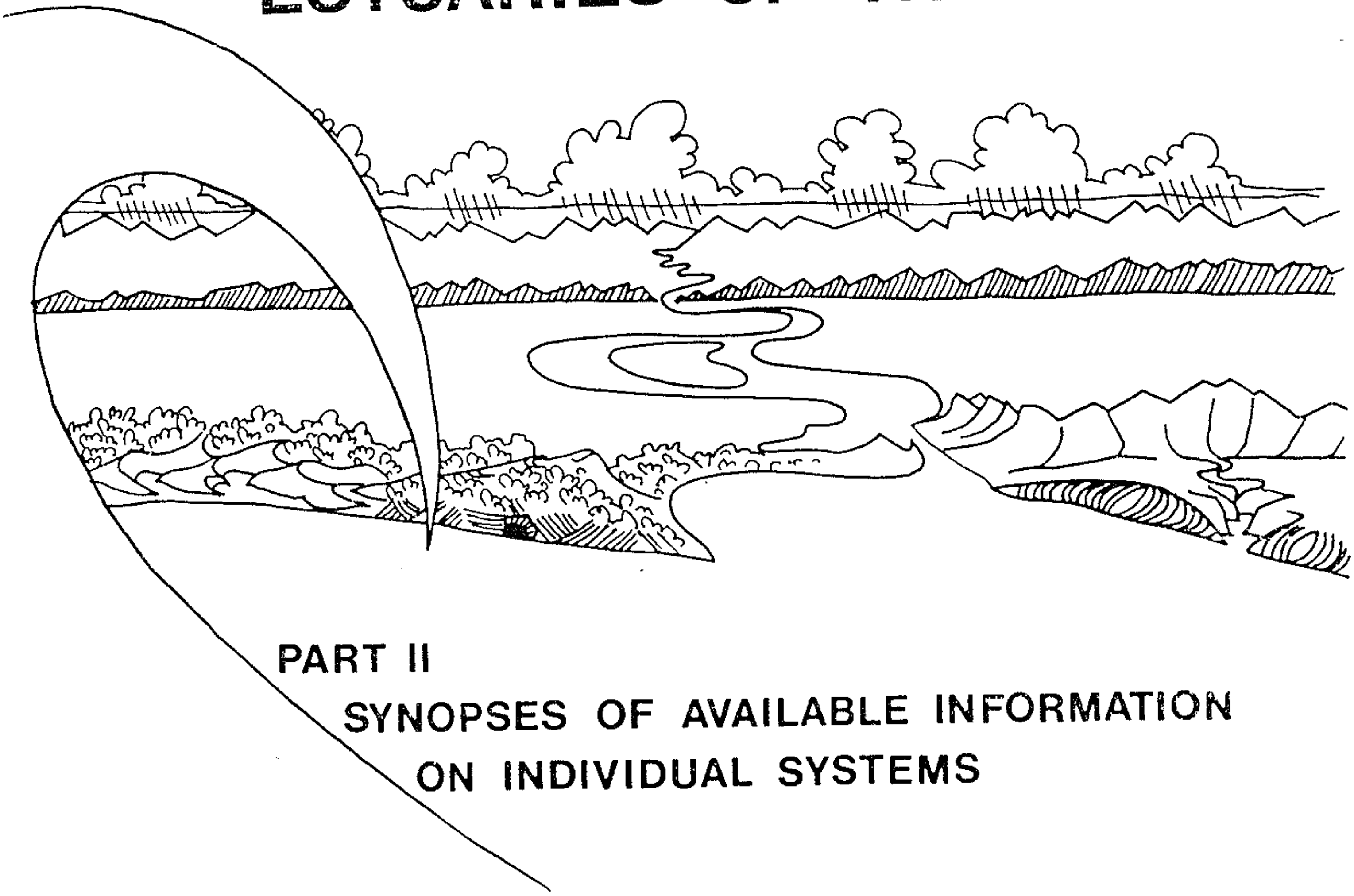
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT - ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 21
BREË (CSW 22)

CSIR RESEARCH REPORT 420

Stellenbosch, South Africa
December 1983

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PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS:
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FRONTISPIECE: THE BREË RIVER ESTUARY – ALT. 150m, ECRU 79-10-16

REPORT NO. 21: BREË (CSW 22)

(CSW 22 – CSIR Estuary Index Number)

BY: R A CARTER

ESTUARINE AND COASTAL RESEARCH UNIT — ECRU
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December 1983

BREË

ECRU Survey: 29 November - 3 December 1982

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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

[+] CSIR Research Report 380

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BREË

1. HISTORICAL BACKGROUND

1.1 Synonyms

Rio de Nazaré	(early Portuguese explorers; Axelson, 1973)
Breede	(early Dutch explorers; Burrows, 1952; Burman, 1970; Axelson, 1973)
Breë	(1:50 000 sheet 3420 BC, BD).

1.2 Historical Aspects

The first records of the Breë River estuary were those of Bartholomew Dias who landed in the area in 1488. He named the river 'Nazaré' and the bay into which it empties Shelter Bay (Axelson, 1973). Perestrello, another Portuguese explorer, renamed the bay St. Sebastian Bay in 1575 and also gave Cape Infanta its name (after a captain of one of Dias's ships). Perestrello recommended St. Sebastian Bay as a safe winter anchorage and considered the Breë to be navigable although he anticipated trouble with the bar (Axelson, 1973).

Overland the Breë River was first encountered by European explorers in the second half of the 17th century; Sergeant P Cruijthoff in 1667 being considered the first pioneer to have seen it (Burman, 1970).

Middens near the coast on Witklip estate suggest earlier human habitation of the area but there are no formal records. Dias encountered Hottentots in the vicinity of Mossel Bay and undoubtedly these nomadic people would have also been in the area of the Breë Estuary but again there are no formal records.

Despite Perestrello's recommendations and the use of St. Sebastian Bay as an anchorage by passing Portuguese ships, no survey was carried out until the 1790s. Also despite Portuguese, Dutch and English interests in the area the first survey was actually carried out by a Frenchman by the name of Duminy. Subsequent to this, interest was focussed on the Breë Estuary and River as a possible trade link between the Overberg and Cape Town, Landrosdt Faure reporting on this to Sir George Yonge in 1800. On the basis of this report and recommendations by Baron Von Buchenröder, who visited the mouth in 1802, Sir Charles Somerset instigated the second survey of the area which was carried out in 1817. This survey confirmed the navigability of the bar and, realising the commercial possibilities of the area, Somerset established the village of Port Beaufort (Burrows, 1952).

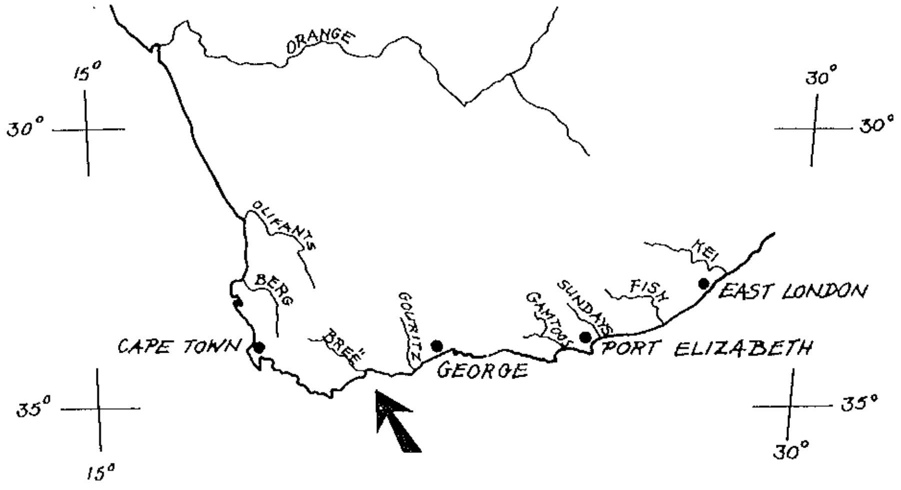
In 1820 Benjamin Moodie, in collaboration with the Cape Town merchants Robertson and Vennig, started exploring the commercial possibilities of the coasting trade between Cape Town, the Breë River and Mossel Bay. In 1822 Joseph Barry arrived in St. Sebastian Bay aboard the charter ship 'Duke of Gloucester'. From this point onwards the early history of Port Beaufort and indeed the commercial and agricultural development of the Overberg was tied up with the fortunes of the trading company 'Barry and Nephews'.

Port Beaufort reached its zenith as a trading port with the purchase and activities of the 'Kadie' during 1859 - 1865. With the wrecking of the 'Kadie' on the bar in 1865 (after 240 crossings) and the effects of the drought of the 1860s the fortunes of Port Beaufort declined. Contributary factors were the difficulty of safely navigating the bar, the rise of Mossel Bay as a sea port and the collapse of the financial empire of 'Barry and Nephews'.

The 'Chubb' (1933 - 1939) resumed coasting links between Malgas and Cape Town but was withdrawn from the service in 1939 because of complaints of unfair competition from the South African Railways (A. Barry, Port Beaufort resident and descendant of Joseph Barry, *in litt.*). From this period onwards, the Breë River estuary has been used mainly for recreational purposes although Port Beaufort was suggested as a commercial fishing base (Agulhas Sole). Difficulties in crossing the bar militated against this.

2. LOCATION

The Breë River estuary is located at 34°24' S, 20°51 E' ; the nearest towns being Swellendam and Heidelberg. Distances by road from these towns are 61 and 46 km respectively. Swellendam is 224 km east of Cape Town on the N2 highway.



2.1 Accessibility

Access to the estuary is through Bredasdorp, Swellendam and Heidelberg. There are no bridges below the National road (N2) and the lowest crossing point is the Malgas pont, 36 km upstream from the mouth. This is one of the last ponts in operation in South Africa. The northern side of the estuary (Port Beaufort and Witsand) has access along a tar road whereas access to the southern side (Infanta village) is along a gravel road.

2.2 Local Authorities

The Breë River below Swellendam forms the boundary between the Divisional Council areas of Bredasdorp/Swellendam and Riversdale. Divisional Council offices are in Bredasdorp and Riversdale. Both Infanta village and Witsand are local areas within the Divisional Council areas. At present two members of the Residents board can be co-opted by the Divisional Councils.

As the river itself forms the boundary between the two Divisional Councils there is some problem in exercising uniform control over the river. This situation is presently exacerbated by staff shortages within the Cape Provincial Administration, Department of Nature and Environmental Conservation whose nearest officer is situated in Mossel Bay.

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Catchment Characteristics

The catchment area of the Breë River is 12 625 km^2 (Noble and Hemens, 1978) and after the Gouritz is the second largest in the southern Cape. The Breë drains large areas of the Cape mountains including the Langeberg mountains and, through the Riviersonderend, the Hottentots Holland and Sonderend mountains.

River length

The Breë is 257 km long measured from the confluence of the Koekedou, Titus, Vals, Skaap and Waboom Rivers, 1,5 km south-east of Ceres and about 36 km longer when its furthest sources near the Theronsberg Pass are taken into account (measured on 1:250 000 Topographical Sheet 3319 Worcester and 1:250 000 Topographical Sheet 3420 Riversdale).

Tributaries

The Breë River has more than 58 tributaries with regular flow. These range from the short Melkhout and Jacobs Rivers draining the Potberg and the Noree River draining the Langeberg to the longer Skaap and Slang Rivers. The major tributary is the 140 km long Riviersonderend. This tributary contributes largely to the catchment area as it drains portions of the Hottentots Holland Mountains.

Rainfall and Run-off

The catchment of the Breë lies in the winter rainfall area with the junction between the Riviersonderend and the Breë as well as the Breë downstream of Swellendam, lying in the boundary between the winter and bimodal rainfall regions (Noble and Hemens, 1978; Heydorn and Tinley, 1980).

Noble and Hemens (1978) estimated the mean annual run-off (MAR) to be 1 893 x 10^6 m^3. This is more than twice as large as the MAR of the Gouritz which, as noted above, has the largest drainage basin in the southern Cape.

Riverflow patterns

Figure 1 depicts the variation in mean monthly run-off in the Breë River 1 km downstream from Swellendam. The dramatic peak in the winter months underlines the contribution of winter rainfall to the Breë River. Figure 2 illustrates the variation in annual run-off for the period 1966 to 1981. The data were obtained from the same gauging station as that used for Figure 1. There is a large variation in run-off estimated for each of the years. High run-off rates characterised the period 1974 - 1977 and low run-off the period 1969 - 1973. The mean annual run-off estimate for the period is 1 112 x 10^6 m^3. This is substantially lower than the Noble and Hemens (1978) estimate and although the two figures were calculated from different data sources (rainfall vs gauging plate measurements) the discrepancy deserves investigation.

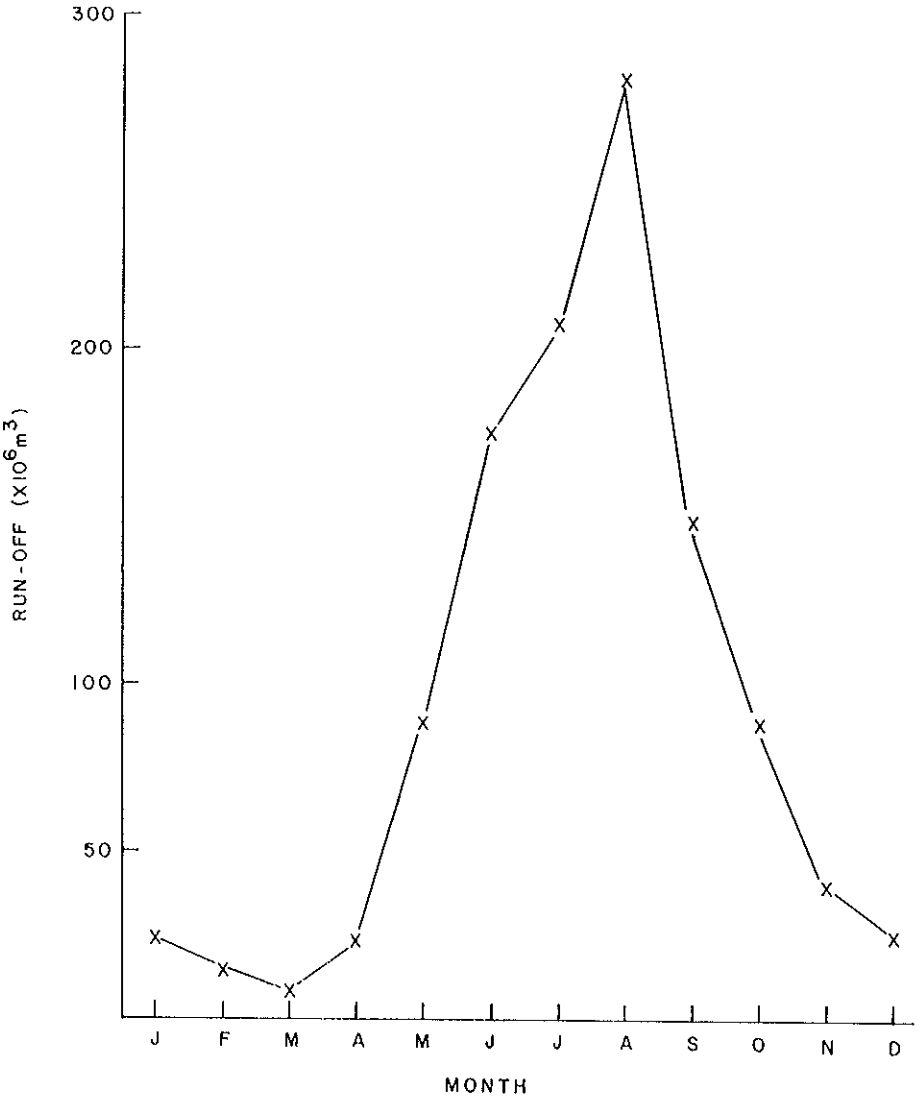


FIG 1: Mean monthly run-off in the Breë River below Swellendam over the period 1966-1981 (Data from Dept Water Affairs).

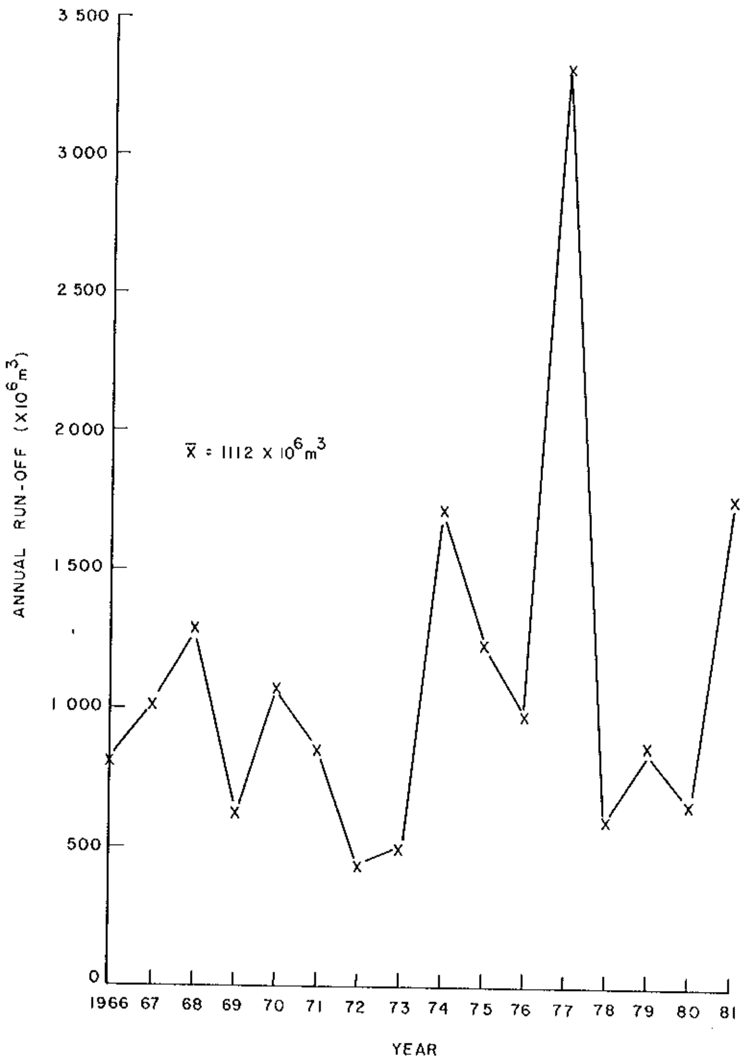


FIG 2: Variation in annual run-off in the Breë River below Swellendam for the period 1966-1981 (Data from Dept Water Affairs).

Geology and Water Quality

The tributaries of the Breë River drain predominantly Table Mountain Sandstone formations as well as Cape granites, Bokkeveld and Witteberg shale. However, the Breë River flows primarily through Bokkeveld shales with the river valley itself being composed of alluvium. These features lead to the river being turbid due to deflocculation of colloidal material caused by low salinities within the river. pH levels range from slightly acidic, particularly in the upper reaches, to slightly alkaline.

At the gauging station 1 km downstream from Swellendam, pH ranges from 3,87 - >8,00. This large range is due to the proximity of the gauging station to the junction of an acidic blackwater stream with the Breë.

Chlorinity levels also vary widely at the gauging station but the salinity is generally low, ranging from 0,1 to 1,2 parts per thousand. Seawater typically has a sodium to calcium ratio of 26. Sodium to calcium ratios at the gauging station were all less than 12 for the period 1966 - 1981, indicating that the salts are land derived. The salinity in the Breë is derived from groundwater sources in Bokkeveld and Witteberg shales (Anon, 1982). Groundwater appears to be cycled relatively rapidly through these shales, compared to Table Mountain Sandstones, and thus the potential for saltloading is high (Anon, 1982). The salt content of the Breë River affects farming practices and has thus led to canalization of the river in the upper reaches for irrigation purposes.

3.1.2 Obstructions and Impoundments

There are 14 major dams in the Breë River system (McVeigh, 1979; Shelley of Ninham Shand, pers. comm.), these being situated on the tributaries rather than on the Breë River itself. This is due to the brackish nature of the Breë River waters (section 3.1.1). The dams are mostly small (surface area 12 - 128 ha) and used for local irrigation and domestic purposes. Examples are the Arch Dam on the Koekoedou River, the Roode Els Berg Dam on the Spek River, the Stettynskloof Dam on the Holsloot River, the recently constructed Fairy Glen Dam on the Hartebees River and the Buffelsjag Dam on the Buffelsjag River above Swellendam.

The Brandvlei Dam, on the Holsloot River and the Theewaterskloof Dam on the Riviersonderend are exceptions in that they are very much larger (surface area *ca.* 2 000 ha). In addition to local irrigation, waters from these dams are used to supplement domestic water supplies in urban areas such as Cape Town and it is planned to use Theewaterskloof Dam water to supplement irrigation supplies in the Berg River valley.

In addition to these larger dams there are numerous smaller impoundments in the Breë River drainage region used for farm irrigation purposes. Weirs are also numerous in the tributaries.

The lowest bridge on the Breë River is that over the N2 near Swellendam. This is a single span bridge and as such does not impede river flow. There is a weir immediately above this bridge. This is the lowermost weir on the Breë River.

3.1.3 Land Ownership/Uses

Most of the land bordering on the Breë River is privately owned and devoted to agriculture. Due to its length the river flows through a variety of land types with associated variations in farming practice, irrigation water availability, etc.

In the upper reaches of the Breë, i.e. above Swellendam, farming concentrates on vineyards and deciduous fruit with smaller efforts directed towards lucerne, tobacco, vegetables and cattle. Most of the area is served by the Breërivier Irrigation Scheme and is thus well watered. There are exceptions such as the Mowers farming unit near Worcester where the supply of water is limited and sheep, buck and ostrich are farmed.

In the vicinity of Swellendam farming practices are varied. For example in the Langeberg foothills mixed farming is practised; concentrating on grapes, peaches, citrus, loganberries, vegetables, cereals, dairy products, wool and mutton. In the Malgas area efforts are focussed more on cereals, wool, dairy products and wheat. On the vlaktes of the northern bank wheat and wool are dominant. In the Potberg area most of the land is reserve with beef being grazed on natural veld and sheep on pastures.

In the area between Malgas and the mouth, the southern bank has been subdivided into land units too small to farm and holiday cottages are being erected upon them. The northern bank remains farmland with some historic farms e.g. Renosterfontein.

3.2 Estuary

Sections 3.2.1 and 3.2.2 were contributed by Dr GAW Fromme of the Sediment Dynamics Division of NRIO.

3.2.1 Estuary Characteristics

Estuary Type and Area

The Breë River estuary is a single sand spit estuary perennially open to the sea. The sand spit, situated on the northern bank, consists of a highly variable intertidal section adjacent to the mouth and a semi-permanent supratidal section adjoining the northern embankment of the estuary. The mouth itself is against the southern bank which is a wave cut terrace of Bokkeveld shales. The main channel is maintained by strong tidal scour and extends to a boulder bed.

The area of the estuary, between the mouth and Rooiheuwel (18 km upstream) is 1 113 ha. This estimate includes macrophyte and saltmarsh areas. The area of open water surface is 835 ha (Duvenage, 1983).

Geomorphology and Geology

The Breë River estuary is a drowned river valley incised as a steep 40 - 50 m deep trench into the mid-palaeozoic Bokkeveld shales of the relatively flat coastal terrace. This coastal terrace is a relic of wave erosion during widespread land subsidence relative to sea level in the Miocene (10 - 5 million years B.P.). The terrace attained its highest level (≃ 300 m) above sea level during the Pliocene (5 - 1,5 million years B.P.). These crustal movements were compounded by glacio-eustatic sea level regressions during the Pleistocene ice ages (1,5 million - 10 thousand years B.P.). These caused a repeated lowering of the base of erosion to more than 100 m below the present sea level and consequently a deepening and extension of the river valley across the present continental shelf. This effect is demonstrated by the presence of canyons leading from present estuaries. These canyons have become filled with both fluvial and marine sediments (Birch, 1979; B. Flemming, NRIO, *in litt.*).

Tidal effects

The gradient of the coastal plain over which the Breë River flows below Swellendam is very gentle. Moreover, the river has cut steep banks which has lessened the gradient over the axis of flow. These features allow tidal effects to penetrate far inland. Both Day (1981) and Flemming and Martin (1983) recorded tidal effects as far upstream as Malgas. The latter authors recorded full tidal effects 25 km upstream from the mouth: range 1,8 m; tidal delay 1,5 hours at high tide, 2,0 hours at low tide. Day (1981) states that the head of tidal effect is 50 km upstream.

Bathymetry

Table 1 lists bathymetric data for the Breë River estuary obtained by Flemming *(in litt)*; Figure 3 shows the locations of the transects. The table shows that the upper reaches of the region between the mouth and Malgas are generally deep. Some spectacularly deep holes occur e.g. transects 1 and 9. The middle reaches are shallower with depth increasing again towards the mouth. Again some deep holes are apparent in the latter two areas. The overall mean depth of the estuary was 3,04 (± 2,07) m.

TABLE 1: Bathymetry of the Breë River estuary (after Flemming, *in litt.*). Tidal corrections were applied to the raw data. The positions of the transects on which the depth soundings were made are shown in Figure 3.

Distance from mouth (km)	Transect No.	Depth (m)	
		max.	mean
0	36	7,8	4,8
1	35	5,8	2,8
2	34	4,9	3,5
3	33	7,7	3,7
4	32	3,5	2,2
5	31 - 32	11,6	9,6
5	31	2,6	1,5
6	30	8,6	3,4
7	29	3,2	2,2
8	28	4,5	2,3
9	27	4,1	2,3
10	26	2,8	1,0
11	25	3,2	1,7
12	24	2,5	0,7
13	23	2,0	1,2
14	22	3,4	0,8
15	21	2,8	0,6
16	20	7,7	3,7
17	19	3,4	1,5
18	18	8,1	3,3
19	17	10,0	4,0
20	16	-	-
21	15	2,2	1,5
22	14	4,0	2,8
23	13	7,3	2,8
24	12	4,8	3,4
25	11	3,9	2,1
26	10	6,0	4,6
27	9	10,7	4,7
28	8	2,4	1,8
29	7	8,6	4,8
30	6	4,4	2,3
31	5	7,6	4,8
32	4	3,5	1,2
33	3	8,2	4,7
34	2	2,5	1,7
35	1	17,6	9,6

Bottom Material

Comprehensive sediment surveys have been carried out by NRIO in the Breë River estuary. Figure 4 summarizes particle size, mud and sand composition data as well as the contribution of calcium carbonate to the sediment. The sampling positions are denoted on Figure 3. Figure 4 shows that the Breë River estuary can be divided into three zones:

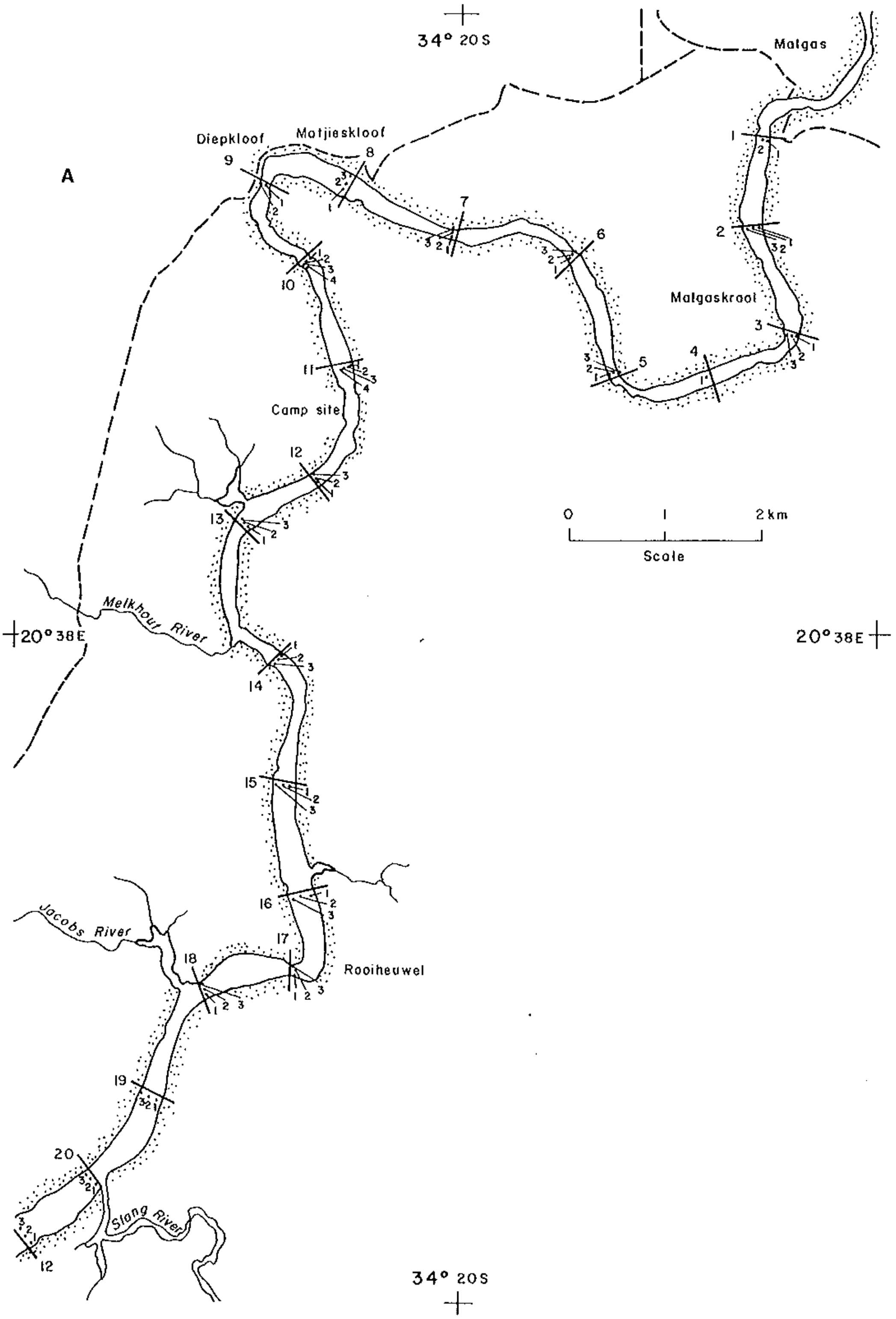


FIG 3A: Bathymetry transects, sediment sampling stations and locality map for the Breë River estuary, Malgas to the Slang River.

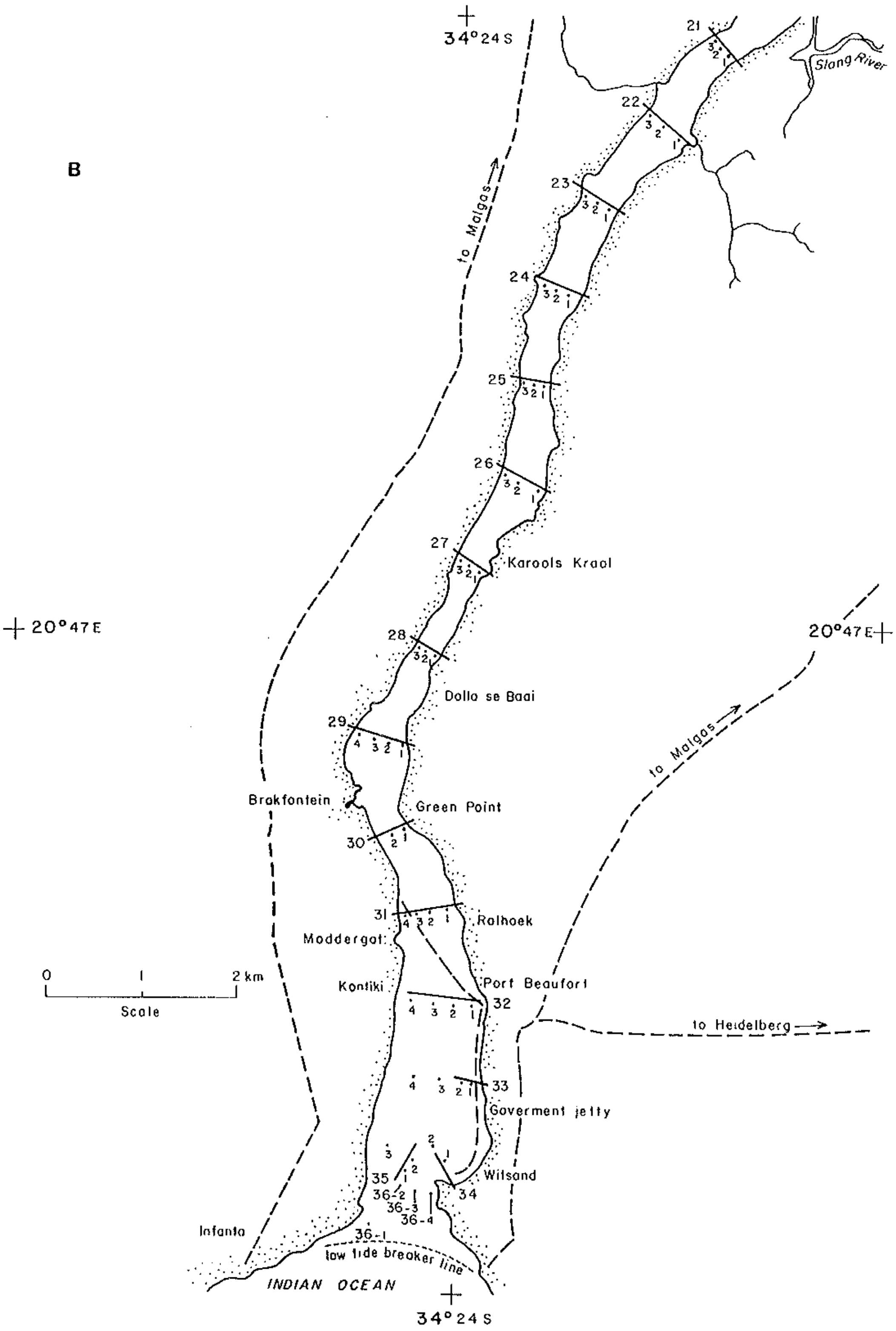


FIG 3B: Bathymetry transects, sediment sampling stations and locality map for the Breë River estuary, Slang River to the estuary mouth (after Flemming and Martin, 1983).

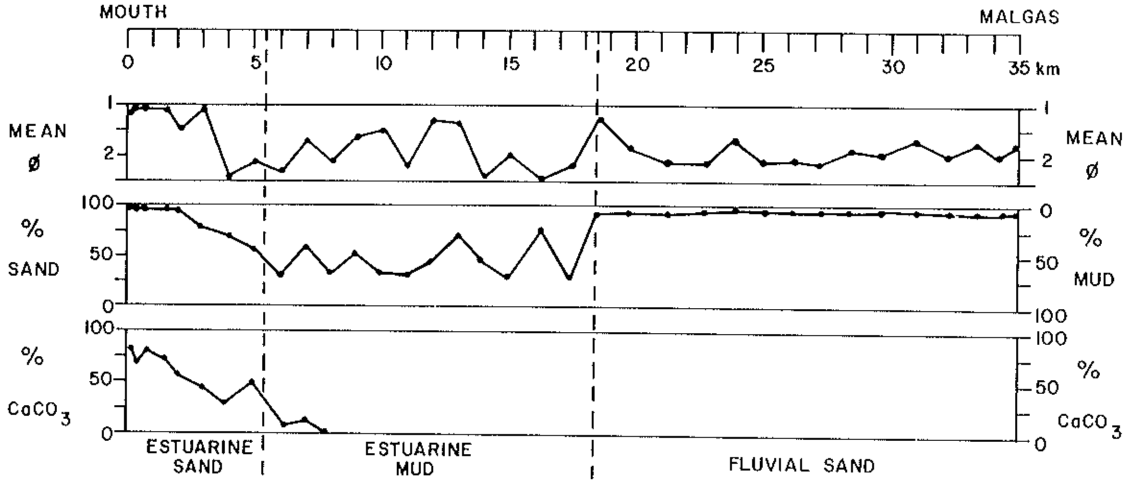


FIG 4: Sediment particle size, mud and sand composition as well as calcium carbonate concentrations in Breë River estuary sediments (after Flemming and Martin, 1983).

(a) The estuarine sand zone: This zone extends from the mouth to 5,5 km upstream. Particle sizes vary from coarse close to the mouth to finer sediments *ca.* 5 km upstream. The coarse sediments near the mouth are predominantly sand with muds making a larger contribution further upstream. The calcium carbonate content, derived from marine and/or estuarine organisms, is highest near the mouth and thereafter decreases with increasing distance upstream.

(b) The estuarine mud zone: This zone extends from 5,5 to 18,5 km upstream. Sediments are not as coarse as near the mouth but vary from medium to fine. The sediments in this zone contain the highest proportion of mud. The calcium carbonate content is low and in fact drops to zero 8 km from the mouth.

(c) The fluvial sand zone: This zone extends from 18,5 km to Malgas 35 km upstream. Sediments are of medium size and the contribution of mud is low.

The sediment distribution displayed in Figure 4 demonstrates two major features.

(a) Marine and estuarine sediments occur quite far upstream (8,5 km) as is shown by the calcium carbonate distribution.

(b) Typically fine sediments (muds) settle out where the gradient in salinity occurs. This is due to flocculation caused by ionization. The distribution of muds in Figure 4 shows that the salinity gradient can vary in position over 13 km (estuarine mud zone). This variation in position is obviously due to the interaction of riverflow and the tidal cycle. It is apparent that sea water does not generally extend further than 18,5 km upstream and is usually at least 2,5 km upstream from the mouth.

Comparison of the morphology of the Breë River estuary derived from the 1867 British Admiralty chart, with that evident from recent aerial photography (Figure 5) indicates that there has been little overall change in the estuary since 1865 (the date of the survey for the 1867 chart). Aerial photographs taken in 1942 and 1981 (Figures 6A and B), support this conclusion. Although the nature of the soundings taken in early bathymetric surveys of the estuary (e.g. 1865) does not allow comparison with Flemming's data (Table 1), it is apparent that the depth of the channels, as typified by the deepest soundings, has remained more or less constant. Whether there have been any changes in the cross-sectional characteristics of the channels cannot be shown with the available data.

The incursion of marine sediments into the estuary does, however, seem to have increased. Circumstantial evidence for this is the decline in area of the macrophyte *(Zostera)* beds on the southern side of the estuary (see section 5). Day (University of Cape Town, *in litt.*) concurs with this, maintaining that particle size on the intertidal sand flat (flood tide delta) has increased since 1950. According to Figure 4 the source of these larger particles is the sea.

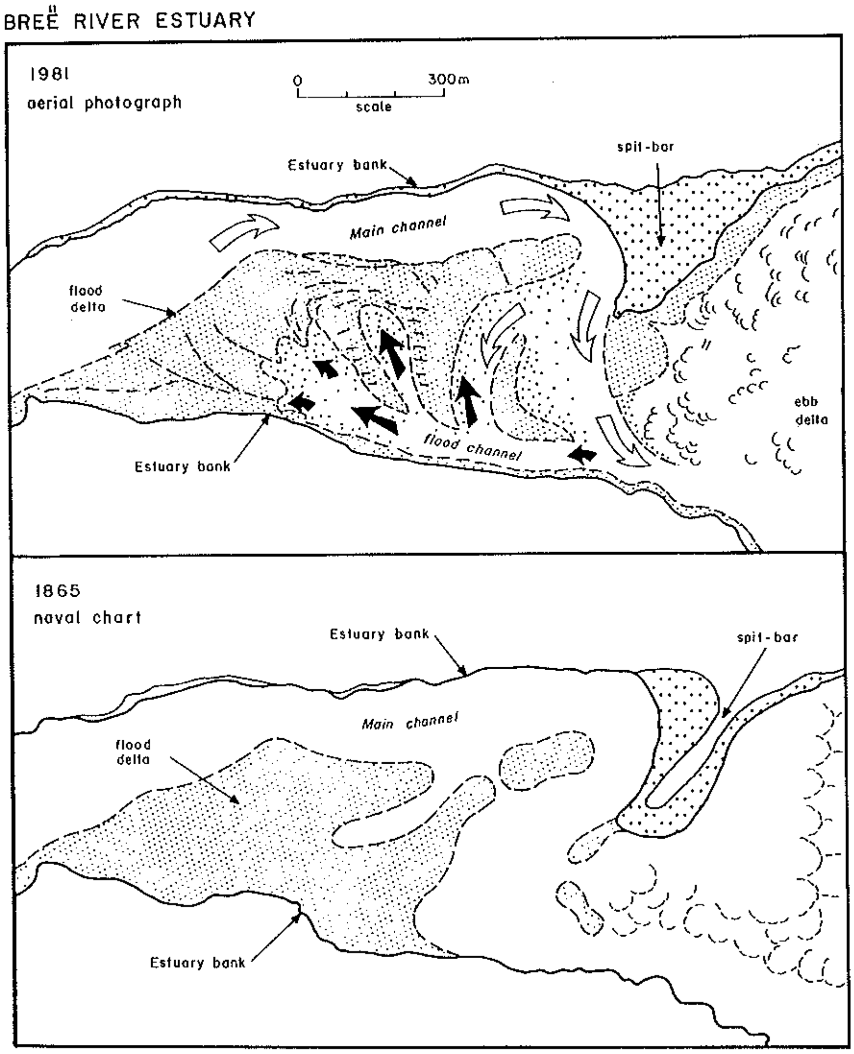


FIG 5: Breë River estuary and channel configurations in 1981 (Aerial photograph Job No. 391, 1981) and 1865 (British Admiralty chart No. 2083, 1867).

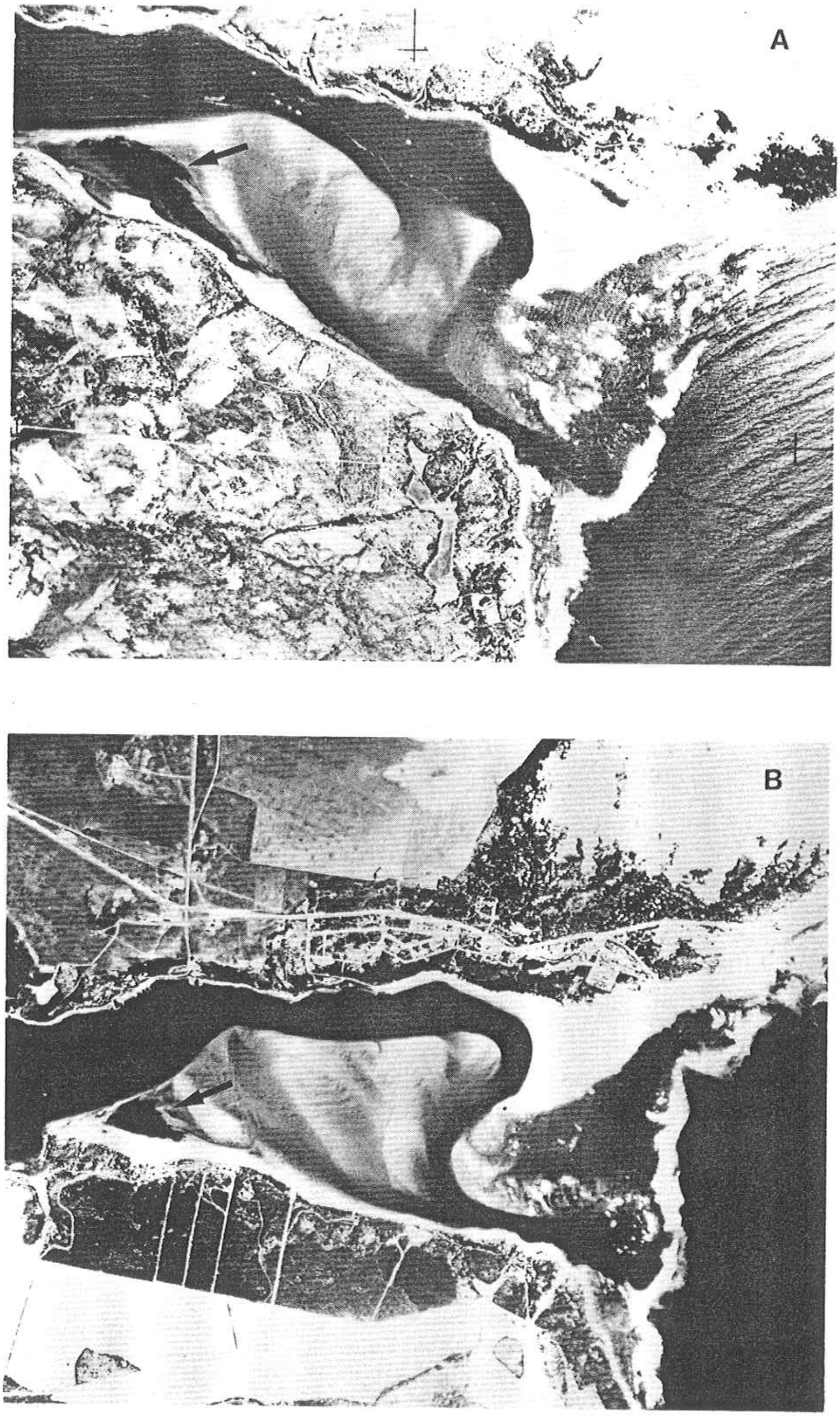


FIG 6: Aerial photographs of the Breë River estuary in A, 1942 (Job No. 17042, 1942) and B, 1981 (Job No. 391, 1981). The arrows show the position of the *Zostera* beds.

3.2.2 Mouth Dynamics

Swart and Serdyn (1981) demonstrated from 19 years of data, summarized in Figure 7, that 64 percent of deep-sea waves on the southern Cape coast are from the south-westerly sector. Further the highest significant wave[*] height was also recorded in this sector. The Median deep sea wave height for the area was 2,4 m and the highest waves, on an annual basis, were 7,8 m (Swart and Serdyn, 1981).

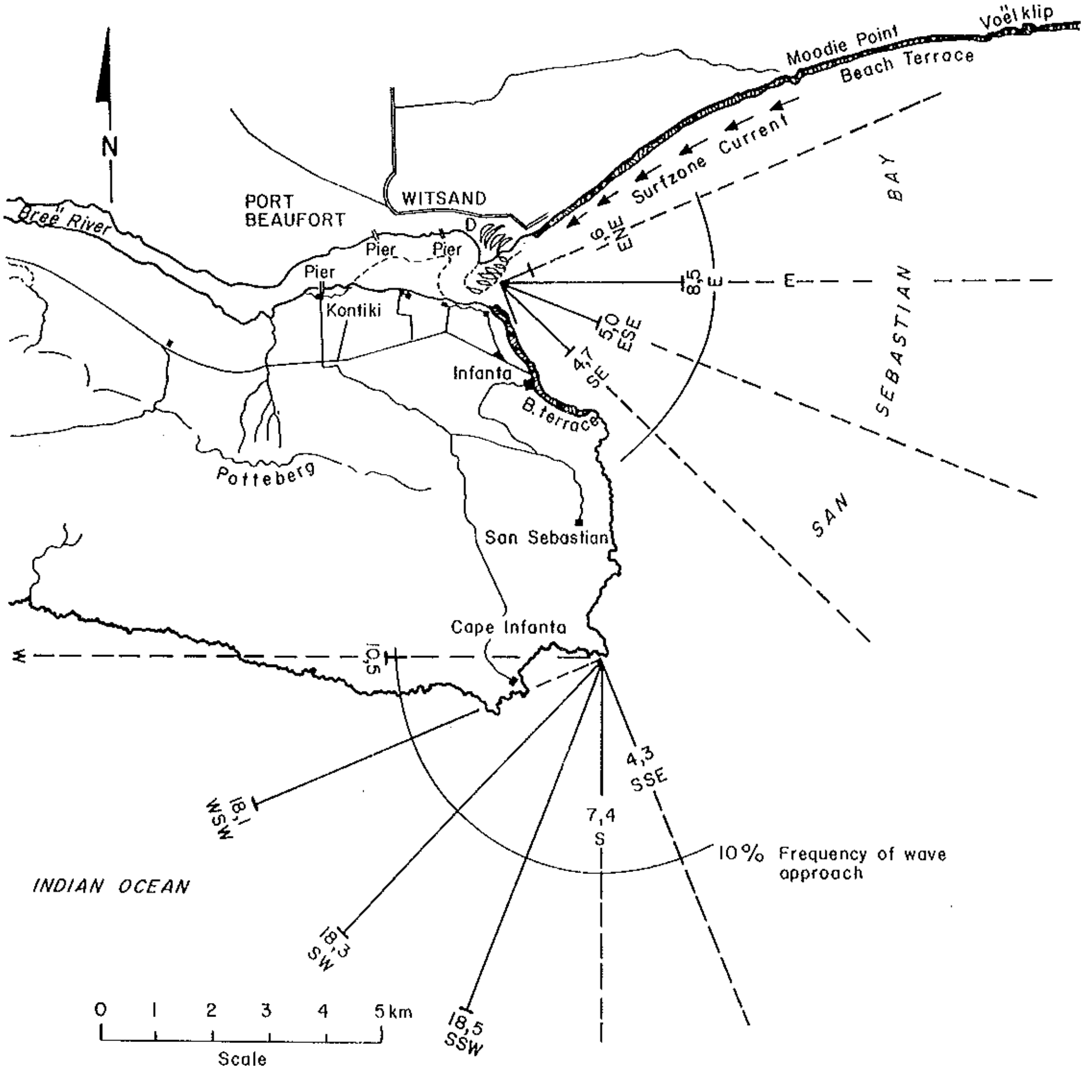


FIG 7: Relative frequencies of wave approach at the Breë River estuary and Cape Infanta (data from Swart and Serdyn, 1981). The inferred surfzone current between Moodie Point and the estuary mouth is shown.

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[*] Median wave height: a significant mean over the measurement period obtained from probability computation.

The Cape Infanta promontory shelters the Breë River estuary from these high waves but energy is fed into the estuary area and the lee of the headland by wave diffraction around the promontory. Refraction of waves as they shoal landwards tends to change the approach direction of the waves closer to normal (90°) to the beach. Therefore the wave diffraction and refraction processes work together to both dissipate wave energy and also to change the direction of approach of waves. Thus waves at the Breë River estuary itself are generally small relative to the deep sea waves and approach the beach from a south-easterly direction.

Both wave diffraction and refraction effects decrease north-eastwards of Cape Infanta and consequently waves at Moodie Point and Voëlklip are generally higher than those at the estuary itself. This gradient in wave height leads to a gradient in 'wave set-up' which induces longshore surfzone currents flowing from the region of high waves (Moodie Point) to the region of low waves (Breë River estuary).

North-easterly longshore surfzone currents will only occur when the deep sea incident wave direction falls in a narrow sector around south-east. Figure 7 indicates that this may occur for about 20 per cent of the time. Current measurements carried out during separate ECRU surveys in November and December, 1982 confirmed this north-eastward flow.

Hydraulics and Sedimentation in the Estuary

The two major sedimentation areas in the estuary are the ebb and flood tide deltas, situated outside and inside the estuary respectively. The present location and sizes of these deltas are shown in Figures 5 and 6B. Some historical evidence points to an increase in size and extent of both deltas but this is not conclusive.

The flood tide delta is probably a composite feature of recent marine and fluvial sediments and relic delta formations associated with sea level regressions (B. Flemming, pers. comm.) and is dynamically stable. This is due to flow patterns arising from the tidal cycle; the mouth itself being sufficiently wide and deep to allow full tidal effects in the estuary. Sand from the ebb tide delta is washed into the estuary during flood tide and deposited on the flood tide delta. Evidence of this are the upstream-facing sand fans apparent on recent aerial photographs (e.g. 1977). These sand fans grow towards the margin of the inner shoal from where they are eroded during ebb tide and in turn either deposited on or transported over the ebb tide delta. There is some evidence of currents flowing north-east offshore of the ebb tide delta. These currents may transport sediment away from the ebb tide delta. Currents, however, are weak as is characteristic of this part of St. Sebastian Bay.

The ebb tide delta receives some sediments from the beach north-east of the mouth where sediment is eroded and transported to the mouth by the surfzone 'wave set-up' current. This beach in turn probably receives sediment from the overall longshore sand drift which bypasses Cape Infanta. This does not appear to be a major source of sediment.

The present major source of sediment for the ebb tide delta appears to be erosion of sand deposits within the estuary itself. Currently there is considerable erosion of the bank downstream of the Government jetty (Plate I) and this sediment would be deposited on or carried over the ebb tide delta. Again the sediment supply does not appear to be large compared with the amounts of sand already 'stored' in the deltas or the dune fields.

The active dune field adjacent to the mouth has its origin in the deposition of sand, mainly of marine but also some of fluvial origin, on the spit at the estuary mouth (see Figure 6, sandspit and beach north-east of sand spit). Sediment transport in this active dunefield area is complicated by short term and seasonal variations in wind speed and direction. Both ripple and dune slip-face orientation demonstrate transport processes by south-easterly, southerly, south-westerly and north-westerly winds. During south-easterly winds there appears to be a circular sand transport route from the active dunefield area into the estuary and then back onto the dune field via the ebb tide delta and Witsand beach. The dominant transport agent, however, appears to be southerly and south-westerly winds with the result that the dunes migrate north-eastwards.

The isolated relic dune field inland from Witsand beach and north-east of the estuary (shown in Figures 6 and 9) is part of the ancient vegetated coastal dune belt. The area was probably devegetated by burning or overgrazing by early inhabitants of the region.

Both the active and relic dune fields discussed above are important features of the mouth area and also constitute major problems in the region (e.g. Plate II). This will be discussed further in the synthesis.

3.2.3 Land Ownership/Uses

(a) North bank: In the region between Malgas and the old Oyster Beds Hotel, land is privately owned and used for farming. Attention is mainly focussed on wheat and sheep. From the Oyster Beds Hotel to the mouth the land is privately owned but developed in the townships of Port Beaufort and Witsand. These two townships consist mainly of holiday and retirement homes as well as having a hotel and holiday chalets. Further towards the mouth there are camping grounds.

On the actual banks of the estuary are a slipway, now used primarily for boat angling, and a jetty. The jetty extends into a shallow area, now sanded up, although it was designed for use by sea going trawlers and line fishing boats.

North-east of the mouth are the bathing beaches and a large camping ground area developed for use by the Coloured community. This camping ground has been set up in the primary dune area.

Between the White and Coloured camping areas is a region currently being developed for holiday houses. This development shows all the symptoms of future severe drift sand problems. These could have been avoided had advice regarding the maintenance of vegetated zones on this former dune area been heeded. The procedure followed, bulldozing the entire area flat, has devegetated this unstable region and may remobilize dunes in the area. Although this procedure may facilitate erf layout, it is contrary to modern coastal zone management procedures and indeed to common sense.

(b) South bank: The south bank has small holdings and holiday houses in the region below Malgas. Some of these houses have been built on what little flood plain there is as well as on marsh ground adjoining small tributaries. The Breë River has handled most floods since 1902 well but these houses may be vulnerable. The Breede River Holiday Resort may also be considered to be vulnerable to flooding.

Below the Breede River Holiday Resort low-intensity farming is carried out. Nearer to the mouth are private holiday homes which limit public access to the river bank.

There are two nodes of development near the estuary mouth on the southern bank. Infanta village is some distance south-east of the mouth and is an environmentally sound development of 106 erven, of which 73 are currently built upon, mainly used for holiday and retirement homes (Vosloo, Bredasdorp Divisional Council, pers. comm.). Space limits further development of the area. Infanta Village Extension One is situated within the estuary region itself just downstream of Moddergat. This development consists of 16 erven which are not yet fully developed. There is considerable concern on the part of the Infanta Village Ratepayers Association (PM Retief, *in litt.*) about further development because of space limitations on recreational areas (see Plate III). This aspect will be pursued in the Synthesis (section 5).

3.2.4 Obstructions

The Breë River estuary has no obstructions or bridges below Malgas.

3.2.5 Physico-chemical Characteristics

Sporadic surveys on the physical and chemical characteristics of the Breë River estuary have been carried out. Day (1981) investigated variations in temperature and salinity at various locations in the estuary during summer and winter, among other aspects. His results are summarized in Table 2.

Table: 2 Summer and winter values of temperature and salinity at various locations in the Breë River estuary (data from Day, 1981). The salinity values are means of the surface and bottom measurements.

Location in Estuary	Distance upstream(km)	Temperature(^{o}C) Summer	Temperature(^{o}C) Winter	Salinity(^{o}/oo) Summer	Salinity(^{o}/oo) Winter
Mouth	0	22,0	13,0	-	-
Port Beaufort	3	22,0	15,2	35,0	17,7
Karool's Kraal	7	22,6	13,1	25,0	5,0
Malgas	36	24,0	12,5	1,0	0,0

The low salinity values observed in winter were a result of increased run-off during this period. Short term fluctuations may be imposed on the temperature and salinity distributions by variations in rainfall in the catchment and thus river flow. Further, as pointed out by Day (1981), sharp horizontal gradients occur in the mouth as with the rising tide clean sea water flows into the estuary along the south bank and there is a sharp demarcation with the estuarine water still flowing out along the north bank.

Summer temperatures ranged from 22,0^{o}C at the mouth to 24,0^{o}C at Malgas and winter temperatures ranged from 13,0^{o}C at the mouth to 12,5^{o}C at Malgas.

Day's (1981) results agree with the observations made during the ECRU survey of November 1982. In this period temperature varied from 21,3^{o}C at the mouth to 22,7^{o}C at Malgas and salinity from 28 parts per thousand (LWOST) at the mouth to zero at Malgas.

Turbidity in the estuary varies with riverflow and the state of the tide. During periods of high flow the waters are generally turbid with secchi disc readings lower than 0,5 m (Day, 1981). During low flow conditions secchi disc readings at the mouth are usually >1 m (Day, 1981; ECRU survey, 1982) but may still be in the region of 0,5 m in the estuarine mud zone (ECRU survey, 1982). During incoming tide and at high tide in low flow conditions, sea water generally penetrates 4 km upstream and secchi disc readings are usually above 1,5 m (Day, 1981; ECRU survey, 1982) in this region. High-salinity water, approaching the salinity levels of sea water, has been measured as far upstream as Malgas (GA Eagle, NRIO pers comm.).

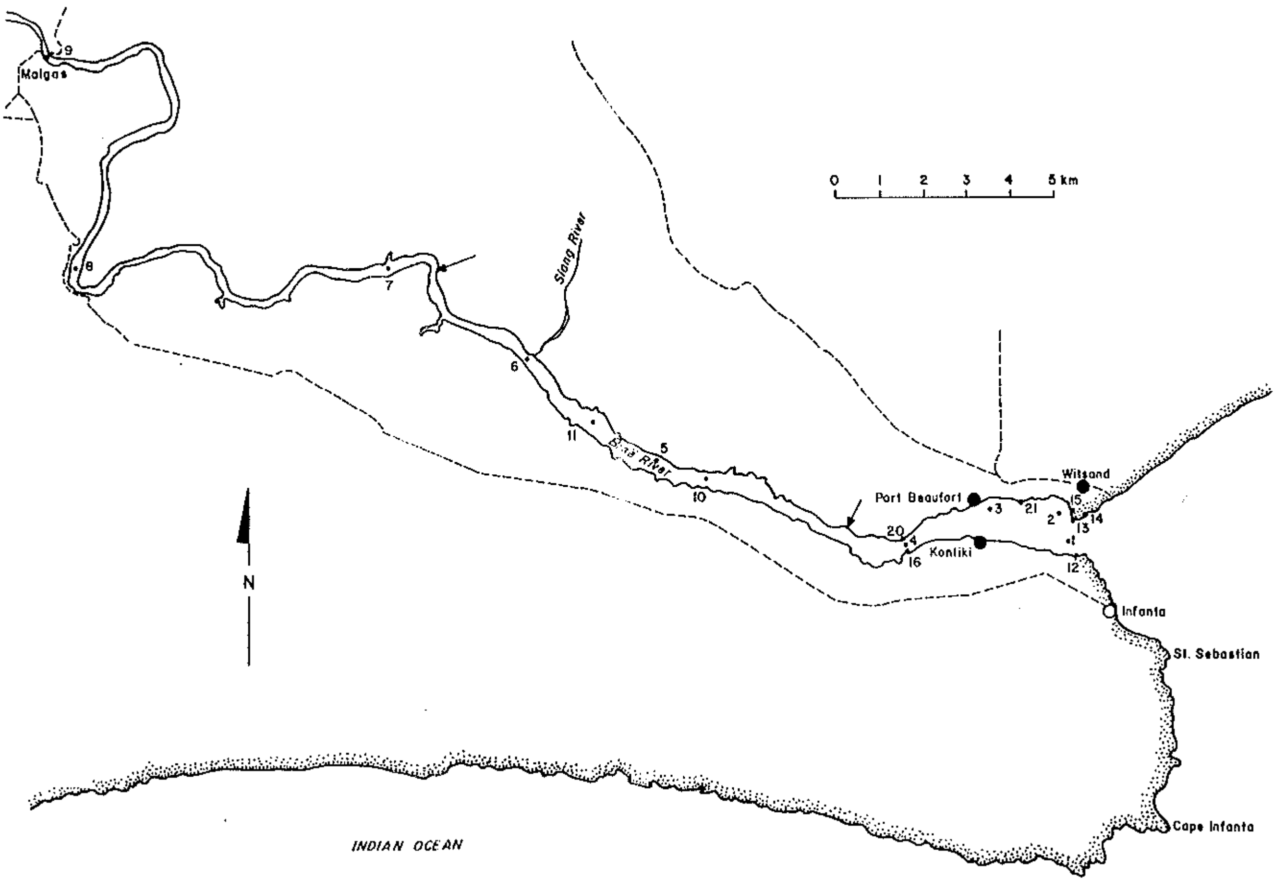


FIG 8: National Pollution Monitoring Programme station positions in the Breë River estuary, 1979. Stations 17, 18 and 19 are not marked on the figure but were located on a transect between stations 16 and 20. (After Eagle and Bartlett, 1983).

TABLE 3: Physical and Chemical characteristics of the Breë River estuary, November 1979 (Data from Eagle and Bartlett, 1983).

WATER SAMPLES - BREË RIVER ESTUARY

Station No	Salinity (^{o}/oo)	Total Phosphorus (μmol/ℓ)	Silicate (μmol/ℓ)	Nitrate (μmol/ℓ)	OA (mg/g)	Dissolved oxygen (mg/ℓ)	Temp (^{o}C)	pH
Low Tide Cycle								
1S	32,50	2,1	24,2	1,2	0,004	7,67	20,0	7,8
2S	28,95	4,0	13,5	3,0	0,006	6,71	20,0	7,8
3S	23,9	3,2	31,0	3,1	0,006	6,90	21,4	8,0
B	23,95	3,8	51,0	3,4	0,003	7,49	-	8,0
4S	12,05	2,8	-	4,3	0,002	7,22	23,0	8,0
B	20,74	3,4	46,3	4,0	0,003	7,37	-	8,0
5S	6,98	0,5	46,2	5,8	0,006	5,58	23,5	8,0
B	7,03	1,4	51,0	3,0	0,007	7,54	-	8,0
6S	3,44	0,2	33,0	2,8	0,002	7,40	23,7	8,0
B	4,09	1,4	50,5	4,9	0,003	7,30	-	8,0
7S	1,0	0,2	30,2	3,4	0,006	7,49	24,0	8,2
B	1,0	0,1	21,2	3,7	0,002	7,56	-	8,2
8S	1,0	1,2	54,6	2,2	0,003	7,85	24,7	7,1
9S	1,0	0,1	23,6	2,2	0,007	7,87	25,0	8,1
High Tide Cycle								
1S	35,18	4,2	34,1	1,8	0,002	6,90	19,5	7,7
B	35,15	3,1	1,6	0,7	-	5,25	-	7,8
2S	34,02	4,0	20,3	1,0	0,007	5,35	19,7	7,9
B	35,00	4,0	19,8	3,0	0,003	6,28	-	7,9
3S	34,87	4,1	4,0	2,9	0,004	7,17	19,7	7,9
B	34,63	2,0	2,2	1,8	0,004	4,33	-	7,9
4S	22,59	3,7	24,0	2,8	0,002	6,94	20,05	7,8
B	34,03	3,7	3,1	1,7	0,001	6,97	-	7,9
10S	17,02	1,2	28,6	3,5	0,004	5,22	22,5	7,8
B	19,13	3,8	27,6	3,4	0,003	5,36	-	7,8
5S	14,61	1,1	33,3	3,6	0,005	6,80	22,1	7,8
B	17,95	3,2	26,6	3,0	-	6,72	-	7,8
11S	13,48	3,1	33,3	3,8	0,003	7,16	22,5	7,8
B	17,63	0,5	12,7	2,3	0,003	6,49	-	7,7
6S	7,83	2,6	33,7	3,9	0,003	5,79	23,5	7,7
B	11,90	0,9	32,6	4,7	0,002	6,98	-	7,7
7S	2,0	0,2	30,2	4,2	0,001	7,05	23,7	7,8
B	2,0	2,4	26,6	4,3	0,001	7,50	-	7,5
8S	1,0	0,1	22,8	2,2	0,002	5,20	24,0	7,9
B	1,0	0,1	29,7	2,3	0,002	5,23	-	7,7
9S	-	0,1	18,5	2,0	0,004	7,89	24,3	7,9
B	-	0,1	17,5	1,8	0,007	8,02	-	7,8

S = Surface, B = Bottom

The most intensive physico-chemical investigation carried out on the Breë River to date is that of the National Pollution Monitoring Programme carried out in early summer, 1979 (Marine Pollution Monitoring Group, 1980; Eagle and Bartlett, 1983). This investigation covered the estuary from the mouth to Malgas; the station positions occupied are indicated in Figure 8. A summary of the results obtained is presented in Table 3. Several points emerge from this table:

(a) Salinities were very low at Station 7, about 19 km upstream under both high and low tide conditions. Thus during the period of this investigation the maximum distance of sea water intrusion was less than 19 km upstream. The maximum salinity gradient under high tide conditions was situated between stations 4 and 7 (4 - 19 km upstream) corresponding with the estuarine mud zone as shown in Figure 4. During the low tide cycle estuarine water extended to station 1 in the mouth. Orren, *et al.* (1981) have measured depressed salinities (relative to sea water) in the surfzone 6 km north-east of the mouth during high river flow conditions in winter. Under these conditions the Breë River can exert considerable influence over nearshore biota. This feature will be discussed further in section 4.2.2.

During the high tide cycle, high-salinity water extended in a lens on the bottom 4 km upstream (station 4). This large intrusion of sea water attests to the vigorous tidal flushing that occurs in the mouth area.

(b) Phosphate concentrations decreased with increasing distance upstream indicating that the phosphates were derived from the sea. No clear trends were evident in either the silicate or nitrate data although Eagle and Bartlett (1983) did find slight evidence of some addition of nitrates to the Breë River estuary from the catchment.

(c) OA represents the amount of oxygen absorbed during either acid or alkaline permanganate oxidation of a sample and as such it is an index of the easily oxidisable organic material. High values are representative of organically enriched areas. All the values listed in Table 3 are low, indicating that the Breë River estuary does not at present suffer from organic pollution.

(d) The dissolved oxygen levels measured are all near the theoretical saturation limit. These high values both support the conclusion reached in (c) above and indicate vigorous mixing in the estuary.

(e) There are no trends evident in the pH data, all values lying in the narrow range 7,1 - 8,2 indicating slight alkalinity.

Trace metal surveys were also carried out on sediments (<250μ) collected at the water sampling points. The results are listed in Table 4. None of the trace metal levels is high and it can be concluded that the Breë River estuary is not polluted by trace metals. This accords with the lack of industrial activity and low density urban development of the area. A feature of the trace metal distribution in the sediments is the higher nickel, lead and zinc concentrations found in samples from stations 5, 6, 10 and 11. These samples were obtained in the estuarine mud zone (Figure 4) and the higher levels may be due to coprecipitation with iron and manganese oxides or adsorption onto the surfaces of organic particles in the process of settling out.

TABLE 4: Breë River estuary sediment (<250μ) trace metal concentrations in surface samples obtained during November, 1979. The station numbers refer to the station positions depicted in Figure 8. Units are μg/g sediment (Marine Pollution Monitoring Group, 1980).

Station Number	Element							
	Cd	Co	Cu	Fe	Mn	Ni	Pb	Zn
1	<0,03	<1,9	0,9	760	57,0	<1,5	<0,4	1,5
2	<0,03	<1,9	<0,2	1140	27,3	<1,5	0,8	1,7
3	0,05	<1,9	0,4	790	47,0	<1,5	<0,4	2,0
4	<0,03	<1,9	0,2	3810	122,5	<1,5	1,4	4,2
5	<0,03	<1,9	1,3	4830	122,0	2,4	3,1	7,9
6	<0,03	<1,9	1,4	4520	274,3	3,7	4,3	10,1
7	<0,03	<1,9	0,3	270	158,5	<1,5	1,6	4,1
8	<0,03	<1,9	0,2	180	37,6	<1,5	1,7	3,1
9	<0,03	<1,9	<0,2	140	13,2	<1,5	1,6	2,4
10	<0,03	3,1	2,4	1140	135,8	3,3	4,7	11,6
11	<0,03	<1,9	2,4	6520	139,8	4,3	4,8	11,8
12	0,04	<1,9	0,2	810	16,8	<1,5	<0,4	1,2
13	<0,03	<1,9	0,2	780	16,9	<1,5	<0,4	1,1
14	0,04	<1,9	0,2	990	17,1	<1,5	<0,4	1,4
15	<0,03	<1,9	0,4	720	16,7	<1,5	<0,4	1,2
16	<0,03	<1,9	1,5	2350	37,8	3,4	2,4	5,6
17	0,04	<1,9	1,5	3950	118,3	2,2	2,8	7,9
18	<0,03	<1,9	0,6	2380	66,1	<1,52	1,4	4,0
19	<0,03	<1,9	0,9	3090	37,6	<1,52	2,0	5,8
20	<0,03	<1,9	1,8	5610	32,3	2,0	4,0	12,3
Detection Limit.	0,03	1,9	0,17	22	0,44	1,52	0,42	0,15

4. BIOTIC CHARACTERISTICS

4.1 Flora

4.1.1 Phytoplankton

Phytoplankton has not been studied in the Breë River estuary. During the ECRU survey carried out in 1982 green sheen was noted on intertidal muds at the Breede River Holiday Resort. Microscopic inspection, however, did not reveal diatoms.

4.1.2 Aquatic and Semi-aquatic Vegetation

(Sections 4.1.2 and 4.1.3 were contributed by Mr M O'Callaghan of the Botanical Research Institute.)

Semi-aquatic vegetation types are not extensively developed along this estuary because of the steepness of the river banks (Day, 1981). *Zostera capensis* beds are notable from Port Beaufort to above Karools' Kraal (for locations see Figure 3) while *Potamogeton pectinatus* is found higher up in the river.

The largest saltmarsh is found at Green Point while less extensive marshes are found at Moddergat and in small coves along the river. These marshes are well stratified with *Cotula coronopifolia* (gansgras) directly above the *Zostera* zone. *Sarcocornia decumbens* is found on the lower saltmarsh and *Triglochin bulbosa* (arrow grass) and *Limonium scabrum* (sea lavender) at the mid-high neap tide mark. Above this level a zone of *Juncus kraussii* is often present followed by an upper saltmarsh vegetation consisting of *Sarcocornia perennis, Chenolea diffusa* (soutbossie), *Apium graveolens* (wild celery) and *Plantago carnosa.*

On the lower flood plain, *Sarcocornia pillansiae* and *Samolus* sp. are found, followed by *Salsola* sp. and *Dysphyma crassifolia.* Terrestrial vegetation gradually becomes dominant.

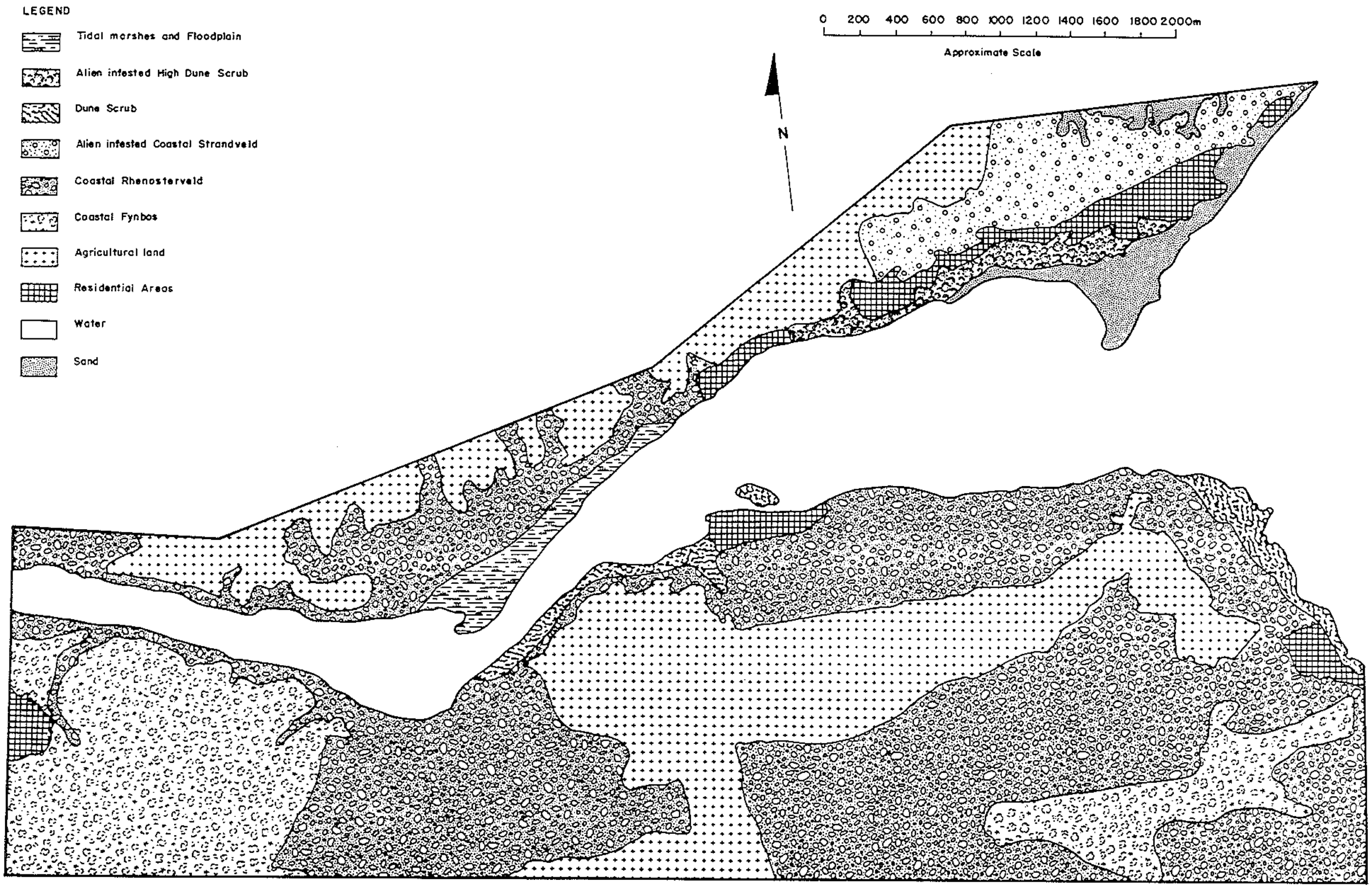
Sarcocornia natalensis is found in areas flooded by fresh water. *Spartina capensis* (strandkweek) dominates large areas in the lower estuary, especially along the southern shore.

Further upstream, the mud flats are dominated by *Cotula coronopifolia* and *Triglochin* spp. *Juncus kraussii* becomes more prevalent and the flood plain vegetation, where present, is similar to that described above. Approximately 10 km from the mouth, *Phragmites australis* becomes dominant along the river banks with patches of reeds such as *Cyperus textilis* (kooigoed) and *Typha capensis* (bulrush).

4.1.3 Terrestrial Vegetation

Figure 9 shows the spatial distribution of the five terrestrial vegetation mapping units identified at the Breë River estuary and Appendix I lists some of the species and physical features of each vegetation type.

FIG. 9 : Vegetation mapping units recognized at the Breë River Estuary.



(a) Alien Infested High Dune Scrub

This vegetation is found on the steep coastal slopes to the north of the estuary. Although dominated by *Acacia cyclops* (rooikrans), much natural vegetation is still present in the form of *Sideroxylon inerme* (milkwood), *Cassine peragua* (bastard saffron) *Chrysanthemoides monilifera* (bietou), *Rhus* spp. (taaibos) and numerous others.

Numerous riverine species are also found here, these becoming more prevalent westward along the river. Species such as *Zygophyllum morgsana* (leeubos), *Lycium afrum* (kraaldoring) and *Tarconanthus camphoratus* (camphor bush) are common.

(b) South of the estuary near Infanta village, typical south coast dune scrub is found. This vegetation type was not sampled during the ECRU survey, but consists of shrubs such as *Chrysanthemoides monilifera*, *Rhus glauca* (korentebessie), *Passerina* spp. and numerous others.

(c) Alien Infested Coastal Strandveld

The extensive dune fields to the north of Witsand are still fringed by strandveld vegetation, although this vegetation type is rapidly being ousted by the invading *A. cyclops*. Species such as *Psoralea fruticans*, *Helichrysum teretifolium*, *Crassula subulata* var *subulata* and *Rhus* spp. are found here. Nearer the sea, *Agropyron distichum* (sea wheat), *Arctotheca populifolia* and others are found together with *Scaevola thunbergii* (seeplakkie) which is probably near its southern most distribution.

(d) Coastal Rhenosterveld

Much of the natural vegetation of this coastal belt has been replaced by extensive wheat farms. However, in those areas not suitable for farming, remnants of coastal rhenosterveld remain. Acocks (1975) describes this vegetation as a dense thorny scrub, dominated by *Olea africana* (wild olive) and *Sideroxylon inerme*. Other species are *Aloe ferox*, *Budleia saligna*, *Grewia occidentalis*, *Azima tetracantha* and numerous others.

(e) Fynbos

This vegetation is still found on the more acid soils. These areas have not been ploughed severely as the soils are largely unsuitable for crops. The vegetation has a typical fynbos structure with a proteoid stratum approximately 1,8 m tall, an ericoid stratum 0,75 m tall and a restioid stratum.

The natural vegetation of this area is very interesting, showing interactions between numerous vegetation types. However, infestation by *Acacia cyclops* is rife and will have severe effects on the natural vegetation which is still present.

4.2 Fauna

4.2.1 Zooplankton

Grindley (University of Cape Town, *in litt.*) has investigated the zooplankton of the estuary. He found a mean biomass of 4,56 mg DW/m^3 and 22 taxa. Although the number of taxa is comparable with those of adjacent systems, biomass is low (Table 5). The reason for this is probably the rapid tidal exchange in the estuary and the small macrophyte beds and thus potentially low detritus concentrations.

TABLE 5: Zooplankton species numbers and mean biomass for selected southern Cape estuaries (data from Grindley, *in litt.*).

System	No of taxa.	Biomass (mgDW/m^3)
Gouritz	17	13,81
Kafferkuils	19	51,88
Duiwenhoks	12	9,98
Breë	22	4,56
Klein	27	22,40

Grindley *(in litt.)* sampled zooplankton from the mouth area through to the fluvial zone in the Breë River estuary. Mean biomass estimates for each of the zones were:

Estuarine sand zone	6,57 mgDW/m^3
Estuarine mud zone	3,32 mgDW/m^3
Fluvial sand zone	5,21 mgDW/m^3

There were four stations situated in the fluvial zone the furthest upstream of which had a biomass measurement of 14,10 mgDW/m^3, 2,5 times higher than the next highest biomass estimate. Grindley (1981) has pointed out that zooplankton biomass is often significantly higher in the upper reaches of estuaries where species diversity is low and estuarine species predominate.

Grindley *(in litt.)* recorded 22 taxa but only eight of these were assigned to genus or species level. These were *Pseudodiaptomus hessei*, *Acartia natalensis*, *Harpacticoid* spp., *Harpacticus* sp., *Hemicyclops* sp., *Gastrosaccus brevifissura*, *Cirolana* sp. and *Austrochiltonia subtenuis*. In addition *Ostracod* spp., *Copepod* nauplii, *Zoeae* larvae, *Gastropod* larvae and fish eggs were also recorded.

The only addition to this list is the mysid *Rhopalopthalamus terranatalis* recorded during the ECRU, 1982 survey.

The most important species in terms of numbers was *Pseudodiaptomus hessei*. This species is also common in other Cape estuaries (Grindley, 1981; Koop, 1982).

4.2.2 Invertebrates (Macrofauna)

The Breë River estuary has been subjected to a number of surveys on the distribution and ecology of its invertebrate fauna. Biologists from the University of Cape Town Zoology Department carried out investigations in the area in 1951, 1952 and 1974; results from these surveys being summarized in Day (1981). Bait organisms in the estuary have been investigated by Gaigher (1978) with additional *ad hoc* investigations by Day *(in litt.)*. Supplementary information is also available from the 1982 ECRU survey.

A total of 149 invertebrate taxa has been recorded from the estuary during these surveys. Appendix II lists the taxa recorded.

There are 4 distinct substrate types in the estuary zone of the Breë River and the immediately adjacent beaches. Table 6 shows the distribution of taxa according to substrate and the number of taxa restricted to any one of the substrate types.

Table 6: Substrate types and the distribution of benthic invertebrate taxa in the Breë River estuary

Substrate	Number of Taxa	Number of taxa restricted to substrate
Rock ledges in estuary	48	19
Sand flats	32	15
Fine sand/mud associated with *Zostera* and salt-marshes	52	24
Rock ledges on beaches adjoining estuary	55	35

Table 6 shows that within the estuary itself, fine sands and muds support both the highest number of taxa and the highest number of taxa with restricted distributions. The lowest number of taxa were associated with the sand flats.

Important bait organisms, however, are associated with both these areas. *Upogebia africana* (mud prawn) occurs in high densities in fine sands and muds at the intertidal level in the vicinity of *Zostera* beds. Gaigher (CDNEC*, *in litt.*) in 1979 recorded 1 440 holes/m^2 at the intertidal level in the vicinity of Greenpoint. If all the burrows were occupied, which is unlikely, this implies a density of 720 individuals/m^2. It is more probable that the actual density was not more than half of this figure which is still a very densely packed population. *Arenicola loveni* (blood worm) and *Solen capensis* (pencil bait) also occur in high numbers but mainly in the sandflat areas. *A. loveni* adult density is slightly less than five worms per square metre in the richest area (Gaigher, 1978). There are no reliable density estimates for *S. capensis*.

* CDNEC = Cape Provincial Administration, Department of Nature and Environmental Conservation.

All three of the species discussed above are heavily exploited as bait during peak holiday periods when fishing pressure increases upon the estuary. Gaigher (1978) investigated aspects of the ecology of *Arenicola* in the Breë River estuary and found a substantial portion of the population to be distributed subtidally. This section of the population is therefore not available to bait collectors and Gaigher surmised that it acted as a reservoir to the exploitable intertidal section of the population. Due to this, the restriction in catch to five specimens per angler per day (Cape of Good Hope Provincial Proclamation 357 of 1972) and the large population size in the Breë River estuary, Gaigher (1978) did not think it necessary to impose any further conservation measures apart from the banning of commercial exploitation. He did recommend, however, that the *Arenicola* population and the exploitation levels be monitored to determine changes. Gaigher (1978) further recommended that if exploitation increased, consideration be given to farming *Arenicola* both to establish a reliable bait supply and to protect wild populations; e.g. that at the Breë River estuary.

Although *Upogebia* attains high densities and is important as a bait organism in the Breë River estuary, no in depth ecological studies have been carried out in this locality. *U. africana* ecology has, however, been studied intensively in some eastern Cape estuaries (e.g. Hill, 1967; Wooldridge, 1968; Hill and Bok, 1977) and features found there can be extrapolated to the Breë River estuary. Hill (1967) found that most of the *Upogebia* population was distributed in the region of the LWOST level and thus, in contrast to *Arenicola* (above), there is no reservoir buffering the effects of exploitation. Coupled with this are the high numbers that can be taken (70/angler/day, Cape of Good Hope Provincial Proclamation 357 of 1972). Further, *Upogebia* appears to be restricted to fine sediment/mud substrates because of its inability to construct burrows in coarser sediments. This restricted distribution, generally to the region of *Zostera* beds, coupled with the lack of a reservoir population and the high permissible catch makes *Upogebia* sensitive to exploitation.

More important, however, is the apparent retreat of the *Zostera* beds due to the incursion of marine sands in the Breë River estuary and thus the contraction of suitable areas for *Upogebia*. Measures therefore need to be taken to monitor *Upogebia* population levels in the face of habitat retreat and the viability of the population under the existing exploitation levels before excess stress is placed upon the Breë River estuary *Upogebia* population.

There is little information available on *Solen* (pencil bait) apart from University of Cape Town Zoology Department (U.C.T., unpublished) survey data. The species appears to be more common on the intertidal sand flats than the finer sediment substrates in the vicinity of *Zostera* and the saltmarshes. Present catch restrictions are 20/angler/day (Cape of Good Hope Provincial Proclamation 357 of 1972).

Callianassa kraussi (sand prawn) are rare in both the sandflat and *Zostera* bed areas of the Breë River estuary. As this species occurs in large numbers in adjacent estuaries its absence from the Breë is puzzling and deserves investigation.

The effect of freshwater outflow from the Breë River on the intertidal biota of the rocks bordering the north and south banks of the estuary is demonstrated by the apparent 'barrenness' of these rocks compared to similar substrates further from the estuary mouth. This is especially evident when comparing the attached algae on the rocks immediately in front of the car park north-east of the mouth with that further along the beach closer to Moodie Point. For example *Hypnea* sp. alone are mainly visible in front of the car park whereas *Bifurcaria, Laurencia* and *Zonaria* sp. become progressively more evident with increased distance from the mouth.

The situation on the south bank follows a similar but not as marked gradient. This may be influenced by gradients in wave height as well.

4.2.3 Invertebrates (Meiofauna)

Meiofaunal surveys have been carried out as part of an investigation into pollution effects in the Breë River estuary and immediate vicinity (Marine Pollution Monitoring Group, 1980; Orren, *et al.*, 1981; Hennig, *et al.*, 1982). Eight meiofaunal taxa were identified from stations located near the mouth of the estuary with a mean density of 222 animals per 100 cm^3 of sand (Marine Pollution Monitoring Group, 1980). Hennig, *et al.* (1982) concluded that the meiofauna did not deviate largely from that expected according to particle size distribution in the sediments. This supports the conclusions reached in the section on Physico-chemical Characteristics that the Breë River estuary is at present unpolluted.

4.2.4 Fish

Surveys of the fish fauna of the Breë River estuary have been carried out by workers from the University of Cape Town Zoology Department, Cape Provincial Administration and the Oceanographic Research Institute (U.C.T., unpublished; Day, 1981; Ratte, 1978; Van der Elst, Oceanographic Research Institute, *in litt.)* as well as during the ECRU survey of November, 1982. Appendix III A lists the 47 fish taxa recorded from the estuary during these surveys. Although large sharks have been observed in the estuary (U.C.T., unpublished, A. Barry, pers. comm.) no specimens have been collected and no positive species identifications made.

Although all the surveys mentioned above were carried out by means of netting, mesh sizes, sampling locations and sampling periods differed between the surveys and thus the results are not truly comparable. However, several features were common to each of the surveys:

(a) The fish sampled were predominantly juveniles or sub-adults.

(b) The dominant species in all the catches were *Tachysurus feliceps, Liza richardsoni* and *Hepsetia breviceps*. Ratte (1978) found *Mugil cephalus* to be common and although reported by Day (1981) and recorded during the ECRU, 1982 survey, Van der Elst *(in litt.)* despite searching a large sample of mugil specimens did not find this species. Further investigation of fish movements appears to be necessary.

(c) Highest numbers of individuals and species were caught in the estuary mouth and mud reach areas with lowest numbers being caught in the fluvial zone near Malgas. For example, University of Cape Town workers (U.C.T., unpublished) and Ratte (1978) recorded only eight species in the fluvial zone; *Monodactylus falciformis, Liza richardsoni, Mugil cephalus* and *Gobius nudiceps* dominating in terms of numbers.

The high number of both species and specimen numbers found in the mouth and mud reach areas is due to the fact that the predominance of fish species found are migrants from the sea. They do not, as a rule, penetrate far across the salinity gradient of the estuary and are thus restricted to the lower reaches. Another feature operative here is the large numbers of food organisms found in association with the *Zostera* and saltmarsh areas as well as the bait organisms found on the sand flats.

Examples of these marine migrants include the main angling fishes found in the estuary, namely: *Lichia amia, Pomatomus saltatrix, Argyrosomus hololepidotus, Lithognathus lithognathus* and *Rhabdosargus* spp. Juvenile *L. amia, A. hololepidotus* and *L. lithognathus* have been recorded (Ratte, 1978) and caught as far upstream as Malgas. Most frequent catch records are made during the dry summer months and thus may be associated with periods of low flow in the Breë River.

Lichia amia was purportedly previously abundant in the estuary but numbers caught have declined in recent years (A. Barry, pers. comm.). This does not appear to be the case with either *A. hololepidotus* or *Lithognathus lithognathus,* catches of which, although varying according to conditions in the estuary, are still fair.

There are no comparative net data for the sea in the immediate vicinity of the estuary. P. Zoutendyk (NRIO, *in litt.*) has supplied observation and catch records from Cape Infanta. Appendix III B lists selected species of fish occurring in the area together with some comments on frequency of occurrence etc. Sandy beaches are limited in the area which probably accounts for the rarity of *Lithognathus lithognathus.* Apart from this and the listing of some deeper water species the lists are remarkedly similar.

4.2.5 Reptiles and Amphibians

No formal herpetological surveys have as yet been carried out between Malgas and Cape Infanta (A de Villiers, CDNEC, *in litt.*). Data on reptiles and amphibians are therefore limited and consist of occasional records only. These records are listed in Appendix IV. Due to the lack of survey data Appendix IV also lists species, which although not recorded, have geographic ranges that encompass the area under review. Further sight record data have been derived from sporadic observations made by the owners of Witklip Estates on Cape Infanta (P Zoutendyk, *in litt.*). These data are also listed in Appendix IV.

The final source of data on reptiles and amphibians is the ECRU survey of November, 1982. During this survey the only reptile seen was a large puffadder *(Bitis arietans)* in the appropriately named Slang River valley. No amphibians were recorded.

Of all the species listed in Appendix IV only the arum frog, *Hyperolius horstokii,* appears in the red data book (McLachlan, 1978) but there are no records of this species in the study area as yet.

4.2.6 Birds

Despite its large size the Breë River estuary has not been subjected to an in depth study of its avifauna. A single census of waders *(Charadrii)* has been made (Summers, *et al.*, 1976, 1977) and Bird club sighting data have been compiled (Underhill and Cooper, 1983). In surrounding areas the sight records of Zoutendyk *(in litt.)* at Cape Infanta and the ECRU survey of November, 1982 are the only formal data available.

Appendix V A lists all the bird species recorded from the area during the above surveys.

The large number of bird species observed (177) in the Breë River estuary and environs reflects the wide range of habitats available to birds.

The breakdown of waders into migrant palaearctic and resident species shows the overwhelming dominance of the former group in terms of numbers of individuals (733 vs 85; Summers, *et al.*, 1976). This points to the significance of the area as a feeding ground for migrants. Summers *et al.* (1976) carried out counts in three areas within the estuary and recorded the highest numbers of individuals in association with saltmarsh and *Zostera* bed areas.

45 of the 177 species listed in Appendix V A breed in the Breë River estuary area. These species are listed in Appendix V B. Ten of the species listed in Appendix V A (marked with an asterisk) are regarded as being rare, vulnerable or threatened (Siegfried, *et al.*, 1976). Two of these 10 species, the Cape Vulture and Martial Eagle, breed in the vicinity of the Breë River estuary.

There is a breeding colony of Cape Vultures in the Potberg Mountains. As part of conservation measures aimed at the Cape Vulture, carrion is being provided in the area.

The Martial Eagle, although still relatively common in the drier areas of South Africa, is becoming increasingly under pressure because of persecution by farmers and the destruction of nesting sites. This eagle plays a valuable role in the control of rock hyrax populations and thus requires protection. Nesting sites should therefore not be disturbed.

Waders *(Charadrii)* are top predators in estuarine systems and, being extremely mobile, any disturbance in the system, e.g. collapse of primary production levels, pollution etc., is rapidly reflected in the wader population. Regular wader censuses should therefore be carried out on the Breë River estuary as a convenient means of monitoring its biological status.

4.2.7 Mammals

In common with data on other classes of organisms, that on mammals is not extensive. Appendix VI lists the mammal species recorded in the vicinity of the Breë River estuary; sources being Stuart, *et al.* (1980), Stuart (CDNEC, *in litt.*) and Zoutendyk *(in litt.)*. Included in the Appendix are some remarks about the status of particular species, including red data book listings.

Three species occur in the red data books (Meester, 1976; Skinner, *et al.*, 1977). The honey badger *(Mellivora capensis)* is listed as rare but has a wide distribution and is thus not threatened. This species is protected in the Cape Province. The aardwolf *(Proteles cristatus)*, also regarded as rare, appears to be declining because of habitat destruction which is attributed to agricultural practices. The Cape greater gerbil *(Tatera afra)*, also listed as rare, may be locally abundant in areas of suitable habitat.

Southern right whales *(Eubalaena glacialis)* are frequently observed close inshore in St. Sebastian Bay. This species is protected both as far as hunting and molestation are concerned. The presence of these whales is an asset to the region and the protection measures are strongly supported.

The mammal list presented in Appendix VI is by no means exhaustive. Further surveys are required to assess the true situation as regards the mammalian fauna of the Breë River estuary area.

5. SYNTHESIS

The Breë is one of the larger rivers of the Cape and drains the winter rainfall region of the south-western and southern Cape. Although having a smaller catchment basin than the Gamtoos, Gouritz and Olifants Rivers, the mean annual run-off for the Breë River catchment is second only to that of the huge Orange River in the Cape Province.

The history of the Breë River estuary is dominated by its development as a coasting and foreign trade port. The rise of Mossel Bay as a safe harbour as well as other factors, not the least of which were difficulties in navigating the bar and competition from South African Railways, have contributed to the decline and eventual eclipse of the estuary as a port. Subsequent to its decline as a coasting port, the Breë River estuary area has mainly been utilised for recreation. Presently the estuary is used for angling, mostly from boats but also from the shore, and associated bait collecting. Netting for bait purposes, e.g. harders for kob and leervis fishing, is allowed but trek and set netting for commercial purposes is illegal (Ratte, 1982). Other activities pursued are power boating, canoeing, yachting and sailboarding (wind surfing). The estuary is also used as a launching site for offshore skiboat anglers. The region between Dolla se Baai and Karools' Kraal was previously used as a seaplane landing area. This usage has fallen away but perhaps consideration should be given to using this area as a 'loading' site for water bombing (as used by the Canadian Forestry Department) the all too frequent veld fires that occur in the southern Cape.

The recreational features outlined above have led to the development of the estuary area for holiday and retirement homes. At present there are four nodes of development; Witsand and Port Beaufort, proclaimed as townships in 1909 and 1943 respectively, on the north bank and Infanta Village and Infanta Village Extension One, proclaimed in 1929 and 1953 respectively, on the south bank of the estuary. There are further subdivisions in the Malgas area (South African Department of Planning and the Environment, 1976).

These developments have not been devoid of problems linked to modification of the environment and exploitation of its resources. These problems are manifold and varied with some being tractable to solution and some being only amenable to management. The ensuing discussion will be under the broad categories of jurisdiction and physical and biological problems but the order of presentation is not a statement of the order of priority of solution.

(a) Jurisdiction: The Breë River below Swellendam forms the boundary between the Divisional Council areas of Bredasdorp/Swellendam and Riversdale. This split jurisdiction over the estuary area leads to problems regarding houseboat control etc. Further complicating factors relate to the control of boating, bait collecting and fishing, these being the responsibility of the Cape Provincial Administration, Department of Nature and Environmental Conservation (CDNEC). The problem of split jurisdiction either between local authorities or between government departments is neither new nor restricted to the Breë River estuary. Day (1981) has discussed this problem. It is imperative that this matter be resolved either on national or local level. Consideration should perhaps be given to the appointment of a river control officer, with the necessary staff and legal backup, for control of the Breë River between Swellendam and the sea.

(b) Physical problems: The most striking problem at Witsand and the one that has received much attention recently is that of driftsand encroachment on houses bordering on the dune fields immediately north east of the sandspit. Dunes in this area can reach heights greater than 10 m and due to migration can threaten houses built in their close proximity, e.g. the 'Opstalletjie'.

Aerial photographs, e.g. 1942, Figure 6A, indicate that there was a connection between the dune field near the estuary mouth and the relic dune field inland of the camping sites. Thus sand dumped on the sand spit could be blown inland and subsequently stored in the relic dune field. The building of roads and houses across the connecting corridor has impeded this process and thus the sand has had to be accommodated in the dune field near the mouth. The source of new sand for this dune field is the same as that for the ebb and flood tide deltas. It is evident, however, that compared with the amount of sediment already stored in the dune field this supply is small. Thus the problem appears to be due to mobilization of old stabilised dunes as well as smaller accentuations due to new sand supply. This is a problem that appears to be insoluble, i.e. the sand supply cannot be cut off and it is not feasible to remove a significant amount of the dune field, and therefore the problem must be managed.

Management lies in the direction of consolidation and stabilization. There are two approaches that may be followed here. The first consists of mechanically flattening the dune field (e.g. by bulldozer) and then consolidating with brushwood and subsequent stabilizing with indigenous dune vegetation. *Acacia cyclops* is not suitable because, not having the ability to grow up through covering sand, it becomes engulfed and thus smothered (e.g. Plate II). Moreover, *A. cyclops* is an aggressive alien and has the ability to invade and take over indigenous vegetation. It should not be introduced to these areas. The second approach rests on the artificial build up of dunes by trapping windblown sand with sandfences and then stabilization of the dunes with indigenous vegetation.

The latter procedure has been successfully applied on the coasts of Virginia and North Carolina, USA, where dune fields similar to those occurring at Witsand have been vegetated and stabilized (Goldsmith, 1977). On the basis of a site inspection and consultation with ECRU, NRIO and Dept of Forestry staff, Goldsmith (National Institute of Oceanography, Israel *in litt.*) considered that the procedure was appropriate for the Witsand dune field. He recommended (Goldsmith, *in litt.*) that the stabilization process be initiated by placing sand fences and/or vegetation strips along the seaward perimeter of the dune field approximately 5 m above the storm tide line. When the wind blows from any of the northerly directions, sand will be caught by these fences and thus dunes will develop. Once built up the dunes should be stabilized with indigenous vegetation as recommended by the Department of Forestry (P. Reyneke, pers. comm.) and Heydorn and Tinley (1980). New sand fences should then be erected inland of these dunes and the dune build up and stabilization process repeated. This whole procedure can then be repeated still further inland until the whole dune field is stabilized. Because the supply of new sand to the dune field appears to be low this stabilization process will lead to a flattening of the dune field as the sand contained therein is redistributed. Thus the present high dunes threatening the road and houses north of the dunefield will be reduced in height.

The advantage of the 'bulldozing' approach is that it is quick and can be carried out within the tenure of a Local Authority. The advantage of the sand fence approach is that it leads to a dynamically stable system but takes much longer (*ca.* 5 years). The dynamically stable system will have better aesthetically appealing features and may become an asset to Witsand if properly maintained. However, development and maintenance requires a competent authority and it is evident that the Local Authority does not have the necessary resources for the task. The Department of Forestry has amply demonstrated its ability for such a task (e.g. consolidated dunes at De Mond on the Heuningnes Estuary) and it is recommended that they be requested to undertake the project. Once complete, human access to the consolidated dunes must be strictly controlled to prevent the formation of blowouts and thus remobilization of the dunes. For similar reasons, development in the dune area, e.g. erection of holiday homes or establishment of camping areas, must not be allowed as this will undo the work of consolidating the dunes.

The approaches outlined above all depend upon the sand supply to the dune field being relatively small. Even if small, however, ultimately the beach in front of the most seaward dune will prograde, albeit slowly. A prograding beach here can disturb the sediment dynamics of the estuary mouth region. It is imperative, therefore, that any consolidating effort be accompanied by detailed sediment budget measurements so that the consequences of the dune consolidation and the time scale of the development of these consequences can be determined.

Currently development of the Witsand/Port Beaufort area is limited by water, present supplies being drawn from a borehole. This has kept the pace of development of the area at a low intensity. However, the area is due to be incorporated into the Duiwenhoks/Vlaktes water scheme and this will remove the present restrictions on development. Despite advice, current development projects in the Witsand region (i.e. that taking place inland of the camping site for Whites) have not taken cognisance of the environmentally sensitive nature of the area. The result of this 'insensitive' approach is that problems are created for the future, the worst probably being destabilization of sand and hence the danger of driftsands. The financial burden of solving these problems should not be imposed on purchasers of property in the development or on present property owners in the Witsand/Port Beaufort area, i.e. they should be met by the developer.

The Cape Coastal Survey of 1973 (Cape Provincial Administration, 1973) recommended that new developments in this area only be allowed inland of the then developed areas. It was further recommended that any development be aimed at utilising natural rather than man-made features. These recommendations appear to have been followed up to the present. It is imperative that these guidelines, which were supported by the South African Department of Planning and the Environment (1976), be adhered to in future developments when the water limitation is alleviated.

The Infanta village on the southern side of the estuary appears to be well situated. There are some problems, however. At present refuse is dumped on private property as the Divisional Council has no servitude property in the area. The present arrangement should either be formalised or some ground must be made available to the Council. Currently boating and swimming activities take place in the same area. Again this may suffice at present but with further development proposed in Infanta Village Extension One (South African Department of Planning and Environment, 1976) as well as in the immediate vicinity of Infanta village itself, alternative arrangements will have to be made. Another problem is that the beach areas in front of the Infanta village, at the mouth and extending to Infanta Village Extension One are small at low tide and non-existent at high tide (Plate III). Increased population levels will put more pressure on the available areas especially in view of the fact that occupancy is, and is likely to remain, very seasonal. Development in this area must be carefully planned so that the carrying capacity of the area is not exceeded. A study on the carrying capacity of the south bank of the estuary is presently being instituted by the School of Environmental Studies of the University of Cape Town (J. Grindley, pers comm.). It is recommended that further development of the area be predicated on the results of this study. Further development will also have to take account of the lack of Local Authority servitude areas as well as provide alternative recreation sites.

(c) Biological problems: The Bokkeveld shales of the coastal terrace are soft and therefore the Breë River has cut steep banks (Day, 1981). This has led to small flood plain development and consequently there are no extensive saltmarsh areas in the estuary. Further, the estuary area does not support very large macrophyte beds. Table 6 (section 4.2.2) showed that the fine sand and mud substrates associated with the macrophyte *(Zostera)* and saltmarsh areas supported both the largest number of invertebrate taxa and had the largest number of taxa restricted to it in the estuary. Thus apart from the role of these areas as zones of primary production they also play a role in maintaining the diversity of habitats in the Breë River estuary and therefore add to the species diversity and carrying capacity of the system. *Upogebia* (mud prawn) is associated with the macrophyte and saltmarsh areas as are most of the migrant waders *(Charadrii)* in the estuary. The waders utilise the saltmarsh areas because of the rich feeding grounds they represent.

Destruction of the macrophyte and saltmarsh areas can therefore lead to a reduction of the areas available for *Upogebia* colonisation and reduce the bird population. More importantly, however, such destruction would lead to a decline of primary production levels in the estuary and thus ultimately a decline in fish stocks etc. that utilise the estuary.

There is some evidence that the macrophyte beds were more extensive previously than they are at present (cf Figures 6A and 6B). Day *(in litt.)* has attributed this decline in macrophyte beds to a coarsening of the sediments on the intertidal banks. He cites the reason for this as being reduced river flow, due to increased agricultural activities in the catchment, and thus increased incursion of marine sediments. The increased sinuosity of the lower portion of the estuary evident when comparing the situation in 1942 with that in 1981 (Figures 6A and B) supports the lower flow hypothesis. This being the case there is little that can be done to enable the macrophyte beds to regain their former extent. However, what is necessary is that the existing beds be conserved and that human activities that damage the beds, e.g. bait digging, trampling, be prohibited.

The largest saltmarsh is situated at Greenpoint with other marshes in the vicinity of creeks entering the estuary (Section 4.1.2). These areas are vitally important to the biological structure of the estuary and must therefore be conserved with vigour. Saltmarshes must not be seen as convenient development or dumping areas.

The popularity of the lower estuary for angling places some strain on the bait resources of the area. Due to the existence of a subtidal reservoir population and low catch limits *Arenicola* (bloodworm) does not appear to be as sensitive to exploitation as does the *Upogebia* (mud prawn) population (section 4.2.2). Some steps must be taken to conserve these bait populations to provide a ready source of bait for anglers but more importantly to maintain adequate prey stocks within the estuary for the fish populations. Consideration should be given to farming *Arenicola*, as suggested by Gaigher (1978), to supplement bait supplies obtained from the estuary.

Removal of alien vegetation, particularly *Acacia cyclops*, from the Breë River estuary area is desirable in order to ensure the survival of the remaining natural vegetation. This is particularly important in areas of dune scrub and coastal Strandveld where alien encroachment has been severe. Care must be exercised, however, to avoid drift sand problems.

Most of the present and anticipated biological problems have their roots in physical disturbance with over exploitation playing a small role. Physical disturbances are potentially severe in their consequences because of alteration of the environment. Activities and development which may lead to physical disturbances of the environment, e.g. further reductions in freshwater inflow by increased agricultural take-off in the catchment, infilling and development of saltmarsh areas, must therefore be avoided.

Conclusions

After a long (for South Africa) history of development as a coasting port the Breë River estuary has been developed into a recreation area. Its current low overall population levels, sport angling and once out of the immediate environs of the development nodes, ambience of primitiveness, lend a unique character to the area. At present environmental problems in the area are mainly due to man's activities, either in the estuary itself or the catchment, and fortunately most of them appear tractable to management if the necessary resources are made available.

The Breë River estuary is very large and although there are problems associated with limited fresh water supplies and an active dune field on the north bank of the mouth, there is considerable potential for development. This will be especially the case when the area is connected with the Duivenhoks/Vlaktes water scheme and ESCOM electricity is provided. This applies particularly to the north bank where amenities are not as limited as on the south bank. It is important that in any further development of the area cognisance be taken of the recommendations of the Cape Coastal

Survey of 1973 and of Heydorn and Tinley (1980). It is especially important that the sensitive dune areas fringing the estuary and sea be left undisturbed.

Neither irresponsible nor overdevelopment of the area must be allowed, the only advantage of which may be short term financial gain, when such developments may lead to future environmental problems and also destroy the features of the area that attracted development in the first place.

6. SUMMARY OF RECOMMENDATIONS

(a) Jurisdiction over the Breë River estuary and its environs should be consolidated under one body. It is important that this body should have a representative in the area to deal with problems that arise on a day-to-day basis.

(b) The active dune field on the north bank of the estuary mouth should be stabilised and re-vegetated with indigenous vegetation. The Department of Forestry should be requested to undertake this task. The procedure outlined by Goldsmith *(in litt.)* should be followed as this will result in a dynamically stable dune field.

(c) Concurrent to (b), above, the sediment budget of the Breë River estuary should be investigated to determine both the rates and consequences of sediment supply to the dune field.

(d) Development of the Breë River estuary area should follow the recommendations of the guideplan drawn up by the Cape Provincial Administration (1973) as modified by the South African Department of Planning and the Environment (1976). No development should be allowed in the stabilised dune field.

Further developments on the south bank of the estuary should be predicated on the results of a study on the carrying capacity of the area presently being carried out by the School of Environmental Studies of the University of Cape Town.

(e) Servitude property should be allocated to the Local Authority on the south bank for disposal of refuse.

(f) Macrophyte *(Zostera)* beds and saltmarsh areas in the Breë River estuary must be conserved with vigour because of their important roles in the biology of the estuary.

(g) Populations of bait organisms, eg *Arenicola, Upogebia* and *Solen,* should be monitored so that conservation measures, if required, can be taken timeously.

(h) Wader bird censuses should be made on a regular basis to monitor the ecological state of the Breë River estuary.

(i) Alien vegetation types, e.g. *Acacia cyclops,* should be removed from the Breë River estuary area and indigenous vegetation types encouraged.

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8.

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9. 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: orginating 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 the 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 gastrointestinal 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.

EDDY: 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.

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 saline 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.

ISOBATH: a line joining points of equal depth of a horizon below the surface.

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 to the shore.

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.

MEIOFAUNA: microscopic or semi-microscopic animals that inhabit sediments but live quite independently of the benthic macrofauna.

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.

OLIGOTROPHIC: poor in nutrients and hence having a paucity of living organisms.

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.

PERIPHYTON: plants and animals adhering to parts of rooted aquatic plants.

PHOTOSYNTHESIS: the synthesis of carbohydrates in green plants from carbon dioxide and water, using sunlight energy.

PHYTOPLANKTON: plant component 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 silica. 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.

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.

WAVE HEIGHT (average energy wave height): an index which reflects the distribution of average incident wave energy at inshore sites along the coast presented as a wave height.

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 component of plankton.

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APPENDIX I: Physical features and species composition of the vegetation units studied at the Breë Estuary.

Mapping Unit	Area* (ha)	% of area studied	Height (m)	Cover (%)
Saltmarsh and Flood Plain	41,08	1,96	0,30	60
Alien Infested High Dune Scrub	24,56	1,17	4,00	80
Dune Scrub	15,89	0,76	1,00	50
Alien Infested Coastal Strandveld	88,24	4,24	0,80	30
Coastal Rhenosterveld	781,69	37,24	1,75	80
Coastal Fynbos	268,68	12,80	1,50	60
Agricultural Land	405,85	19,33		
Residential Areas	58,19	2,76		
Water	370,74	17,67		
Sand	43,46	2,07		
Total	2098,28			

*Estimated values.

Saltmarsh and Flood Plain

Apium graveolens (+); *Chenolea diffusa* (4); *Cotula coronopifolia* (3); *Dysphyma crassifolium* (+); *Juncus kraussii* (3); *Limonium scabrum* (+); *Ruschia* sp (1); *Salsola* sp (4); *Samolus* sp (+); *Sarcocornia decumbens* (1); *S. natalensis* (2); *S. perennis* (2); *S. pillansiae* (2); *Senecio littorea* (1); *Plantago carnosa* (+); *Triglochin bulbosa* (1); *T. striata* (1).

Alien Infested High Dune Scrub

Acacia cyclops (4). *Asparagus aethiopicus var aethiopicus* (+); *Azima tetracantha* (+); *Carissa bispinosa* (+); *Carpobrotus edulis* (+); *Cassine peragua* (1); *C. tetragona* (+); *Chrysanthemoides monolifera* (2); *Colpoon compressum* (+); *Cotyledon orbisculata* (r); *Cymbopappus adenoselon* (+); *Drosanthemum* sp (O'Callaghan 439*) (+); *Ehrharta villosa* (1); *Elytropappus rhinoceratus* (+); *Euphorbia* sp (+); *Gnidia squarosa* (+); *Helichrysum dasyanthum* (2); *Koeleria capensis* (1); *Lobostemon echioides* (+); *Lycium afrum* (1); *Malva parviflora* (+); *Maytenus heterophylla* (+); *Metalasia strictifolia* (1). *M. muricata* (1); *Olea exasperata* (1); *Passerina* sp (1); *Pennisetum clandestinum* (1); *Printzia polifolia* (1); *Pterocelastrus tricuspidatus* (1); *Pteronia hirsuta* (r); *P. incana* (2); *Putterlickia pyracantha* (+); *Relhania pungens* subsp *pungens* (+); *Restio eleocharis* (2); *Rhus augustifolia* (+); *R. glauca* (1); *R. laevigata* (+); *R. longispina* (+); *R. undulata* (+); *Rhyricarpus rugosus* (1); *Senecio elegans* (+); *Sideroxylon inerme* (2); *Tarconanthus camphoratus* (r); *Tetragonia decumbens* (+); *T. fruticosa* (+); *Viscum capensis* (1); *Zygophyllum morgsana* (1).

APPENDIX I: (Cont.)

Alien Infested Coastal Strandveld

Acacia cyclops (5); *Aloe ferox* (r); *Agropyron distichum* (1); *Arctotheca populifolia* (+); *Carpobrotus edulis* (+); *Chrysanthemoides monilifera* (1); *Colpoon compressum* (+); *Crassula subulata var subulata* (+); *Ficinia* sp (O'Callaghan 423) (1); *Ficina tribacteata* (+); *Metalasia muricata* (1); *Myrica cordifolia* (1); *Nylandtia spinosa* (+); *Olea* sp (r); *Passerina* sp (1); *Psoralea fruticans* (+); *Restio eleocharis* (1); *Rhus glauca* (+); *R. incisa* (1); *R. laevigata* (+); *Scaevola thumbergii* (+); *Senecio elegans* (+); *Sideroxylon inerme* (+); *Sutherlandia frutescens* (+); *Tetragonia decumbens* (1); *Trachyandra divaricata* (+).

Coastal Rhenosterveld

Acacia karroo (1); *Aloe ferox* (+); *Asparagus africanus* (+); *A. pinguis* (+); *Azima tetracantha* (+); *Berkheya rigida* (+); *Budleia saligna* (+); *Carissa bispinosa* (1); *Carpobrotus acinaciformis* (r); *C. edulis* (+); *Chrysanthemoides monolifera* (1); *Chrysanthemum* sp (O'Callaghan 374) (+); *Chrysocoma tenuiflora* (+); *Cotyledon* cf *orbiculata* (+); *Cussonia spicata* (+); *Cymbopogon plurinodes* (r); *Eriocephalis africanus* (+); *Euclea racemosa* (+); *E. undulata* (+); *Euphorbia* sp (+); *Ficinia zeyheri* (+); *Galenia africana* (+); *Grewia occidentalis* (1); *Helichrysum rosum* var *coucolorum* (1); *Maytenus heterophylla* (+); *Olea africana* (2); *Passerina* sp (2); *Pterocelastrus tricuspidatus* (+); *Relhania uniflora* (1); *Rhus glauca* (1); *R. lucida* (+); *Ruschia* sp (O'Callaghan 366) (+); *Sideroxylon inerma* (2); *Tylecodon paniculata* (r); *Zygophyllum morgsana* (+).

Fynbos

Acacia cyclops (4); *Anapalina nervosa* (r); *Asparagus africanus* (r); *Athanasia dimorpha* (+); *Berzelia cordifolia* (+); *Bobartia longicyma* (r); *Brunia* sp (+); *Cassine peragua* (r); *Colpoon compressum* (r); *Crassula* sp (r); *Elegia* cf *stipularis* (2); *Erica cerithoides* (+); *Gnidia virides* (+); *Helichrysum paniculatum* (1); *Hypolaena digitata* (+); *Leucodendron salignum* (+); *L. spissifolium* (+); *Leucospermum* sp (O'Callaghan 415) (1); *L.* cf *cuneiforme* (r); *Metalasia muricata* (+); *Passerina* spp (2); *Phaenocoma prolifera* (r); *Protea laurifolia* (1); *P. repens* (1); *Phylica* spp (O'Callaghan 394, 397) (+); *Rhus glauca* (+); *Selago glomerata* (+); *Serruria acrocarpa* (1); *Sideroxylon inerme* (r); *Syndesmanthus zeyheri* (+); *Sysidium* sp (+); *Thamnochortus guthrieae* (r); *Thesium* sp (O'Callaghan 399) (+).

Symbols in brackets following each species name, represent Braun-Blanquet 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 51 - 75% of area
5 - any number, cover 76 - 100% of area.

(*O'Callaghan species numbers e.g. O'Callaghan 439, refer to specimens not yet identified at the time of writing).

APPENDIX II:

MACROINVERTEBRATE TAXA RECORDED IN THE BREË RIVER ESTUARY

CNIDARIA: HYDROZOA

Hydractinia kaffraria
Sertularia distans gracilis

Physalia sp.
Vellela sp.
Porpita sp.

CNIDARIA: SCYPHOZOA

Rhizostomea sp.

CNIDARIA: ANTHOZOA

Bunodosoma sp.
Anthothoe stimpsoni

PORIFERA

Hymeniacedon sanguinea

PLATYHELMINTHES

Notoplana patellarum

NEMERTEA

Gorgonorhynchus sp.

ANNELIDA: POLYCHAETA

Bhawania goodei
Eulalia capensis
Gunnarea capensis
Lepidonotus semitectus
Lysidice natalensis
Perinereis capensis
P. falsovariegata
P. nuntia vallata
Thelepus plagiostoma
T. pequenianus
Arenicola loveni
Boccardia polybranchia
Ceratonereis erythraeensis
Glycera tridactyla
G. natalensis
Lumbrineris tetraura
Marphysa sanguinea
Mercierella enigmatica
Nephtys hombergi
Pectinaria neapolitana
Phyllodoce castanea
Platynereis dumerilii
Notomastus latericeus
Pomatoleios kraussii
Sabellastarte longa
Syllis armillaris
Orbinia augrapequensis

ANNELIDA: OLIGOCHAETA

Branchiura sowerbyi

ARTHROPODA: CRUSTACEA CIRRIPEDIA

Balanus amphitrite amphitrite
B. trigonus
Chthamalus dentatus
Tetraclita serrata

MALACOSTRACA: PERACARIDA ISOPODA

Cirolana fluviatilis
C. parva
Corollana africana
Cyathura carihata
Deto echinata acinosa
Exosphaeroma hylecoetes
E. krausii
Ligia dilatata
Tylos capensis
Eurydice longicornis

MALACOSTRACA: PERACARIDA AMPHIPODA

Grandidierella lignorum
G. Lutosa
Hyperia galba
Lysianassa ceratina
Melita zeylanica
Paramoera capensis
Orchestia rectipalma
Talorchestia capensis
Eriopisa epistomata

MALACOSTRACA: PERACARIDA TANAIDACEA

Apseudes cooperi

MALACOSTRACA: PERACARIDA MYSIDACEA

Gastrosaccus brevifissura
Mesopodopsis slabberi
Rhopalopthalamus terranatalensis

MALACOSTRACA: EUCARIDA DECAPODA

Alpheus crassimanus
Betaeus jucundus
Palaemon capensis
P. pacificus

APPENDIX II: (Cont.)

MALACOSTRACA: EUCARIDA (Cont)
DECAPODA

Penaeus japonicus
Diogenes brevirostris
Callianassa kraussi
Upogebia capensis
U. africana
Cleistostoma algoense
C. edwardsii
Cyclograpsus punctatus
Dotilla fenestrata
Hymenosoma orbiculare
Plagusia chabrus
Rhynchoplax bovis
Sesarma catenata
Thaumastoplax spiralis
Emiphia smithii

INSECTA
ODONATA larva
EPHEMEROPTERA Larva
DIPTERA larva

ARACHNIDA: ARANEIDA

spiders

MOLLUSCA: AMPHINEURA

Acanthochiton garnoti
Chiton tulipa
C. crawfordi

PELECYPODA

Donax serra
Loripes clausus
Solen capensis
Aulacomya ater
Barbatia alfredensis
Crassostrea margaritacea
Donacilla africana
Dosinia hepatica
Kellya rotunda
Lamya capensis
Lasaea turtoni
Ostrea algoensis
Perna perna
Psammotellina capensis
Pteria zebra

GASTROPODA

Assiminea ovata
Burnupena cincta
Cymatium parthenopeum
Diodora spreta
Gibbula beckeri

GASTROPODA (Cont)

Helcion dunkeri
H. pruinosus
Littorina knysnaensis
Nassa kraussiana
Natica genuana
Oxystele tigrina
O. variegata
Patella longicosta
P. granularis
P. oculus
Siphonaria capensis
S. oculus
S. deflexa
S. aspera
Thais capensis
T. dubia
Turbo sarmaticus
Lymnaea natalensis
Tritonalia puncturata
Philine aperta
Barnardaclesia cirrhifera
Cratena capensis

CEPHALOPODA

Octopus granulatus
Sepia officinalis

ECHINODERMATA: ASTEROIDEA

Asterina exigua
Patiriella exigua

ECHINOIDEA

Parechinus angulosus
Echinodiscus bisperforatus

HOLOTHUROIDEA

Cucumaria frauenfeldii

OPHIUROIDEA

sp.

PROTOCHORDATA: ASCIDIACEA

Didemnum stilense
Microcosmus oligophyllus
Pyura stolonifera

APPENDIX III A: Fish recorded from the Breë River estuary

SPECIES/TAXA	COMMON NAME	AUTHOR
	Shark sp.	Day
Elops machnata	Ten pounder	Day
Gilchristella aestuarius	Estuarine round herring	Day, Ratte
Tachysurus feliceps	Sea catfish	Day, Ratte, Van der Elst; ECRU.
Hemiramphus tar	Spotted halfbeak	Ratte
Hyporhamphus knysnaensis	Knysna halfbeak	Van der Elst
Heteromycteris capensis	Cape sole	Day, ECRU.
Solea bleekeri	Blackhand sole	Day, Ratte, Van der Elst; ECRU.
Syngnathus acus	Longnose pipefish	Day
Lichia amia	Leervis	Day, Ratte
Seriola lalandi	Cape yellowtail	Day
Pomatomus saltatrix	Elf	Day, Ratte; ECRU.
Argyrosomus hololepidotus	Kob	Day, Ratte; ECRU.
Atractoscion acquidens	Geelbek	Ratte
Otolithes ruber	Snapper kob	Day
Umbrina capensis	Baardman	Day
Monodactylus argentus	Natal moony	Day
M. falciformis	Cape moony	Day, Ratte; ECRU.
Coracinus capensis	Galjoen	Day
Pomadasys commersoni	Spotted grunter	Day, Ratte
P. olivaceum	Piggy	Day; ECRU.
Diplodus sargus	Blacktail	Day.
D. cervinus	Zebra	Day.
Lithognathus lithognathus	White steenbras	Day, Ratte, Van der Elst; ECRU.
Rhabdosargus globiceps	White stumpnose	Day, Van der Elst.

APPENDIX III A: (Cont.)

SPECIES/TAXA	COMMON NAME	AUTHOR
Sarpa salpa	Strepie	Day, Ratte, Van der Elst.
Liza dumerili	Groovy mullet	Day; ECRU.
L. macrolepis	Largescale mullet	Van der Elst; ECRU.
L. richardsoni	Southern mullet	Day, Ratte, Van der Elst; ECRU.
L. tricuspidens	Striped mullet	Ratte, Van der Elst.
Mugil cephalus	Flathead mullet	Day, Ratte, Van der Elst; ECRU.
Strializa (Mugil) canaliculatus	Haarder	Ratte.
Myxus capensis	Freshwater mullet	Day.
Hepsetia breviceps	Cape silverside	Ratte, Van der Elst.
Siganus canaliculatus	Whitespotted rabbit fish	Van der Elst.
Gobius caffer	Banded goby	Day.
G. multifasciatus	Prison goby	ECRU.
G. nudiceps	Bareheaded goby	Day.
Psammogobius knysnaensis	Knysna sandgoby	Day; ECRU.
Omobranchus striatus	Blennie	Day.
Clinus superciliosus	Super klipfish	Day.
Trigla sp.	Gurnard	Day.
Ambyrhynchotes honckenii	Evileyed blaasop	Day.
Chelondon patoca	Milkspotted blaasop	Van der Elst.
Cyprinus sp.	Carp	Day.
Micopterus sp.	Bass	Day.

APPENDIX III B: Direct observations and angling records of the larger fish species at Cape Infanta, 1947 - 1982. (Acknowledgement to P Zoutendyk)

SPECIES	COMMON NAME	STATUS	REMARKS
FISH			
Odontaspis taurus	Spotted ragged tooth shark	Present	Largest recorded was 2 700 mm long
Chirodactylus brachydactylus	Twotone fingerfin	Common	Recorded by diving
Epinephelus gauza	Yellowbelly rockcod	Present	Largest recorded was 6,4 kg
Oplegnathus conwayi	Cape knifejaw	Present	Recorded by diving
Lichia amia	Leervis	Present	
Seriola lalandi	Cape yellowtail	Present	Largest recorded 20 kg
Pomatomus saltatrix	Elf	Present	Common summer visitor. Largest recorded 5,5 kg
Argyrosomus hololepidotus	Kob	Common	Numbers have dropped over recent years. Largest recorded 51 kg
Umbrina capensis	Baardman	Rare	Largest recorded 5 kg
Boopsoidea inornata	Fransmadam	Very common	
Chrysoblephus cristiceps	Dageraad	Present	Numbers have declined over the past 10 years
C. gibbiceps	Red stumpnose	Present	
C. laticeps	Roman	Common	
Cymatoceps nastus	Poenskop	Common	Largest recorded 27 kg
Diplodus cervinus	Zebra	Common	

APPENDIX III B: (Cont)

SPECIES	COMMON NAME	STATUS	REMARKS
FISH			
Diplodus sargus	Blacktail	Very common	
Gymnocrotaphus curvidens	Janbruin	Present	
Lithognathus lithognathus	White steenbras	Rare	
Pachymetopon grande	Bronze bream	Present	
Petrus rupestris	Red steenbras	Present	Largest recorded 33,2 kg. Numbers have dropped over recent years
Polysteganus undulosus	Seventyfour	Rare	Present thirty years ago but now extremely rare
Sarpa salpa	Strepie	Abundant	Diving observations confirm large numbers
Sparodon durbanensis	Musselcracker	Present	Largest recorded was 15,5 kg. Numbers have dropped in recent years
Sarda sarda	Atlantic bonito	Rare	Largest recorded was 3,6 kg
Liza richardsoni	Southern mullet	Common	Frequently seen in shoals near the rocks
Conger wilsoni	Cape conger	Rare	
Amblyrhynchotes honckenii	Evileyed blaasop	Common	

APPENDIX IV: Reptiles and Amphibians of the Breë River estuary.

(X = recorded, L = locality falls within the species' geographical range).

		Quarter degree square		
		BC	BD	REFERENCE
FROGS				
Xenopus laevis	Common platanna	L	L	
Bufo angusticeps	Sand toad	L	X	*CDNEC
B. rangeri	Raucous toad	L	L	
Breviceps rosei	Sand rain frog	-	L	
B. montanus	Cape mountain rain frog	X	-	CDNEC
Tomopterna delalandii	Cape sand frog	L	L	
Rana fuscigula	Cape rana	X	L	CDNEC
R. grayii	Spotted rana	X	-	CDNEC
R. montana	Cape grass frog	X	-	
R. fasciata	Striped grass frog	L	L	
Cacosternum boettgeri	Common caco	L	L	
C. nanum	Bronze caco	L	L	
Kassina weallii	Rattling kassina	L	L	
Hyperolius horstockii	Arum frog	L	L	
TORTOISES				
Geochelone pardalis	Mountain tortoise	L	-	
Chersina angulata	Angulate tortoise	L	X	Zoutendyk
Homopus areolatus	Padloper tortoise	L	X	Zoutendyk
Pelomedusa subrufa	Water tortoise	L	L	
SNAKES				
Typhlops lalandei	Pink earth snake	L	L	
Leptotyphlops nigricans	Black worm snake	L	-	
Lycodonomorphus rufulus	Brown Water snake	L	L	
Lamprophis inornatus	Olive house snake	L	L	
Prosymna sundevallii	Southern shovel-snout	L	L	
Pseudaspis cana	Mole snake	L	L	
Duberria lutrix	Southern slug-eater	X	L	FitzSimons 1962
Dasypeltis scabra	Common egg-eating snake	L	L	
Crotaphopeltis hotamboeia	Herald snake	L	L	
Amplorhinus multimaculatus	Cape many-spotted snake	L	L	
Dispholidus typus	Boomslang	L	L	
Psammophylax rhombeatus	Spotted skaapsteker	L	L	
P. rhombeatus	Rhombic skaapsteker		X	Zoutendyk
Psammophis notostictus	Whip snake	L	L	
P. crucifer	Cross-marked sand snake	L	L	
Aspidelaps lubricus	Coral snake	L	L	
Elaps lacteus	Spotted dwarf garter snake	L	L	
Naja nivea	Cape cobra	L	X	Zoutendyk
Bitis arietans	Puff adder	X	X	ECRU, Zoutendyk
B. cornuta	Horned adder		X	Zoutendyk

*CDNEC = Cape Provincial Administration, Dept Nature and Environmental Conservation.

APPENDIX IV: (Cont)

		Quarter degree square BC	Quarter degree square BD	REFERENCE
LIZARDS				
Pachydactylus geitje	Ocellated gecko	L	–	
Phyllodactylus porphyreus	Marbled gecko	L	L	
Bradypodion pumilum	Cape dwarf chameleon	L	L	
Agama atra	Rock agama	L	X	Zoutendyk
Acontias meleagris	Golden sand lizard	L	L	
Scelotes bipes	Silver sand lizard	L	X	Zoutendyk
Mabuya capensis	Common skink	L	X	Zoutendyk
M. homalocephala	Cape speckled skink	L	X	Zoutendyk
Gerrhosaurus flavigularis	Yellow-throated plated lizard	L	L	
Tetradactylus seps	Short-legged plated lizard	L	L	
T. tetradactylus	Long-tailed seps	L	L	
Cordylus cordylus	Cape girdled lizard	L	X	Zoutendyk
Chamaesaura anguina	Cape snake lizard	L	L	

APPENDIX V A: Birds recorded in the vicinity of the Breë River estuary (quarter degree squares 3420 BC and 3420 BD). Data from Summers, *et al.* (1976), Hockey and Underhill (1983), Zoutendyk *(in litt.)* and ECRU, 1982 survey.

Roberts Number	Species	Roberts Number	Species
1	Ostrich	89	Egyptian Goose
2	Jackass Penguin	90	African shelduck
44	Cape Gannet	94	Cape Shoveller
47	Whitebreasted Cormorant	96	Yellowbilled Duck
48	Cape Cormorant	97	Redbill Teal
50	Reed Cormorant	105	Secretary Bird
51	Crowned Cormorant	106	Cape Vulture
52	Darter	113	Peregrine
54	Grey Heron	123	Rock Kestrel
55	Blackheaded Heron	129	Yellowbilled Kite
57	Purple Heron	130	Blackshouldered Kite
59	Little Egret	133	Black eagle
60	Yellowbilled Egret	142	Martial Eagle
61	Cattle Egret	149	Fish Eagle
72	Hammerkop	152	Jackal Buzzard
79	Black Stork	154	Buzzard
80	Sacred Ibis	156	Redbreasted Sparrow
83	Glossy Ibis	160	African Goshawk
84	Hadeda	165	Chanting Goshawk
85	Spoonbill	167	African Marsh Harrier
86	Greater Flamingo	169	Black Harrier
88	Spurwing Goose	171	Gymnogene

APPENDIX V A: (Cont.)

Roberts Number	Species
176	Greywing Francolin
181	Cape Francolin
189	African Quail
192	Crowned Guineafowl
212	Redknobbed Coot
216	Blue Crane
217	Kori Bustard
219	Stanley Bustard
220	Karoo Korhaan
225	Black Korhaan
231	Black Oystercatcher
233	Ringed Plover
235	Whitefronted Sandplover
237	Kittlitz's Sandplover
238	Threebanded Plover
239	Great Sandplover
241	Grey Plover
242	Crowned Plover
245	Blacksmith Plover
251	Curlew Sandpiper
254	Knot
257	Terek Sandpiper
258	Common Sandpiper
262	Marsh Sandpiper
263	Greenshank
266	Bar-tailed Godwit
268	Whimbrel
269	Avocet
270	Stilt
275	Cape Dikkop
286	Subantarctic Skua
287	Kelp Gull
290	Caspian Tern
291	Common Tern
296	Sandwich Tern
298	Swift Tern
311	Rock Pigeon
314	Redeyed Turtle Dove
316	Turtle Dove
317	Laughing Dove
343	Redchested Cuckoo
351	Klaas's Cuckoo
352	Diederik Cuckoo
357	Burchell's Coucal
359	Barn Owl
368	Spotted Eagle Owl
373	Fierynecked Night Jar
383	Whiterumped Swift
386	Alpine Swift
390	Speckled Mousebird
391	Whitebacked Mousebird
392	Redfaced Mousebird
394	Pied Kingfisher
395	Giant Kingfisher
418	Hoopoe
432	Pied Barbet
440	Greater Honeyguide
445	Ground Woodpecker
450	Cardinal Woodpecker
463	Thickbilled Lark
466	Clapper Lark
475	Longbilled Lark
488	Redcapped Lark
493	European Swallow
495	Whitethroated Swallow
498	Pearlbreasted Swallow
502	Greater Striped Swallow
506	Rock Martin
509	African Sand Martin
517	Forktailed Drongo
519	European Golden Oriole
522	Pied Crow
523	Black Crow
524	Whitenecked Raven
525	Grey Tit
531	Cape Penduline Tit
540	Rock Jumper
543	Cape Bulbul
551	Sombre Bulbul
553	Olive Thrush
559	Cape Rockthrush
568	Capped Wheatear
570	Familiar Chat
576	Stone Chat
581	Cape Robin
583	Karoo Scrub Robin
584	Brown Robin
618	Grassbird
621	Crombec
622	Barthroated Apalis
629	Fantailed Cisticola
637	Neddicky
638	Greybacked Cisticola
651	Karoo Prinia
655	Dusky Flycatcher
665	Fiscal Flycatcher
672	Cape Batis
682	Paradise Flycatcher
686	Cape Wagtail
692	Richard's Pipit

APPENDIX V A: (Cont.)

Roberts Number	Species
703	Orange-throated Longclaw
707	Fiscal
709	Boubou
713	Tchagra
722	Bokmakierie
733	European Starling
735	Wattled Starling
745	Redwinged Starling
746	Pied Starling
749	Cape Sugar bird
751	Malachite Sunbird
753	Orangebreasted Sunbird
760	Lesser Doublecollared Sunbird
775	Cape White-eye
784	House Sparrow
786	Cape Sparrow
799	Cape Weaver
803	Masked Weaver
808	Red Bishop
810	Cape Widow
812	Golden Bishop
843	Common Waxbill
846	Pintailed Whydah
855	Cape Siskin
857	Cape Canary
861	Blackhead Canary
863	Bully Seedeater
865	Whitethroated Seedeater
866	Yellow Canary
873	Cape Bunting

APPENDIX V B: Birds that breed in the vicinity of the Breë River estuary (quarter degree squares 3420 BC and 3420 BD). Data from Hockey and Underhill (1983) and Zoutendyk *(in litt.)*.

Roberts Number	Species
1	Ostrich
48	Cape Cormorant
105	Secretary Bird
106	Cape Vulture
123	Rock Kestrel
133	Black Eagle
142	Martial Eagle
181	Cape Francolin
189	African Quail
192	Crowned Guineafowl
212	Redknobbed Coot
225	Black Korhaan
231	Black Oystercatcher
242	Crowned Plover
287	Kelp Gull
311	Rock Pigeon
316	Turtle Dove
368	Spotted Eagle Owl
445	Ground Wood Pecker
502	Greater Striped Swallow
506	Rock Martin
523	Black Crow
524	White-necked Raven
531	Cape Penduline Tit
543	Cape Bulbul
570	Familiar Chat
581	Cape Robin
584	Brown Robin
622	Barthroated Apalis
651	Karoo Prinia
686	Cape Wagtail
745	Redwinged Starling
746	Pied Starling
749	Cape Sugarbird
751	Malachite Sunbird
753	Orangebreasted Sunbird
760	Lesser Double-collared Sunbird
799	Cape Weaver
808	Red Bishop
812	Golden Bishop
855	Cape Siskin
861	Blackhead Canary
865	Whitethroated Seedeater
866	Yellow Canary
873	Cape Bunting

APPENDIX VI: Mammals recorded in the vicinity of the Breë River estuary.

Species	Common Name	Status
Chrysochloris asiatica	Golden mole	common
Amblysomus hottentatus	Shrew	present
Thiroptera spp	Bats	common in deep caves on Cape Infanta coast
Papio ursinus	Chacma baboon	troops in Potteberg
Ictonyx striatus	Striped polecat	common
Mellivora capensis	Honey badger	rare (red data book)
Aonyx capensis	Clawless otter	common along estuary and coast
Felis caracal	Caracal	common in coastal belt
Proteles cristatus	Aardwolf	rare (red data book)
Atilax paludinosus	March mongoose	present
Herpestes palverulentus	Grey mongoose	common
H. ichneumon	Egyptian mongoose	present
Cynictis pencillata	Meerkat	present
Genetta genetta	Spotted genet	present
Vulpes chama	Cape fox	present
Arctocephalus pusillus	Cape fur seal	occassional visitor
Mirounga leonina	Southern elephant seal	rare vagrant
Eubalaena glacialis	Southern Right Whale	2 or 3 usually close inshore
Delphinus delphis	Common dolphin	abundant
Sylvicopra grimmia	Common duiker	present
Raphicerus melantis	Grysbok	common - most frequently seen small antelope
R. campestris	Steenbok	common
Pella capreolus	Grey rhebuck	1 herd resident, 8-13 individuals
Oreotragus oreotragus	Klipspringer	present
Damaliscus dorcas dorcas	Bontebok	reintroduced to farms in the area
Lepus sascatilis	Scrub hare	common
Tatera afra	Cape greater gerbil	locally abundant; listed as rare in the red data book due to restriction of habitat
Rhabdomys pumilio	Striped mouse	abundant
Aethomys namaquensis	Namaqua rock mouse	present
Hystrix africaeaustralis	Cape porcupine	seen singly in kloofs or fynbos away from the coast
Bathyergus scillus	Cape dune mole-rat	locally abundant
Procavia capensis	Dassie	abundant among rocks of coastal cliffs at Cape Infanta

APPENDIX VII: Guide to available information

ESTUARY / RIVERMOUTH / LAGOON	BREE (Estuary)	Sources of information	Acocks	Anon.	Axelson	Birch	Burman	Cape of Good Hope Provincial Administration	Cape of Good Hope Provincial Administration	Day	Duvenage	Eagle and Bartlett	Flemming and Martin	Gaigher	Grindley	Hennig *et al*	Heydorn and Tinley	Hockey and Underhill	Marine Pollution Monitoring Group	McVeigh
YEAR (DATE OF INFORMATION)			1975	1982	1973	1979	1970	1972	1973	1981	1983	1983	1983	1978	1981	1982	1980	1983	1980	1979
Guide to available information																				
MANAGE-MENT		Historical			*		*													
		Conservation/Utilization							*	*				*			*			
		Management/Planning							*								*			
		Legislation						*												
		Water																		
BIOTIC		Food webs/Ecosystems																		
	Fauna	Mammals																		
		Birds																*		
		Reptiles																		
		Amphibians																		
		Fish								*										*
		Molluscs								*										
		Crustaceans								*										
		Other aquatic invertebrates								*				*		*				
		Terrestrial invertebrates																		
		Zooplankton																		
	Flora	Terrestrial vegetation	*												*					
		Semi-aquatic vegetation																		
		Aquatic vegetation																		
		Algae																		
		Phytoplankton																		
		Microbiology																		
ABIOTIC	Chemistry	Pollution										*				*			*	
		Eutrophication																		
		General Chemistry										*							*	
		Salinity		*						*		*								
	Physics	Circulation and mixing								*			*							
		Hydrology / Flood regime																		
		Oceanography															*			
		Climate															*			
	Geology	Sedimentology											*							
		Palaeoenvironment																		
		Geology				*							*				*			
	Physio-graphy	Morphology									*									
		Dams/Obstructions																		*
		Catchment characteristics		*													*			*

APPENDIX VII: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: BREE (Estuary)

		Sources of information	Noble and Hemens	Orren *et al*	Ratte	Ratte	Roberts	South Africa (Republic) Dept. of Planning	Stuart *et al*	Summers *et al*	Summers *et al*	Swart and Serdyn	Underhill and Cooper	University of Cape Town Zoology Dept.	University of Cape Town Zoology Dept.	University of Cape Town Zoology Dept.				
YEAR (DATE OF INFORMATION)			1978	1981	1978	1982	1978	1976	1980	1976	1977	1981	1983	1951	1952	1974				
		Guide to available information																		
MANAGEMENT		Historical																		
		Conservation/Utilization																		
		Management/Planning						*												
		Legislation																		
		Water																		
BIOTIC		Food webs/Ecosystems																		
	Fauna	Mammals							*											
		Birds					*			*	*		*							
		Reptiles																		
		Amphibians																		
		Fish			*	*								*	*	*				
		Molluscs												*	*	*				
		Crustaceans												*	*	*				
		Other aquatic invertebrates		*										*	*	*				
		Terrestrial invertebrates																		
		Zooplankton																		
	Flora	Terrestrial vegetation																		
		Semi-aquatic vegetation												*	*	*				
		Aquatic vegetation												*	*	*				
		Algae												*	*	*				
		Phytoplankton																		
		Microbiology																		
ABIOTIC	Chemistry	Pollution																		
		Eutrophication																		
		General Chemistry		*																
		Salinity		*										*	*	*				
	Physics	Circulation and mixing																		
		Hydrology / Flood regime																		
		Oceanography										*								
		Climate																		
	Geology	Sedimentology																		
		Palaeoenvironment																		
		Geology																		
	Physiography	Morphology																		
		Dams/Obstructions	*																	
		Catchment characteristics	*																	

PLATE I: Erosion on the north bank of the Breë River estuary between the Government jetty and the mouth (ECRU 82-02-25).

PLATE II: Dune encroachment on alien vegetation *(Acacia cyclops)* and a road on the north bank of the Breë River estuary (ECRU 82-02-25).

PLATE III: Slipway and restricted beach areas at Infanta Village, south of Breë River estuary (ECRU 82-12-01).

LIST OF REPORTS PUBLISHED BY ECRU TO DATE

Estuaries of the Cape Part I. Synopsis of the Cape Coast. Natural features, dynamics and utilization. AEF Heydorn and KL Tinley. CSIR Research Report 380.

Estuaries of the Cape Part II. Synopses of available information on individual systems. Editors AEF Heydorn and JR Grindley.

Report No.	Estuary Name	CSIR Research Report No.
1	Spoeg	400
2	Buffels	401
3	Groen	402
4	Swartlintjies	403
5	Holgat	404
6	Bitter	405
7	Gamtoos	406
8	Rooiels	407
9	Uilkraals	408
10	Kowie	409
11	Hartenbos	410
12	(Buffels Wes, Elsies, Sir Lowry's Pass) (Steenbras, Buffels Oos.)	411
13	Silvermine	412
14	Sand	413
15	Seekoe	414
16	Eerste	415
17	Lourens	416
18	Bot	417
19	Groot (Wes), Sout	418
20	Groot Brak	419
24	Onrus	423