Snails	-	*Hydrobia* sp.
		Assiminea sp.

Quantitative data on numbers and biomass for these species may be found in Koop *et al.* (in press).

4.2.3 Fish

The fish fauna of the Botriviervlei and Kleinmond lagoon has been investigated by B Bennett of the Zoology Department, University of Cape Town with assistance from the Cape Department of Nature and Environmental Conservation. Only a short summary of the extensive data collected can be given here.

The fish fauna of the system may be divided into four categories:

(i) Freshwater species: these are species which occur in the upper reaches of the estuary where salinities are usually low:

Carp	*Cyprinus carpio*
Tilapia	*Oreochromis mossambicus*
Black Bass	*Micopterus salmoides*

(ii) Marine visitors: these are typically marine species which are much more abundant in the sea than in the estuary. They are restricted to areas of high salinity although some of them may tolerate salinities of not lower than 8 parts per thousand (Whitfield *et al.*, 1981). They move freely in and out of the Bot estuary while it is open but may get trapped when it closes.

Sea barbel	*Tachysurus feliceps*
Gurnard	*Trigla capensis*
Maasbanker	*Trachurus capensis*
Anchovy	*Engraulis capensis*
Strepie	*Sarpa salpa*
Blacktail	*Diplodus sargus*
Zebra	*Diplodus cervimus*

(iii) Species which breed in the estuary: these are numerically the most abundant species, forming the backbone of the fish population in the system. They are usually much less abundant in the sea than in estuaries.

Estuarine round herring	*Gilchristella aestuarius*
Cape silverside	*Hepsetia breviceps*
Banded goby	*Gobius multifasciatus*
Klipvis	*Clinus* sp.
Sand goby	*Psammogobius knysnaensis*
Pipefish	*Syngnathus acus*

(iv) True migrants - species which never breed in estuaries but use them to a large extent. Especially the juveniles of these species are often found in estuaries.

White steenbras	*Lithognathus lithognathus*
Cape stumpnose	*Rhabdosargus globiceps*
Flathead mullet	*Mugil cephalus*
Southern mullet	*Liza richardsoni*
Elf	*Pomatomus saltatrix*
Leervis	*Lichia amia*
Kob	*Argyrosomus hololeptidotus*
Knysna half-beak	*Hyporhamphus knysnaensis*
Sand snake-eel	*Ophisurus serpens*

It can be seen that the majority of fish species caught by anglers fall into category IV. With the tendency of the Botriviervlei to remain permanently closed to the sea recruitment of angling fish to the vlei is problematic. There is some evidence that juveniles of certain species may migrate into the vlei via the Kleinmond lagoon and the swamps when water levels are sufficiently high (B Bennett, pers. comm.). Juveniles may also enter the vlei carried by waves overtopping the dune barrier at several wash-over fans along the coastline, but it appears unlikely that these two recruitment mechanisms can sustain the populations of the migrant species in the vlei.

Low levels of salinities may also profoundly affect the fish populations. After the heavy winter rains in 1981 salinity in the Botriviervlei dropped below 3 parts per thousand and mass mortalities of fish were observed. Investigations showed that species from category (ii) were affected first, followed by species from category (iv). Thus, as long as there is little or no input of seawater to the vlei these species will be threatened annually during the wet season when salinities begin to drop with the increasing inflow of freshwater.

There is, however, no evidence to suggest that fish will cease to exist in the Botriviervlei if it were to remain closed to the sea. Certainly in the short- and medium-term all the species from categories (i) and (iii) will continue to breed in the estuary as long as the link with the Kleinmond system is maintained. It also seems likely that limited numbers of angling fish from the other categories will find their way into the vlei. Only if the Botriviervlei were to become completely isolated from the sea are there likely to be long-term changes in the fish

fauna. In that case it seems likely that only freshwater species would persist with the possible exception of the estuarine round herring, *Gilchristella aestuarius*.

4.2.4 Reptiles and Amphibians

Poynton (1964) records the following species of frogs from the area covered by the 1:50 000 Topocadastral Sheet 3419 AC (Botriviervlei and Kleinmond estuary and immediate surroundings):

Raucous toad	-	*Bufo rangeri*
Leopard toad	-	*Bufo pardalis*
Clicking stream frog	-	*Rana grayii*
Arum frog	-	*Hyperolius horstocki*

No reptiles have been recorded from this area.

The following reptile and amphibian records have been compiled by AL de Villiers and RC Boycott of the Cape Department of Nature and Environmental Conservation for the grid squares 3419 AA-AD (from: FitzSimons, 1943; Loveridge and Williams, 1957; FitzSimons, 1962; Poynton, 1964; Greig and Burdett, 1976; Greig *et al.*, 1979; Boycott, 1982; as well as CDNEC records). These do not include the four species mentioned above and the area covers the entire Bot/Kleinmond catchment.

Frogs:

Cape ghost frog	-	*Heleophryne purcelli*
Sand toad	-	*Bufo angusticeps*
Cape mountain toad	-	*Capensibufo rosei*
Cape mountain rain frog	-	*Breviceps montanus*
Cape river frog	-	*Rana fuscigula*
Banded stream frog	-	*Rana montana*
Cape chirping frog	-	*Arthroleptella lightfooti*

Tortoise:

Padlopertjie	-	*Homopus areolatus*

Snakes:

Blind snake	-	*Typhlops delalandii*
Common slug-eater	-	*Duberria lutrix*
Spotted skaapsteker	-	*Psammophylax rhombeatus*
Dapple-backed sand snake	-	*Psammophis notostictus*
Spotted dwarf garter snake		*Elaps lacteus*

Lizards:

Marbled gecko	-	*Phyllodactylus porphyreus*
	-	*Pachydactylus geitjie*
Golden sand lizard	-	*Acontias meleagris*
Tiger lizard	-	*Nucras tessalatus*
Anguine lizard	-	*Chamaesaura anguina*
Klip salamander	-	*Cordylus cordylus*
	-	*Pseudocordylus microlepidotus*

RC Boycott (pers. comm.) has recorded the following frogs from the Kleinmond swamps in addition to the species list above:

Micro frog	-	*Microbatrachella capensis*
Dainty frog	-	*Cacosternum boettgeri*
Leopard toad	-	*Bufo pardalis*
Clicking stream frog	-	*Rana grayii*
Cape mountain rain frog	-	*Breviceps montanus*

He has also recorded the herald snake, *Crotaphopeltis hotamboeia* and the Cape dwarf chamaeleon *Bradypodion pumilum* from this area. Of all these species, the Arum frog, *Hyperolius horstocki* and the Micro frog, *Microbatrachella capensis* are listed as rare in the South African Red Data Book - Reptiles and Amphibians (McLachlan, 1978). The Micro frog is endemic to the south western Cape, having been recorded only from the Betty's Bay/Kleinmond area. The dwarf chamaeleon is placed in the category "vulnerable" with the possibility of it becoming an endangered species if its habitats are not protected.

4.2.5 Birds

A list of the birds in the catchment of the Botriviervlei and the Kleinmond estuary as well as those around the estuary itself is given in Appendix III. The large number of 118 species of birds recorded from the area, reflects the diversity of habitats represented. Apart from the open ocean shoreline and the wetland habitats in the estuary, there is the scrub and bush around the river courses as well as mountain fynbos on the higher ground.

The Botriviervlei and Kleinmond swamp area is an important wetland for avifauna. It supports about 8 percent of the resident wader population between the Olifants River and Cape Agulhas and 2,4 percent of the resident plus migrant waders (Summers *et al.*, 1976). The estuary also carries a very large coot population, which plays a major role in the ecology of the vlei (C Heyl , Department of Nature and Environmental Conservation and R Bally, Zoology Department, UCT, pers. comm.). A study carried out recently by the Western Cape Wader Study Group (unpublished data) showed that approximately 50 percent of all coots in the area between the Olifants and Great Brak River mouths were on the Botriviervlei. This population also makes up 27,7 percent of the total number of coots that have been estimated to occur on all South African coastal wetlands in a study by the Percy FitzPatrick Institute of African Ornithology (J Cooper, pers. comm.) and thus probably represents a fair proportion of the total South African population.

Several birds recorded from the Bot/Kleinmond area are listed in the South African Red Data Book - Aves (Siegfried *et al.*, 1976). Five of these species are directly associated with the coastal area and the Botriviervlei and Kleinmond estuary while one, the Victorin's scrub warbler *(Bradypterus victorini)* is endemic to the southern Cape. This bird is confined to mature mountain fynbos occurring in the upper catchment and can be considered vulnerable. The white pelican *(Pelicanus onocrotalus)* is listed

as vulnerable and in 1976 it was estimated that not more than 2000 breeding birds remained in South Africa although the species is not endangered. Both the greater and lesser flamingo *(Phoenicopteris ruber* and *P. minor)* populations are subject to erratic fluctuations and although they are in no danger of extinction the conservation of breeding habitats is problematic. The caspian tern *(Hydroprogne caspia)* is listed as vulnerable. It occurs in small numbers along the South African coast and is common only in St. Lucia. The African fish eagle *(Haliaeetus vocifer),* a truly magnificent bird, is listed as vulnerable. Although it is protected by provincial laws, its numbers in estuaries and around manmade dams are declining largely due to destruction of suitable habitat.

4.2.6 Mammals

Stuart *et al.* (1980) and Stuart (1981) record the following species of mammal from the area immediately surrounding the Botriviervlei (1:50 000 Sheet 3419 AC):

Chacma baboon	-	*Papio ursinus*
Caracal	-	*Felis caracal*
Small-spotted genet	-	*Genetta genetta*
Egyptian mongoose	-	*Herpestes ichneumon*
Southern elephant seal	-	*Mirounga leonina*

A fur seal *(Arctocephalus pusillus)* was seen in the lower reaches of the estuary while it was open to the sea at Sonesta and a skull of the Cape dune molerat *(Bathyergus suillus)* was also found (R Bally, pers. comm.).

If the entire catchment area of the vlei is considered (Sheets 3419 AA-AD) a number of additional mammals have been recorded by Stuart *et al.* (1980) and Stuart (1981):

Bats:

Big brown bat	-	*Eptesicus melckorum*
Slit-faced bat	-	*Nycteris thebaica*

Carnivores:

Cape fox	-	*Vulpes chama*
Honey badger	-	*Mellivora capensis*
Leopard	-	*Panthera pardus*
Cape grey mongoose	-	*Herpestes pulverulentus*
Water mongoose	-	*Atilax paludinosus*
Aardwolf	-	*Proteles cristatus*

Rodents:

Cape porcupine	-	*Hystrix africaeaustralis*
Black rat	-	*Rattus rattus*
Striped mouse	-	*Rhabdomys pumilio*
Cape greater gerbil	-	*Tatera afra*

Antelopes:

Common duiker	-	*Sylvicapra grimmia*
Grey rhebuck	-	*Pelea capreolus*

Both the leopard and the aardwolf are listed as rare in the South African Red Data Book - Large Mammals (Skinner *et al.*, 1977). The honey badger is listed as rare in the South African Red Data Book - Small Mammals (Meester, 1976). It is protected in the Cape Province and although it is widely distributed it is nowhere common. The Cape greater gerbil is also listed as rare and although it is not in danger it is included because it is endemic to the southwestern Cape.

5. SYNTHESIS

The Botriviervlei is one of the largest coastal open-water bodies in the Cape although it drains a relatively small catchment area. Yet, as late as 1978 knowledge of the system was described as "very poor" by Noble and Hemens. It is thus gratifying to note that a considerable research effort has been put into the system since the beginning of 1980. This work is ongoing and participating scientists come from the University of Cape Town, the National Research Institute for Oceanology, the Cape Department of Nature and Environmental Conservation (CDNEC) and the Geological Survey, Bellville (Appendix IV). A report on the Bot/Kleinmond system compiled at this stage may thus appear premature. The recent controversy concerning management of the system, particularly with regard to breaching of the dune barrier, has made it important, however, to produce a document containing all the information available to date in order to assist authorities in the task of formulating an effective management strategy for the area.

It appears clear from the information presented that the Botriviervlei is a coastal lake in the making. Although there is some evidence from about the middle of the last century that it may have been a truly tidal inlet, even allowing small boats pursuing a coasting trade to enter the mouth, these reports are not entirely unambiguous. Later evidence points to the fact that the mouth of the vlei was usually closed, but that a connection to the sea via the Lamloch swamp area and the small Kleinmond lagoon was maintained. This is the case to the present day. A questionnaire survey by R Bally (Zoology Dept., UCT) among local residents and visitors shows that the vlei has been opened to the sea artificially by local fishermen fairly regularly. This was done in order to replenish the stocks of marine fish in the vlei, particularly when they were still being commercially exploited. The juveniles of these fish species (e.g. elf, white steenbras, leervis and others - See Section 4.2.3) are trapped in the vlei after the mouth has again closed and there is good angling in subsequent years. There is no doubt that fishing will continue to be good in the Botriviervlei if the dune barrier were to be breached regularly every three to five years. When considering management of our coastal resources it appears prudent, however, to consider not only a single facet such as angling, but rather a range of values and interests such as the ecological value of the area concerned, the research potential, interests of the tourist

industry, as well as the general aesthetic value of the region and the interests of the local community.

In a recent document by the Department of Nature and Environmental Conservation (JD van Wyk, pers. comm.) on estuaries and coastal lakes this view is reflected: "The estuarine management strategy of the CDNEC is the conservation of the estuarine habitat and its flora and fauna; the control of recreation; and the management of those species exploited by man in such a way that the ecology of the estuary is not harmed". The recreational potential of the Bot/Kleinmond system has to date not been fully realised. Although the campsite adjacent to the Kleinmond lagoon and the Sonesta holiday resort are well frequented, only a small proportion of the stands in the Lake Marina area have been occupied and there is clearly considerable room for expansion. Major activities will be water-related, mainly boating and angling in the vlei and adjacent coastal zone, although the attraction of simply being able to spend time in unspoilt natural surroundings with extensive facilities at Hermanus only about 15 km away should not be underestimated.

Compared with many other countries, the South African coastline is extremely poor in wetlands. It is estimated that the total area covered by all the Cape estuaries is less than that of any one of the major European estuaries (Van Wyk, pers. comm.). As a signatory to the 'Ramsar Convention of Wetlands of International Importance, Especially as Waterfowl Habitat', South Africa has undertaken to register and protect important wetlands within her boundaries. Clearly the Bot/Kleinmond system is such a wetland, being one of the ten most important habitats for resident and migrant wading birds in the southwestern Cape (Summers *et al.*, 1979). Almost 90 percent of the waders in this area are Palaearctic migrants which breed mainly in Greenland and the northern Soviet Union where very large areas have been proclaimed reserves. In order to protect these bird populations, however, habitats all along their migratory routes need to be protected and this has been recognised in the management recommendations by the CDNEC (1979) where it is stated that "conservation of birds should be a priority in recreational zonation in estuaries".

An issue of particular relevance to the discussion about management of the Bot/Kleinmond system is the question of artificial opening of the estuary. The intensive research carried out over the past three years by the University of Cape Town in collaboration with the CDNEC and the CSIR has shown that any artificial opening of this particular system which leads to the Botriviervlei becoming a temporary tidal estuary has detrimental ecological consequences. This is clearly illustrated by the events during the latter half of 1981 when the vlei was opened in two places. There is no evidence to suggest that the second opening at Sonesta came just in time and brought relief to the threatened ecology of the vlei as was stated in newspapers at that time (e.g. Die Burger, 10 November 1981).

One of the arguments frequently advanced in favour of artificial breaching of the dune barrier was that estuarine conditions would thus be restored in a naturally estuarine system. It was felt that the vlei would normally make direct contact with the sea if

the "unnatural" connection to the Kleinmond estuary did not exist. Historical evidence has clearly shown that the connection between the Botriviervlei and the Kleinmond estuary has existed since the first accurate maps were drafted. Furthermore, it appears that the vlei has not been truly tidal for extended periods since about the second half of the last century and perhaps longer. Within living memory the vlei has cut a channel through the dune barrier only twice, the last time in the 1950's, and another time it overflowed into the sea without truly breaching the dunes (R Bally, pers. comm.).

Again, it was argued that the opening of the vlei would combat mud pollution. As has been shown in Section 3.2.1, 1980/81 was an extraordinary year both in terms of rainfall and the amount of sediment introduced into the vlei. Despite these factors, the sediment that was deposited, mainly in the upper reaches of the vlei, was only about 29 percent of the total amount of sediment expected annually. Soil erosion is recognised by farmers as one of the problems in the Bot/Kleinmond catchment area and measures such as switching from wheat to pasturage in the Bot River valley, as well as alternating between wheat and pasturage elsewhere will reduce soil erosion. It can be expected, therefore, that less sediment will enter the Botriviervlei as these measures become effective.

It has been stated further that after the artificial breachings, the bird life increased and in particular flamingoes were seen in the shallow water after prolonged absence. Our own records show that flamingoes were observed on the Botriviervlei on many occasions during 1980 when water levels were generally high (at least 1,4 m above MSL). Evidently there are sufficient shallow areas available for flamingoes even when the vlei is rather full. Whereas it is likely that the exposed areas attracted larger numbers of waders, the dropping of the water level and the resultant die-off of weed led to the departure of about 25 000 resident coots. By September 1982, almost a year after the second artificial breaching, a large proportion of the coot population appears to have returned to the Botriviervlei.

As a consequence of the second breaching of the dune barrier on 10 October 1981 the water level in the Botriviervlei dropped by about 120 cm resulting in a reduction of water surface by 40 percent. Extensive areas of the vlei bottom were exposed. Because of the nature of the system this included all those areas where aquatic macrophytes had been established. The vlei became unsightly with an intensive smell of rotting vegetation. The effect on the flora and fauna of the system, with the exception of the marine fish, was highly detrimental. All the aquatic vegetation was destroyed together with a large proportion of its associated fauna. Simultaneously the food source for the thousands of resident coots was destroyed and these birds left the vlei immediately. As has been pointed out, few large wetlands exist along our coastline and, with the Bot/Kleinmond coot population comprising a large proportion of all the coots along the southwestern Cape coast, the pressure on those other system which had to absorb the Bot/Kleinmond population must have been intense.

Furthermore, the submerged aquatic macrophyte beds are important habitats for various types of fauna, particularly small fish, and more than 100 dead fish per square metre were counted in places among the rotting vegetation (AEF Heydorn, pers. comm.). These were either the smaller, less conspicuous estuarine species or juveniles of the larger marine migrants or truly marine species.

It should be noted that, apart from these ecological effects, the recreational potential of the area was severely reduced for some considerable time. Water levels had dropped to the extent where boating became very difficult with both the slipway and the jetty at the Lake Marina Yacht Club unusable, and large areas of rotting vegetation had to be traversed before the water's edge could be reached.

A positive aspect of the opening of the vlei to the sea is that it seems likely that it has been naturally re-stocked with angling fishes, although according to the survey by R Bally mentioned above, no decline in catches had been experienced. There had, however, been a large mortality of the marine fish species immediately prior to the second opening, probably due to low salinities experienced at that time.

A further positive aspect, particularly of the second breaching at Sonesta, was that the Botriviervlei was able to discharge a large proportion of the suspended sediments into the sea through the mouth. Once tidal conditions had been established in the vlei, however, the salinity gradient between the river and the estuary would have led to flocculation and much of the suspended sediment would have settled out in upper reaches again.

It seems doubtful, when all ecological and other considerations are weighed up, whether the negative impact of the opening of the Botriviervlei to the sea on the ecosystem as a whole, can be balanced against the fact that the vlei is now again well stocked with marine angling fish. In its recommendations on management of estuaries, the CDNEC (1979) points out that "angling is one of the most popular recreational activities on estuaries, as such it is of considerable economic importance". At the same time, however, it clearly states that "the scientific, aesthetic and recreational values of estuaries are much more important than the commercial exploitation thereof".

Finally, it must be realised that any decision about management of the Bot/Kleinmond system will profoundly affect the local population, particularly the community at Hawston. In a recent survey, R Bally has found that the Hawston fisherfolk regard the Botriviervlei as an important area which influences their lives continuously. Although they do not appear to use it for recreational purposes, the vast majority of respondents go fishing there. It is thus particularly important that any management decisions should take into account the needs of that community.

Recommendations:

(1) The remains of the earthen service dam used during construction of the road bridge over the Bot River should be removed before the next major rainfalls. All the material should be

removed in order to lower the dry area under the bridge spans to the same level as the surrounding reed floodplains. It is important that the river course be obstructed as little as possible so that the river can use the full span of the bridge, especially during times of strong flow.

(2) The extensive reed beds around the mouth of the Bot and Afdaks rivers should be specially protected from all perturbation. These areas are not only important refuges for birds but they act as filters for the water from the catchment, not only absorbing some of the potential pollutants (e.g. fertilizer run-off) but also acting as sediment traps and thus reducing siltation in the estuary.

(3) An effort should be made to control the spread of alien vegetation (*Acacia saligna* and *A. cyclops*) around the estuary. It is particularly important to check the advance of these plants in the sensitive and hydrologically essential Lamloch swamp area. In other areas they should be gradually removed and the natural fynbos vegetation re-established. The co-operation of the local farmers will have to be obtained since much of this alien vegetation has become established on private land.

(4) As one of the most important wetlands for waders in the southwestern Cape, the Bot/Kleinmond system should be registered with the Ramsar Convention (see above). Simultaneously steps should be taken to protect it locally, and it is recommended that the entire system be given Category B conservation status (see Heydorn and Tinley, 1980 p. 87).

(5) Any decision on artificial opening of the Botriviervlei to the sea should be made only after consultation between the Cape Department of Nature and Environmental Conservation, the participating scientists at the University of Cape Town and the National Research Institute for Oceanology. A firm recommendation regarding breaching of the dune barrier cannot be made at this stage because all the necessary information is not yet available. It is envisaged that after the end of the Bot/Kleinmond research programme in 1986 a follow-up report will be compiled containing all additional information as well as further recommendations in this regard. At this stage the reader is referred to the relevant section of the CDNEC recommendations "A Management Strategy for Estuaries and Coastal Lakes in the Cape Province" (1979 p. 4 - See Appendix V).

(6) A sociological study should be initiated in order to assess the impact that different management strategies might have on the local community, particularly the inhabitants of Hawston. The requirements of the local population with regard to the Botriviervlei should be thoroughly assessed and must be taken into account before management decisions can be taken.

(7) All further development should be restricted to land above the 50-year flood level. The existing legislation in this regard should be strictly enforced.

(8) The area has not reached its full recreational potential and further efforts should be made to encourage responsible development in that field.

6. ACKNOWLEDGEMENTS

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7. GLOSSARY OF TERMS USED IN PART II REPORTS

abiotic: non-living (characteristics).
aeolian (deposits): materials transported and laid down on the earth's surface by wind.
alien: plants or animals introduced from one environment to another, where they had not occurred previously.
alluvium: unconsolidated fragmental material laid down by a river or stream as a cone or fan, in its bed, on its floodplain and in lakes or estuaries, usually comprised of silt, sand or gravel.
anaerobic: lacking or devoid of oxygen.
anoxic: the condition of not having enough oxygen.
aquatic: growing or living in or upon water.
arcuate: curved symmetrically like a bow.
barchanoid (dune): crescent-shaped and moving forward continually, the horns of the crescent pointing downwind.
bathymetry: measurement of depth of a water body.
benthic: bottom-living.
berm: a natural or artificially constructed narrow terrace, shelf or ledge of sediment.
bimodal: having two peaks.
biogenic: originating from living organisms.
biomass: a quantitative estimation of the total weight of living material found in a particular area or volume.
biome: major ecological regions (life zones) identified by the type of vegetation in a landscape.
biotic: living (characteristics).
breaching: making a gap or breaking through (a sandbar).
calcareous: containing an appreciable proportion of calcium carbonate.
calcrete: a sedimentary deposit derived from coarse fragments of other rocks cemented by calcium carbonate.
Chart Datum: This is the datum of soundings on the latest edition of the largest scale navigational chart of the area. It is -0,900 m relative to land levelling datum which is commonly called Mean Sea Level by most land surveyors.
coliforms: members of a particularly large, widespread group of bacteria normally present in the gastro-intestinal tract.
community: a well defined assemblage of plants and/or animals clearly distinguishable from other such assemblages.
conglomerate: a rock composed of rounded, waterworn pebbles 'cemented' in a matrix of calcium carbonate, silica or iron oxide.
cusp: a sand spit or beach ridge usually at right angles to the beach formed by sets of constructive waves.
"D" net: a small net attached to a "D" shaped frame riding on skids and pulled along the bottom of the estuary, used for sampling animals on or near the bottom.
detritus: organic debris from decomposing plants and animals.
diatoms: a class of algae with distinct pigments and siliceous cell walls. They are important components of phytoplankton.
dynamic: relating to ongoing and natural change.
ecology: the study of the structure and functions of ecosystems, particularly the dynamic co-evolutionary relationships of organisms, communities and habitats.
ecosystem: an interacting and interdependent natural system of organisms, biotic communities and their habitats.
eddies: a movement of a fluid substance, particularly air or water, within a larger body of that substance.
endemic: confined to and evolved under the unique conditions of a particular region or site and found nowhere else in the world.
enon: most striking formation in the Cape. Crammed with pebbles and boulders, phenomenally embedded and massive, yellow or brilliantly red in colour, producing remarkable hills. Curiously carved into

epifauna: animal life found on the surface of any substrate such as plants, rocks or even other animals.

epiphyte: a plant living on the surface of another plant without deriving water or nourishment from it.

episodic: sporadic and tending to be extreme.

estuary: a partially enclosed coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage (Day 1981).

eutrophication: the process by which a body of water is greatly enriched by the natural or artificial addition of nutrients. This may result in both beneficial (increased productivity) and adverse effects (smothering by dominant plant types).

flocculation (as used in these reports): the settlement or coagulation of river borne silt particles when they come in contact with sea water.

fluvial (deposits): originating from rivers.

food web: a chain of organisms through which energy is transferred. Each "link" in a chain feeds on and obtains energy from the preceding one.

fynbos: literally fine-leaved heath-shrub. Heathlands of the south and south-western Cape of Africa.

geomorphology: the study of land form or topography.

gill net: a vertically placed net left in the water into which fish swim and become enmeshed, usually behind the gills.

habitat: area or natural environment in which the requirements of a specific animal or plant are met.

halophytes: plants which can tolerate salty conditions.

HAT (Highest Astronomical Tide) and LAT (Lowest Astronomical Tide): HAT and LAT are the highest and lowest levels respectively, which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions; these levels will not be reached every year. HAT and LAT are not the extreme levels which can be reached, as storm surges may cause considerably higher and lower levels to occur (South African Tide Tables 1980).

hummock (dune): a low rounded hillock or mound of sand.

hydrography: the description, surveying and charting of oceans, seas and coastlines together with the study of water masses (flow, floods, tides etc.).

hydrology: the study of water, including its physical characteristics, distribution and movement.

indigenous: belonging to the locality; not imported.

intertidal: generally the area which is inundated during high tides and exposed during low tides.

isohyets: lines on maps connecting points having equal amounts of rainfall.

isotherms: lines on maps joining places having the same temperature at a particular instant, or having the same average, extremes or ranges of temperature over a certain period.

lagoon: an expanse of sheltered, tranquil water. (Thus Langebaan lagoon is a sheltered arm of the sea with a normal marine salinity; Knysna lagoon is an expanded part of a normal estuary and Hermanus lagoon is a temporarily closed estuary (Day 1981)).

limpid: clear or transparent.

littoral: applied generally to the seashore. Used more specifically it is the zone between high- and low-water marks.

longshore drift: a drift of material along a beach as a result of waves breaking at an angle.

macrophyte: any large plant as opposed to small ones. Aquatic macrophytes may float at the surface or be submerged and/or rooted on the bottom.
marls: crumbly mixture of clay, sand and limestone, usually with shell fragments.
matrix: medium in which a structure is embedded.
meiofauna: microscopic or semi-microscopic animals that inhabit sediments but live quite independently of the macrofauna, or benthos.
metamorphic: changes brought about in rocks within the earth's crust by the agencies of heat, pressure and chemically active substances.
MHWS (Mean High Water Springs) and MLWS (Mean Low Water Springs): the height of MHWS is the average, throughout a year when the average maximum declination of the moon is 23°, of the height of two successive high waters during those periods of 24 hours (approximately once a fortnight) when the range of the tide is greatest. The height of MLWS is the average height obtained by the two successive low waters during the same periods (South African Tide Tables 1980).
morphometry: physical dimensions such as shape, depth, width, length etc.
osmoregulation: the regulation in animals of the osmotic pressure in the body by controlling the amount of water and/or salts in the body.
pathogenic: disease producing.
photosynthesis: the synthesis of carbohydrates in green plants from carbon dioxide and water, using sunlight energy.
phytoplankton: plant components of plankton.
piscivorous: fish eating.
plankton: microscopic animals and plants which float or drift passively in the water.
quartzite: rock composed almost entirely of quartz recemented by silicon. Quartzite is hard, resistant and impermeable.
riparian: adjacent to or living on the banks of rivers, streams or lakes.
rip current: the return flow of water which has been piled up on the shore by waves, especially when they break obliquely across a longshore current.
salinity: the proportion of salts in pure water, in parts per thousand by mass. The mean figure for the sea is 34,5 parts per thousand, written 34,5°/$_{oo}$.
secchi disc: a simple instrument used to measure the transparency of water.
sheet flow: water flowing in thin continuous sheets rather than concentrated into individual channels.
slipface: the sheltered leeward side of a sand-dune, steeper than the windward side.
teleost: modern day bony fishes (as distinct from cartilaginous fishes).
trophic level: a division of a food chain defined by the method of obtaining food either as primary producers, or as primary, secondary or tertiary consumers.
trough: a crescent shaped section of beach between two cusps.
wetlands: areas that are inundated or saturated by surface or ground water frequently enough to support vegetation adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.
zooplankton: animal components of plankton.

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APPENDIX I: Tentative species list and physical features of the vegetation units of the area studied at the Botriviervlei.

Mapping Unit	+Area (ha)	% of area studied	Cover (%)	Average height (m)
Semi-aquatic vegetation				
Reeds:	113,5	2,6	95	2,0
Marshes:	92,4	2,1	80	0,1
Dune vegation				
Natural:	125,2	2,9	30	1,0
Aliens:	321,0	7,3	95	2,0
Coastal renosterveld/fynbos	411,3	9,4	70	1,5
Farmed areas	1829,3	41,6		
Sand	152,3	3,5		
Water	1340,2	30,6		
Total	4385,2			

(+Estimated values)

Reeds (Note: These species usually form monospecific stands. Cover/abundance values averaged over all swamp areas).

Acacia cyclops (+); *Chondropetalum tectorum* (+); *Cyperus textilis* (+); *Juncus acutis* (2); *J. krausii* (4); *J. littoralis* (3); *Mariscus thumbergii* (r); *Phragmites australis* (5); *Scirpus nodosus* (1).

Marshes

Acacia cyclops (r); *Chenolea diffusa* (+); *Cotula coronopifolia* (+); *Cynodon dactylon* (r); *Plantago carnosa* (+); *Sarcocornia decumbens* (+); *S. natalensis* (2); *Sporobolus virginicus* (5).

Dune vegetation

Agropyron distichum (2); *Ammophila arenaria* (3); *Arctotheca populifolia* (r); *Carpobrotus aciniformis* (r); *Chrysanthemoides monolifera* (1); *Ehrharta villosa* (1); *Helichrysum dassyanthum* (1); *Helichrysum* sp. (1); *Heteroptilis suffriticosa* (+); *Metalasia muricata* (1); *Myrica cordifolia* (+); *Pelargonium capitatum* (r); *Rhus glauca* (2); *Rhus laevigata* (1); *Salvia aurea* (1); *Senecio elegans* (1); *S. halimifolius* (+); *S. littoreus* (+); *Sideroxylon inerme* (2); *Stoebe plumosa* (1); *Tetragonia decumbens* (1); *T. fruticosa* (1); *Trachyandra divaricata* (+).

Coastal renosterveld/fynbos

Acacia cyclops (1); *A. saligna* (4); *Aizoon sarmentosum* (+); *Aspalathus* cf *asparagoides* (r); *Chondropetalum* cf *rectum* (+); *Erica cordifolia* (3);

E. nudiflora (+); *Eroeda capensis* (+); *Gladiolus tenellus* (r); *Heliophila* sp. (r); *Leucodendron linifolium* (+); *L.* cf *modestum* (1); *L. stelligerum* (+); *L. laevigatum* (+); *Metalasia muricata* (+); *Passerina* sp. (+); *Protea scolymocephala* (+); *Salvia aurea* (+); *Spiloxene* sp. (+); *Mesembryantenaceae* (1).

Note: The symbols in parentheses following each species name represent adapted Braun-Blanquet Cover-Abundance Classes as follows:

r - 1/few individuals, cover less than 0,1% of area
+ - occasional plants, cover less than 1% of area
1 - abundant, cover 1 - 5% of area
2 - any number, cover 6 - 25% of area
3 - any number, cover 26 - 50% of area
4 - any number, cover 52 - 75% of area
5 - any number, cover 76 - 100% of area.

APPENDIX II: Checklist of zooplankton species from the Botriviervlei (from Coetzee, 1982).

PROTOZOA
- Foraminifera

COELENTERATA
- polyps

PLATHYHELMINTHES
- Turbellaria

NEMATODA

ANNELIDA
- Polychaeta
- Hirudinea

ARTHROPODA
- Crustacea
  - Ostracoda
  - Copepoda
    - Nauplius larvae
    - *Pseudodiaptomus hessei*
    - *Acartia longipatella*
    - *Paracalanus crassirostris*
    - *Oithona similis*
    - *Halycyclops* spp.
    - Ergasilidae
    - Other cyclopoids
    - Tegastidae
    - Other harpacticoids
  - Branchiura
    - *Argulus* sp.
  - Isopoda
    - *Exosphaeroma hylecoetes*
    - *Cyathura estuaria*
    - *Corallana africana*
  - Amphipoda
    - *Corophium triaenonyx*
    - *Melita zeylanica*
    - *Grandidierella lutosa*
    - Unidentified amphipods

Mysidacea
Rhopalophthalmus terranatalis
Mesopodopsis slabberi
Gastrosaccus brevifissura
Tanaidacea
Apseudes digitalis
Decapoda
Brachyura
Zoea larvae
Anomura
Callianassa kraussi larvae
C. kraussi post-larvae
Insecta
Chironomidae larvae
Chironomidae pupae
Odonata nymphs
Ephemeroptera nymphs
Terrestrial insects
Arachnida
Hydracarina
MOLLUSCA
Lamellibranch veligers
Lamellibranch juveniles
Gastropod veligers
INVERTEBRATE EGGS
OSTEICHTHYES
Fish eggs
Fish larvae
Syngnathus juveniles

APPENDIX III: List of birds recorded from the Bot/Kleinmond system and its catchment area. The list gives the Roberts number (Roberts, 1978), common name and scientific name. The list is compiled according to the habitats encountered in the area.

A. Vlei including open water and shore

4	Crested grebe	*Podiceps cristatus*
5	Black-necked grebe	*Podiceps nigricollis*
6	Dabchick	*Podiceps ruficollis*
42	White pelican	*Pelicanus onocrotalus*
47	White-breasted cormorant	*Phalacrocorax carbo*
50	Reed-cormorant	*Phalacrocorax africanus*
52	Darter	*Anhinga rufa*
54	Grey heron	*Ardea cinerea*
59	Little egret	*Egretta garzetta*
81	Sacred ibis	*Threskiornis aethiopicus*
85	Spoonbill	*Platalea alba*
86	Greater flamingo	*Phoenicopterus ruber*
87	Lesser flamingo	*Phoenicopterus minor*
89	Egyptian goose	*Alopochen aegypticus*
94	Cape shoveller	*Anas smithii*
96	Yellowbill duck	*Anas undulata*
97	Red-billed teal	*Anas erythrorhyncha*
98	Cape teal	*Anas capensis*
102	Southern pochard	*Netta erythrophthalma*
103	Maccoa duck	*Oxyura punctata*
149	Fish eagle	*Haliaeetus vocifer*

212	Red-knobbed coot	*Fulica cristata*
231	Black oystercatcher	*Haematopus moquini*
235	White-fronted plover	*Charadrius marginatus*
238	Three-banded plover	*Charadrius tricollaris*
245	Blacksmith plover	*Vanellus armatus*
250	Ethiopian snipe	*Gallinago nigripennis*
253	Little stint	*Calidris minuta*
258	Common sandpiper	*Tringa hypoleucos*
262	Marsh sandpiper	*Tringa stagnatilis*
263	Greenshank	*Tringa nebularia*
264	Wood sandpiper	*Tringa glareola*
269	Avocet	*Recurvirostra avosetta*
270	Black-winged stilt	*Himantopus himantopus*
287	Southern black-backed gull	*Larus dominicanus*
288	Grey-headed gull	*Larus cirrocephalus*
289	Hartlaubs gull	*Larus novaehollandiae*
290	Caspian tern	*Hydroprogne caspia*
296	Sandwich tern	*Sterna sandvicensis*
298	Swift tern	*Sterna bergii*
304	White-winged black tern	*Chlidonias leucoptera*
394	Pied kingfisher	*Ceryle rudis*
395	Giant kingfisher	*Ceryle maxima*
397	Malachite kingfisher	*Alcedo cristata*
686	Cape wagtail	*Motacilla capensis*

B. Reeds along edges of vlei and streams

69	Night heron	*Nycticorax nycticorax*
167	African marsh harrier	*Circus ranivorus*
203	Black crake	*Limnocorax flavirostris*
208	Purple gallinule	*Porphyrio porphyrio*
210	Moorhen	*Gallinula chloropus*
357	White-browed concal	*Centropus supercilliosus*
604	Cape reed warbler	*Acrocephalus gracilirostris*
606	South African marsh warbler	*Acrocephalus baeticatus*
609	Cape sedge warbler	*Bradypterus babaecala*
646	Le Vaillant's cisticola	*Cisticola tinniens*
799	Cape weaver	*Ploceus capensis*
808	Red bishop	*Euplectes orix*
843	Common waxbill	*Estrilda astrild*
846	Pin-tailed whydah	*Vidua macroura*

No. 250 also occurs in this habitat.

C. Bush along streams

130	Black-shouldered kite	*Elanus caeruleus*
176	Greywing francolin	*Francolinus africanus*
181	Cape francolin	*Francolinus capensis*
192	Helmeted guineafowl	*Numida meleagris*
275	Cape dikkop	*Burhinus capensis*
311	Rock pigeon	*Columba guinea*
314	Red-eyed dove	*Streptopelia semitorquata*
317	Laughing dove	*Streptopelia senegalensis*
351	Klaas's cuckoo	*Chrysococcyx klaas*
368	Spotted eagle owl	*Bubo africanus*
390	Speckled mousebird	*Colius striatus*

392	Red-faced mousebird	*Colius indicus*
418	Hoopoe	*Upupa epops*
511	Black sawwing swallow	*Psalidoprocne pristoptera*
553	Olive thrush	*Turdus olivaceus*
581	Cape robin	*Cossypha caffra*
622	Bar-throated apalis	*Apalis thoracica*
665	Fiscal flycatcher	*Melaenornis silens*
672	Cape batis	*Batis capensis*
709	Boubou	*Laniarius ferrugineus*
745	Red-winged starling	*Onychognathus morio*
751	Malachite sunbird	*Nectarinia famosa*
760	Lesser double-collared sunbird	*Nectarinia chalybea*
775	Pale white-eye	*Zosterops pallidus*
810	Cape bishop	*Euplectes capensis*
857	Cape canary	*Serinus canicollis*
863	Bully canary	*Serinus sulphuratus*

D. Macchia in catchment area

123	Rock kestrel	*Falco tinnunculus*
152	Jackal Buzzard	*Buteo rufofuscus*
445	Ground woodpecker	*Geocolaptes olivaceus*
559	Cape rock thrush	*Monticola rupestris*
560	Sentinel rock thrush	*Monticola explorator*
570	Familiar chat	*Cercomela familiaris*
576	Stonechat	*Saxicola torquata*
612	Victorin's warbler	*Bradypterus victorini*
618	Grassbird	*Sphenoeacus afer*
637	Neddicky	*Cisticola fulvicapilla*
638	Grey-backed cisticola	*Cisticola subruficapilla*
749	Cape sugar bird	*Promerops cafer*
753	Orange-breasted sunbird	*Nectarinia violacea*
855	Cape siskin	*Serinus totta*
869	Protea seed-eater	*Serinus leucopterus*
873	Cape bunting	*Emberiza capensis*

Nos. 176, 181, 311, 581, 745, 751, 760, 775, 810, 857 and 863 also occur in this habitat.

E. Throughout the catchment area and around the estuary

72	Hamerkop	*Scopus umbretta*
316	Cape turtle dove	*Streptopelia capicola*
380	Black swift	*Apus barbatus*
383	White rumped swift	*Apus caffer*
385	Little swift	*Apus affinis*
386	Alpine swift	*Apus melba*
495	White-throated swallow	*Hirundo albigularis*
502	Greater striped swallow	*Hirundo cucullata*
506	Rock martin	*Hirundo rupestris*
509	African sand martin	*Riparia paludicola*
543	Cape bulbul	*Pycnonotus capensis*
651	Karoo prinia	*Prinia maculosa*

707	Fiscal shrike	*Lanius collaris*
722	Bokmakierie	*Malaconotus zeylonus*
746	Pied starling	*Spreo bicolor*
786	Cape sparrow	*Passer melanurus*

APPENDIX IV: Names and addresses of scientists presently involved in research in the Bot/Kleinmond area

Name/Institution	Field of research
Geochemistry Dept., UCT	
Prof. JP Willis	Geology/Sedimentology
Zoology Dept., UCT	
Prof. GM Branch	Administration/Finance
Dr R Bally	General Ecology
Mr B Bennett	Fish
Mr HP de Decker	Invertebrate Ecology and Energetics
Microbiology Dept., UCT	
Ms C Roberts	Microbiology
Marine Geoscience Dept., UCT	
Dr J Rogers	Sedimentology and Quaternary history
Geological Survey	
Dr JN Theron (Bellville)	Sedimentology
Mr A du Plessis (Pretoria)	Geophysics
NRIO/CEHD, Stellenbosch	
Dr GAW Fromme	Hydraulics

APPENDIX V: A management strategy for estuaries and coastal lakes in the Cape Province. Section pertaining to artificial opening of estuaries (p. 4).

"Estuary mouths may only be opened artificially at predetermined water levels after consultation with the Department. About 90% of South African estuaries are partly or completely closed by a sand bar across the mouth of the estuary for part of the year; in many of these estuaries it has become the custom to open the estuary mouth artificially. An estuary mouth may only be opened artificially after permission has been obtained from the Department of Agricultural Credit and Land Tenure, the Department of Nature and Environmental Conservation should be consulted about the correct positioning of the opening. This artificial opening should be limited only to cases where damage to habitations on private properties can occur, and then only when the water level has reached a point where damage is imminent. In such estuaries a "danger" level should be established and the mouth opened at a predetermined point only when the water reaches that level. Estuary mouths may have to be opened for ecological reasons, but then only after consultation with this Department."

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC																				BIOTIC											
		Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other						Flora		Fauna									Food Webs
BOTRIVIERVLEI		Catchment characteristics	Morphology	Hydrology	Density variations	Circulation & mixing	Geology	Paleoenvironment	Sediment transport & deposition	General chemistry	Eutrophication	Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Other invertebrates	Insects	Fauna on hard substrates	Fauna on soft substrates	Fish	Reptiles & Amphibians	Birds	Mammals	
Sources of Information		Summary of available information																															
Acocks	1975																							*									
Bally	1982															*			*	*	*												
Boycott	1982																													*			
Branch & Day	1981																									*							
Caledon Divisional Council	1975															*				*													
Cape Province Administration	1973															*			*	*													
Coetzee	1982									*															*								
Fitzsimons	1943																													*			
Fitzsimons	1962																													*			
Forbes	1978																									*			*				
Fromme	1982		*	*		*	*	*	*	*						*				*	*												
Greig & Burdett	1976																													*			
Greig *et al*	1979																													*			
Heydorn & Tinley	1980	*		*			*			*						*			*														
Koop *et al*	1982									*												*	*		*	*		*					
Loveridge & Williams	1957																													*			
McLachlan	1978																													*			
Meester	1976																															*	

APPENDIX VI: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: BOTRIVIERVLEI

			Summary of available information	Noble & Hemens	Poynton	River flow data	River flow data (unpub.)	Roberts	Rooseboom	Roussouw	Siegfried *et al*	Skinner *et al*	South Africa (Rep.) Dept. Planning	Stuart *et al*	Stuart	Summers *et al*	Swart & Serdyn	Theron *et al*	Whitfield *et al*	Willis	Willis
YEAR (DATE OF INFORMATION)				1978	1964	1978	-	1978	1980	1982	1976	1977	1968	1980	1981	1976	1982	1981	1981	1981	1982
BIOTIC		Food Webs																			
BIOTIC	Fauna	Mammals										*		*	*						
BIOTIC	Fauna	Birds						*			*					*					
BIOTIC	Fauna	Reptiles & Amphibians			*																
BIOTIC	Fauna	Fish																	*		
BIOTIC	Fauna	Fauna on soft substrates																			
BIOTIC	Fauna	Fauna on hard substrates																			
BIOTIC	Fauna	Insects																			
BIOTIC	Fauna	Other invertebrates																			
BIOTIC	Fauna	Zooplankton																			
BIOTIC	Flora	Terrestrial																			
BIOTIC	Flora	Phytoplankton																			
BIOTIC	Flora	Halophytes																			
ABIOTIC	Other	Historical											*								
ABIOTIC	Other	Utilization											*								
ABIOTIC	Other	Conservation											*			*					
ABIOTIC	Other	Modelling																			
ABIOTIC	Other	Aquaculture																			
ABIOTIC	Other	Management											*								
ABIOTIC		Bacteriology																			
ABIOTIC	Chemistry	Pesticide residues																			
ABIOTIC	Chemistry	Metal residues																			
ABIOTIC	Chemistry	Eutrophication																			
ABIOTIC	Chemistry	General chemistry																			
ABIOTIC	Geomorphology	Sediment transport & deposition							*											*	*
ABIOTIC	Geomorphology	Paleoenviroment																			
ABIOTIC	Geomorphology	Geology																*		*	
ABIOTIC	Physics	Circulation & mixing								*							*				
ABIOTIC	Physics	Density variations																			
ABIOTIC	Physics	Hydrology		*		*	*			*							*				
ABIOTIC	Physiography	Morphology																			
ABIOTIC	Physiography	Catchment characteristics		*					*												

Sources of Information

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC																				BIOTIC										
		Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other						Flora			Fauna								
BOTRIVIERVLEI		Catchment characteristics	Morphology	Hydrology	Density variations	Circulation & mixing	Geology	Paleoenvironment	Sediment transport & deposition	General chemistry	Eutrophication	Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Other invertebrates	Insects	Fauna on hard substrates	Fauna on soft substrates	Fish	Reptiles & Amphibians	Birds	Mammals	Food Webs
Sources of Information		Summary of available information																														
C Baker (pers. comm.)	1982								*											*												
R Balley (pers. comm.)	1982		*							*																				*	*	
B Bennett (pers. comm.)	1982																												*			
RC Boycott (pers. comm.)	1982																													*		
Caledon Divisional Council (pers. comm.)	1981															*												*				
J Cooper (pers. comm.)	1982																														*	
J Delport (pers. comm.)	1982		*																													
C Heyl (pers. comm.)	1982																														*	
AEF Heydorn (pers. comm.)	1981																				*											
AEF Heydorn (pers. comm.)	1982																												*			
JW Lambrechts (pers. comm.)	1981															*																
K Lester (pers. comm.)	1982		*																		*											
R Martin (pers. comm.)	1982																														*	
JD van Wyk (pers. comm.)	1979															*																
D Zietsman (pers. comm.)	1982			*																												
MAPS																																
Africa South Coast	1867																				*											

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC																					BIOTIC												
		Physiography		Physics			Geomorphology		Chemistry				Bacteriology	Other							Flora		Fauna											Food Webs
BOTRIVIERVLEI		Catchment characteristics	Morphology	Hydrology	Density variations	Circulation & mixing	Geology	Paleoenviroment	Sediment transport & deposition	General chemistry	Eutrophication	Metal residues	Pesticide residues		Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Other invertebrates	Insects	Fauna on hard substrates	Fauna on soft substrates	Fish	Reptiles & Amphibians	Birds	Mammals		
Sources of Information		Summary of available information																																	
Cape Coast Recreat. Land Use Classif.	-		*																*															
Cape of Good Hope	1899																			*														
Cape of Good Hope	1903																			*														
Dayman, J and Simpson, HJ	1857																			*														
Dayman, J *et al*	1853																			*														
De Smit, A	1880																			*														
Map of the Colony of Cape of Good Hope	1880																			*														
Map of the Western Cape	1840																			*														
S.A. 1:50 000 3419 AC	1944																			*														
S.A. 1:125 000 Geological Map 3419 A	1966						*																											
S.A. 1:500 000 SE 35/17½	1967																			*														
S.A. 1:250 000 3319	1975	*	*																	*														
S.A. 1:50 000 3419 AC	1976	*	*																	*														
S.A. Navy 1:50 000 Map no 120	1981		*																															
World Aeronautical Chart 1:1 000 000 3422	1976	*	*																	*														
AERIAL PHOTOGRAPHY																																		
Trig Survey:																																		

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC																						BIOTIC												
		Physiography		Physics			Geomorphology			Chemistry					Bacteriology	Other								Flora			Fauna										
BOTRIVIERVLEI		Catchment characteristics	Morphology	Hydrology	Density variations	Circulation & mixing	Geology	Paleoenvironment	Sediment transport & deposition	General chemistry	Eutrophication	Metal residues	Pesticide residues			Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Other invertebrates	Insects	Fauna on hard substrates	Fauna on soft substrates	Fish	Reptiles & Amphibians	Birds	Mammals	Food Webs	
Sources of Information		Summary of available information																																		
Job No. 130 38	1938		*																		*														
Job No. 461	1961		*																		*														
Job No. 719	1973		*																		*														
Univ. of Natal, Dept. Land Surveying																																				
Job No. 295/8	1972		*																		*														
Job No. 282	1977		*																		*														
Job No 326	1979		*																	*	*														
Job No. 349	1980		*																																	
Job No. 374	1980		*																		*														
Job No. 376	1981		*																	*	*														
NRIO Coastal Photogramm. Res. Unit:																																				
Photo No's 1-40	1981		*																		*														

PLATES I, II AND III OVERLEAF

PLATE 1:

Aerial photograph (February 1981, 1 : 10000) showing Lamloch swamps area. The Kleinmond estuary is on the right and the western end of Rooisand on the left. The full overflow channel in the dunes can be seen at the top of the picture.

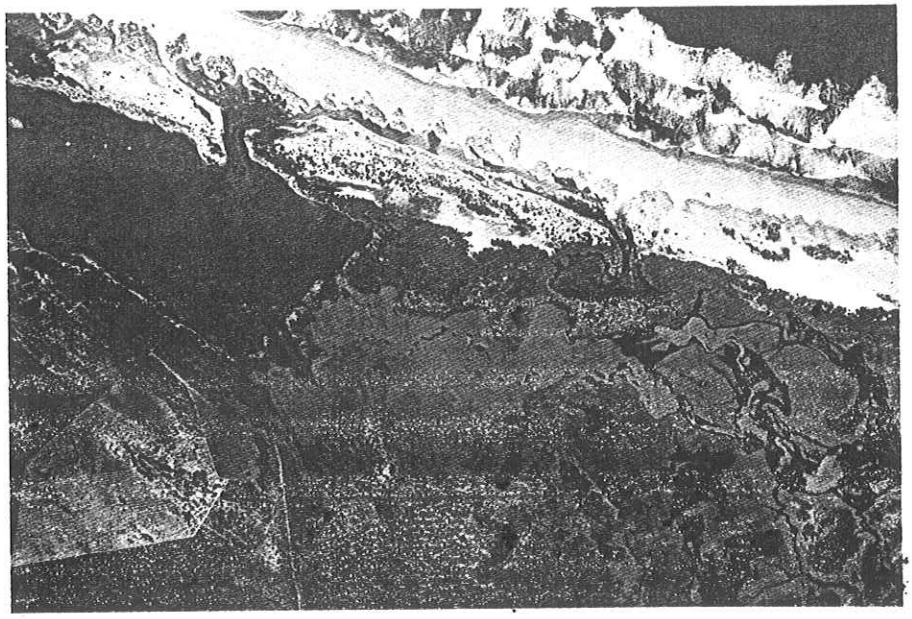

PLATE II:

Channel cut by the artificial opening of the Botriviervlei at Rooisand (10 August 1981). A distinct boundary between black water from the Kleinmond estuary and turbid water from the Bot flowing out to sea on the right of the picture is evident.

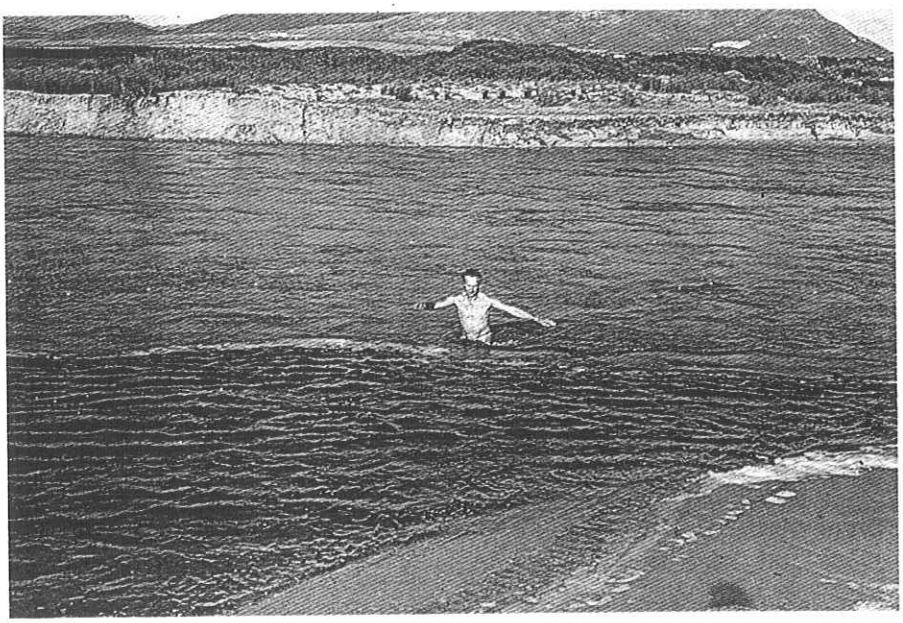

PLATE III:

The new road bridge over the Bot River at the head of the vlei. The remains of the earthen service dam can be clearly seen in the foreground and on the opposite bank. It is urgently recommended that this be removed before the winter rains of 1983.