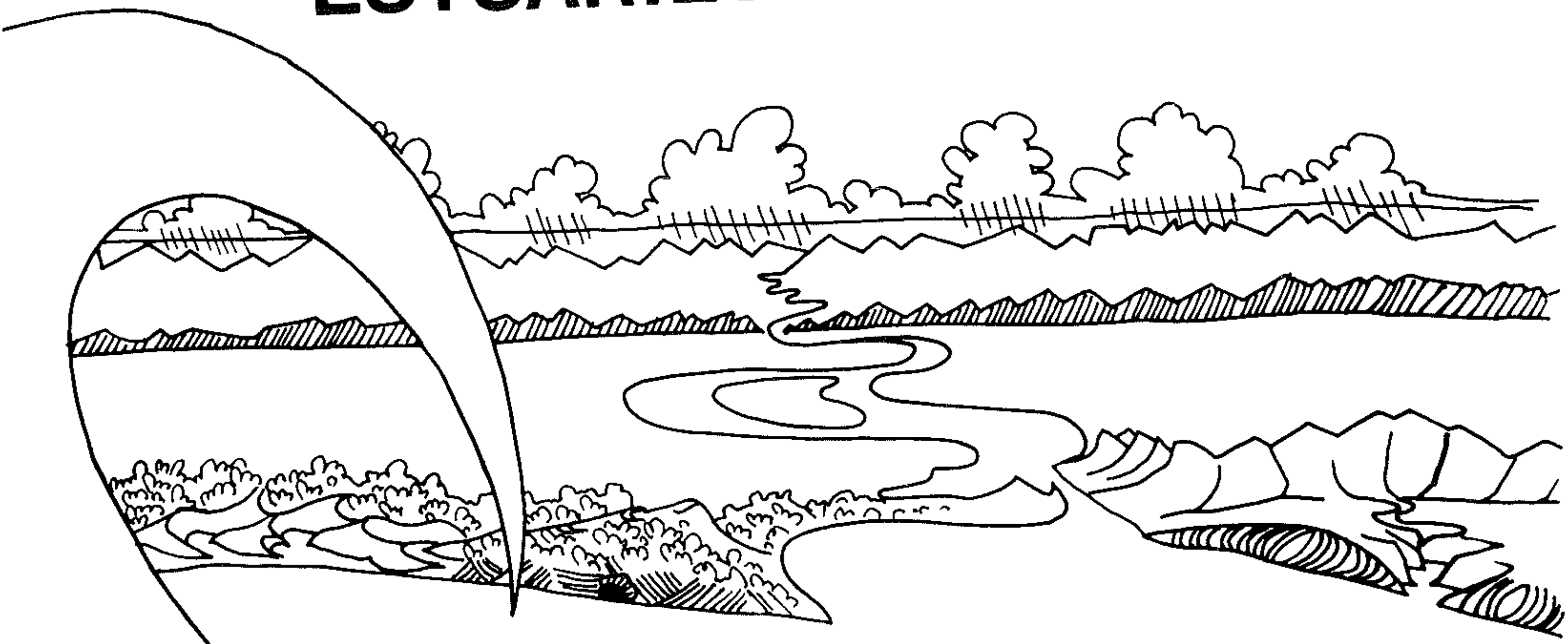
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT - ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 26

OLIFANTS (CW 10)

CSIR RESEARCH REPORT 425

Stellenbosch, South Africa
July 1984

ESTUARIES OF THE CAPE

PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS:
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REPORT NO. 26: OLIFANTS (CW 10)

(CW 10 – CSIR Estuary Index Number)

BY: P D MORANT

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OLIFANTS ESTUARY

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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, CSIR Research Report 380). 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 J R 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.

F P Anderson

F P ANDERSON
CHIEF DIRECTOR

National Research Institute for Oceanology, CSIR

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OLIFANTS

1. HISTORICAL BACKGROUND

1.1 Synonyms and Derivations

RIO DO INFANTE named in January 1488 by or after Joao Infante, captain of the *Panteleao*, the second caravel in Bartholomeu Dias' fleet (Axelson, 1973).

THARAKKAMA the Hottentot name meaning "Bushy River" (Du Plessis, 1973).

OLIFANTS the name given to the river by Jan Danckaert on 8 December 1660 on sighting a herd of elephant 200-300 strong on its banks in the vicinity of Clanwilliam (Du Plessis, 1973). The name has remained in use to this day either in the English form "Olifants River" or the Afrikaans "Olifantsrivier." Burman (1970) referred to the river as the "Nile of South Africa" on account of the extensive irrigation schemes along the lower reaches.

OLIFANTSRIVIER 1:50 000 Topographical Sheet 3118 CA Papendorp.

OLIFANTSRIVIER 1:150 000 SA Navy Charts SAN 116 and SAN 117.

OLIFANTS-RIVIERMOND 1:250 000 Topographical Sheet 3118 Calvinia.

Archaeology

Early travellers encountered the cattle-owning Namaqua and the Soaqua, hunter-gatherers who were semi-dependant on the Namaqua. In *ca.* 1685 Van der Stel noted that "they (the Soaqua) eat nothing but the bulbs of flowers which we call uyentjies, tortoises and a certain large kind of caterpillar, together with locusts which are found here in abundance" (Waterhouse, 1932).

The indigenous peoples of the south-western Cape, the Soaqua, undertook seasonal migrations (transhumance) to and from the coast, between St Helena Bay and the Olifants River mouth, and the Cedarberg and Olifants River valley in the interior. During the winter months, when fresh water was readily available, these people lived on the coast where they exploited the protein-rich marine resources. In late spring/early summer they migrated to the permanent waters of the Olifants River valley in the vicinity of the Cedarberg and Nardouwsberg.

Being hunter-gatherers the Soaquas moved along the coast in search of food, leaving behind middens at rich or sheltered sites (Parkington, 1976). In the vicinity of the Olifants Estuary, there are two midden/late Stone Age sites just south of the saltworks (Figure 1), one late Stone Age site/open scatter about 1,5km north of Viswaters (Figure 1) and, of great interest, a large late Stone Age "factory"/living site on Soutpansklipheuwel (Figure 1) (W J van Ryssen, S A Museum Archaeological Data Recording Centre, Cape Town, *in litt.*).

Historical background

The Olifants River system was explored early in the colonization of the Cape by European settlers. The river was named by Jan Danckaert on 8 December 1660 (Du Plessis, 1973). Before the routes through Du Toit's Kloof and Bain's Kloof

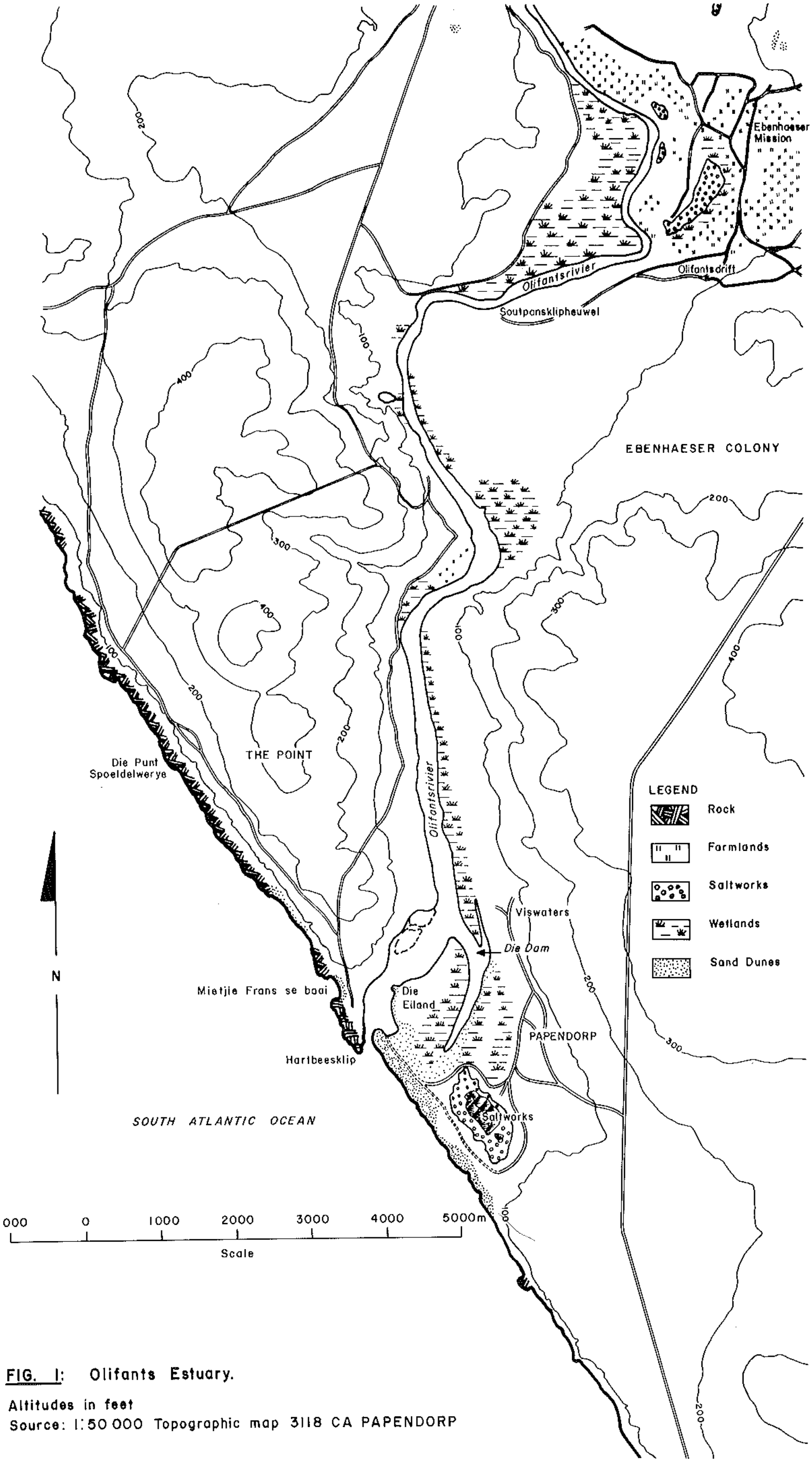


FIG. 1: Olifants Estuary.

Altitudes in feet
Source: 1:50 000 Topographic map 3118 CA PAPENDORP

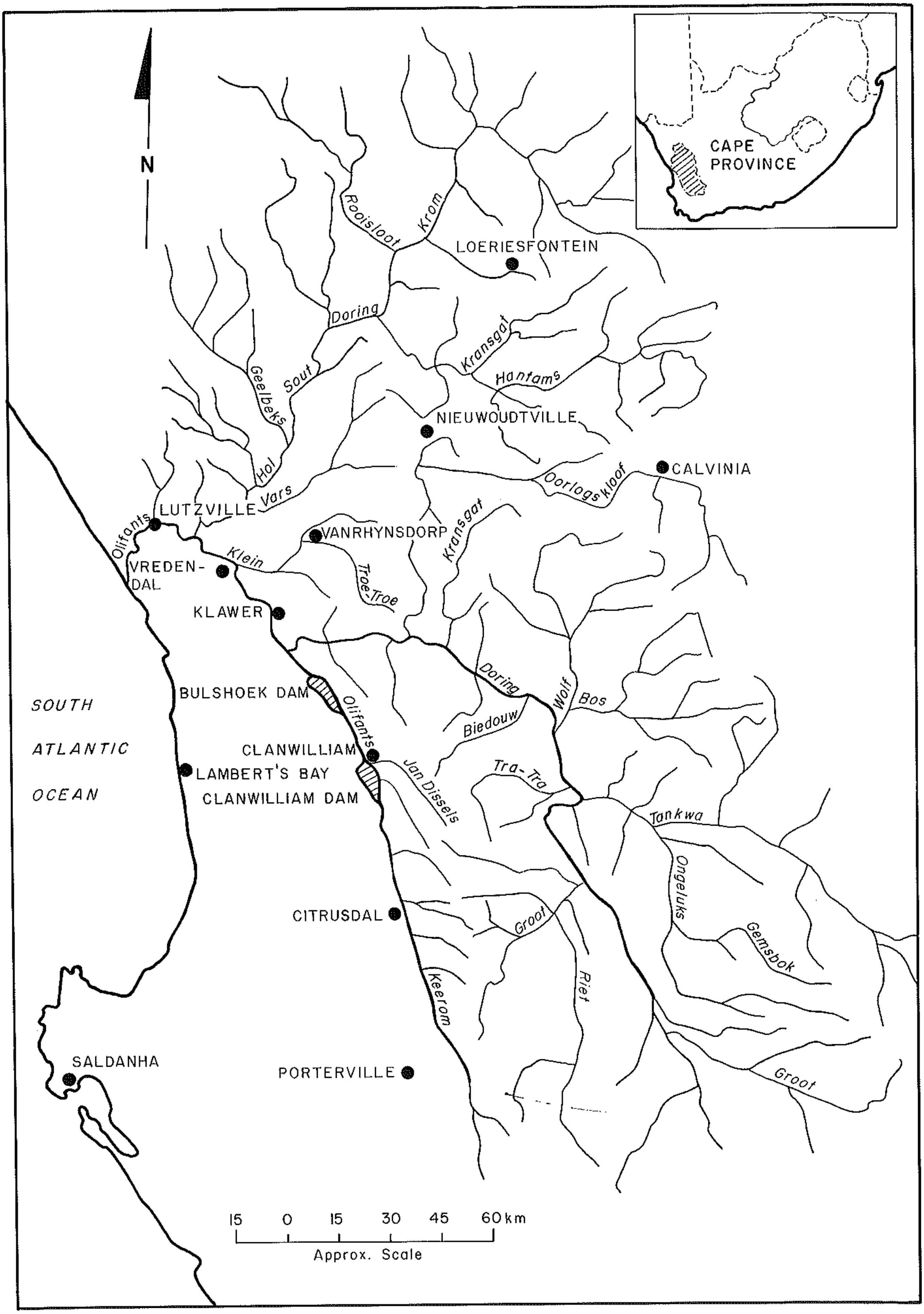


FIG. 2: Olifants River Catchment

Source: Scott (1982)

passes were established the main access to the Karoo was via the Olifants Valley. It was also the main route to the north and the copper mines of Namaqualand (Bulpin, 1980).

European settlement in the Olifants River valley began in the late 1700s and the region has become one of the three main citrus growing areas in South Africa. The main towns on the river are Citrusdal, Clanwilliam, Klawer, Vredendal and Lutzville (Figure 2). Besides livestock, the early farmers in the Citrusdal-Clanwilliam area grew rice. The Batavian government saw the establishment of orange orchards as a threat to the rice farming industry (Burman, 1970). However, fruit farming, citrus, vines and to a lesser extent peaches and apricots, now forms the main activity in the valley itself. To provide more water for irrigation the Bulshoek irrigation barrage was completed in 1919. The barrage, coupled with a canal system, supplies water to farms along 90 km of the lower Olifants River valley as far as the Ebenhaeser Colony some 15 km from the sea. The Bulshoek barrage regulates the flow of water entering the canal system while the main storage capacity is provided by the Clanwilliam Dam built in 1932. The dam wall was raised in 1966 to further increase the storage capacity.

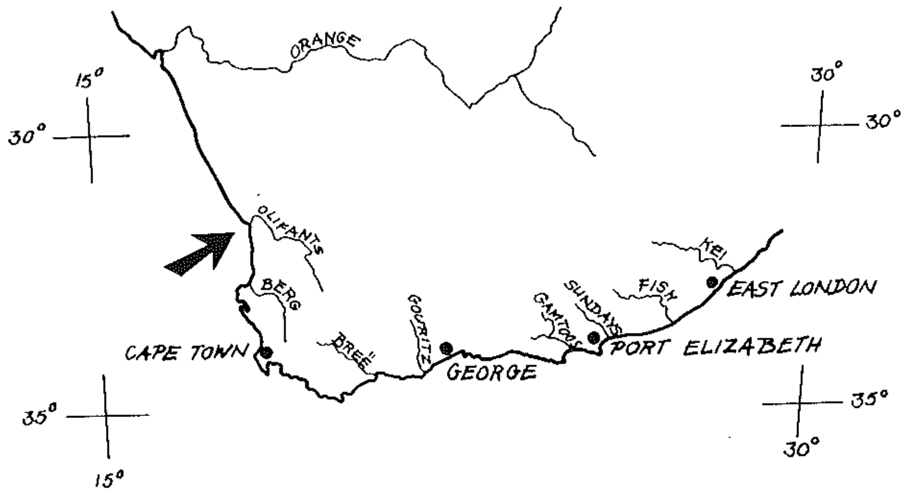
The main settlement near the Olifants Estuary is the Ebenhaeser Colony some 15 km upstream from the mouth. The colony had its origin in 1832 when the Hottentot chief, Kees Louis, asked the Cape government for permission to live at Doornkraal (later called Ebenhaeser) with his people. The area, covering 17 000 morgen (14 570ha), was surveyed at the Government's expense. The same year the chief invited Baron von Wurmb of the Rhenish Mission Society (RMS) to establish a mission in the area (Strassberger, 1969). The actual right to the land at Ebenhaeser was finally settled in 1837 when the Governor of the Cape, Sir Benjamin D'Urban, ruled that 5 270 morgen (4 520ha) belonged to the RMS. The Rhenish Mission Society's policy was that the individual mission stations should be as self-sufficient as possible. However, the story of the mission, and later the colony, has been one of a struggle against drought. Attempts to provide pumps to supply water for irrigation and domestic purposes proved to be expensive failures. Although the mission supplied lime for the tannery at Wupperthal and also acted as an important staging post on the route to Namaqualand it was never really viable. After half a century of struggle with drought the RMS was unable to support the Ebenhaeser mission further, and the work was transferred to the Dutch Reformed Church in 1882 (Strassberger, 1969).

Since 1925 the Ebenhaeser Colony has been entitled to water for 300 morgen (257ha) divided into 2 morgen (1,7ha) plots. One hundred morgen of this ground is low-lying and has become too saline for cultivation. The Department of Internal Affairs (formerly Coloured Affairs) has now assumed control of the settlement. The farmland has been replanned so that there are 103 plots of approximately 5 acres (2ha) each lying on higher ground (Burman, 1970).

Between Ebenhaeser and the sea lie the Coloured settlement of Viswaters, a satellite of Ebenhaeser, and the tiny White hamlet of Papendorp.

2. LOCATION

The Olifants Estuary lies at 31° 42'S; 18° 12'E some 250km north north-west of Cape Town. The nearest towns are Lutzville and Vredendal, 23,5km and 42km respectively east of the estuary on a tarred road. The seaside resort of Strandfontein (Curlew Strand) is 8km south of the estuary. The Olifants River forms the generally accepted southern boundary of Namaqualand.



2.1 Accessibility

The southern shore of the estuary is accessible at Papendorp and Viswaters. The two settlements lie approximately 2,5km north of the road connecting Doringbaai and Lutzville. Vehicular access to the mouth is possible via tracks running from Papendorp: in dry weather a track to the north of the salt pan is negotiable whereas in wet weather a more circuitous route around the south of the pan has to be used. A small boat launching site at Viswaters provides access to the estuary through the salt marsh although at low tide the channel is virtually dry. The north shore of the estuary is comprised of the farm "Die Punt" (also known as "The Point", as shown on the 1:50 000 Topographic Sheet 3118 CA). Marine diamond mining takes place along the Atlantic shore of the farm, thus access by the general public is restricted.

2.2 Local Authorities

The Estuary lies entirely within the authority of the Cedarberg Divisional Council. The Ebenhaeser Colony is managed by a village council under the overall control of the Department of Internal Affairs. Papendorp is State land leased to the present White tenants under the control of the Department of Community Development.

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Catchment Area

The Olifants River catchment is the second largest in South Africa, being exceeded in size only by that of the Orange River. Heydorn and Tinley (1980) give the catchment area as 46 625km^2 whereas Noble and Hemens (1978) give it as 46 084km^2.

There are approximately 1 100km of major rivers and tributaries in the Olifants system (Figure 2).

Lengths of rivers and tributaries of the Olifants system

River	Length (km)
Olifants	260
Major tributaries of the Olifants:	
Hantams/Doring/Sout/Hol	240
Doring	270
Major tributaries of the Doring:	
Oorlogs	180
Tankwa	130
Total river length	1 080

3.1.2 Topography

The Olifants River rises in the Agter Witzenberg, a plateau lying between the Winterhoek (2100m) on the west and the Skurweberg (1850m) on the east. The river flows northwards to Visgat where it enters a narrow gorge through which it runs for the next 30km before emerging into a wide valley near Keerom. For the next 100km the river runs almost due north between the Cedarberg on the east and the Olifantsrivierberge and Swartberg on the west. There are two major dams on this section: the Clanwilliam Dam and, 23km further downstream, the Bulshoek Dam. Below the Bulshoek Dam the Olifants River runs between old river terraces on which there is intensive, irrigated, fruit farming (mainly vines). Twenty kilometres downstream from the Bulkshoek Dam the most important tributary, the Doring River, joins the Olifants.

The Doring is a semi-permanent river whose flow varies considerably: in winter the flow is very strong, whereas in summer the river is reduced to a chain of pools. The Doring River drains the eastern slopes of the Cedarberg, the Swartruggens and the Western Roggeveldberge. The latter form part of the western Karoo escarpment. The Doring River contributes a very large proportion of the silt carried down to the Olifants Estuary. The semi-arid northern third of the Olifants River catchment is drained by a series of seasonal streams of which the Hantams/Doring/Sout/Hol complex is the most important. The confluence of the Hol with the Olifants lies 6km upstream of Lutzville.

The final section of the Olifants River between Lutzville and the sea runs between low hills and receives no tributary of significance.

3.1.3 Geology

The Olifants River itself drains an area consisting almost entirely of quartzitic sandstone and quartzites of the Table Mountain Group of the Cape Supergroup. This accounts for the very clear water in the Olifants River which carries almost no silt except when in spate. The Doring River in the western and extreme southern portions of its catchment drains off sandstones and quartzites of the Table Mountain Group, Bokkeveld Group shales and Witteberg Group quartzites and shales. All three stratigraphic series are components of the Cape Supergroup. The eastern and northern parts of the catchment consist of rocks of the Karoo Supergroup: the easily-eroded Dwyka Formation tillites and the Ecca Group shales and sandstones. The Hantams/Doring/Sout/Hol river complex rises in the Hantamsberge near Calvinia where it drains from Ecca and Dwyka group rocks. The central portion of this catchment consists of shales, greywackes and limestones of the Malmesbury Group. The north-western portion of the catchment consists of schists, gneisses and migmatites of the Namaqua Province.

Work by Dingle and Hendey (1984) has revealed an important aspect of the geomorphological history of the Olifants Estuary. It served as the mouth of the Orange River for millions of years during Palaeogene (Lower Tertiary) times. During the latter part of this period the Cape Canyon was cut across the continental shelf and slope. On the basis of the volume of sediments deposited offshore on the continental slope near the exit of the Cape Canyon it is estimated that sediment discharge was 2,0 x $10^6 m^3$ per year at that time. This relatively low sediment discharge suggests that the Lower Tertiary climate of southwest Africa was drier than that of late Cretaceous times.

During late Cretaceous times the Orange River discharged through its present mouth at 28°S. The middle Orange River followed a different course through the interior up to 150km south of its modern channel. Sediment discharge rates from this river were relatively high, being at least 10 x$10^6 m^3$ per year which resulted in rapid advancement of the continental margin sediment prism west of the mouth by large scale slumping on the continental slope. These remarkable changes in the major drainage system of South Africa were revealed by a combination of aerial photographic study, consideration of onland geology, the volumes of sediment opposite the Orange and Olifants rivers as well as sediment cores obtained from the South East Atlantic during the Deep Sea Drilling Programme.

By the time that real aridity had set in during late Miocene times the Orange/Vaal discharge had switched back to the 28°S exit. Modern sediment discharge rates of 6,5 x $10^6 m^3$ per year are relatively high and reflect soil erosion caused by agricultural activity in the interior.

The two major alterations in the exit point of the Orange/Vaal catchment in late Cretaceous to early Tertiary, and late Oligocene to early Miocene times are related to periods of low sea level. This would have promoted the relevant river captures adjacent to the western escarpment causing these remarkable changes in major drainage patterns in South Africa. An additional factor in the first course change may have been the disruption of the Middle Orange Channel by late Cretaceous igneous intrusions. These river course changes have economic implications for offshore diamond distribution.

Suggestions that there might have been radical changes in the course of the Orange/Vaal River were made by Du Toit as early as 1910 (Du Toit, 1910). ERTS satellite images now provide evidence of palaeo-drainage patterns. Zoological evidence has been provided by Jubb (1964, 1965) citing Howell and Bourlière (1964) who postulated a previous link between the Olifants River system and the Orange/ Vaal on the basis of the similarity of their modern fish faunas.

The link between the Olifants and the Orange/Vaal systems was by the Krom River, an extension of the Sout, which joins the Olifants close to the coast (Figure 2). The deep gorge and 50km cutback of the escarpment of the Krom River is quite out of proportion to its present size. The composition of the sediments off the Olifants River mouth provide further evidence of the changes in drainage patterns. A large increase in the proportion of montmorillonite suggests an influx of weathering products from eroding Karoo lavas in the upper Orange catchment into the Cape Canyon region.

The Cape Canyon on the continental slope off the Olifants River mouth is about 250km long, and up to 10km wide, and has incisions of at least 480m below the top of the Lower Tertiary strata. Stratigraphical data suggests that the Canyon was initiated in Oligocene times during the mid-Tertiary regression of the sea. The proximal parts were presumably subaerial features cut by the westerly extension of the Olifants River.

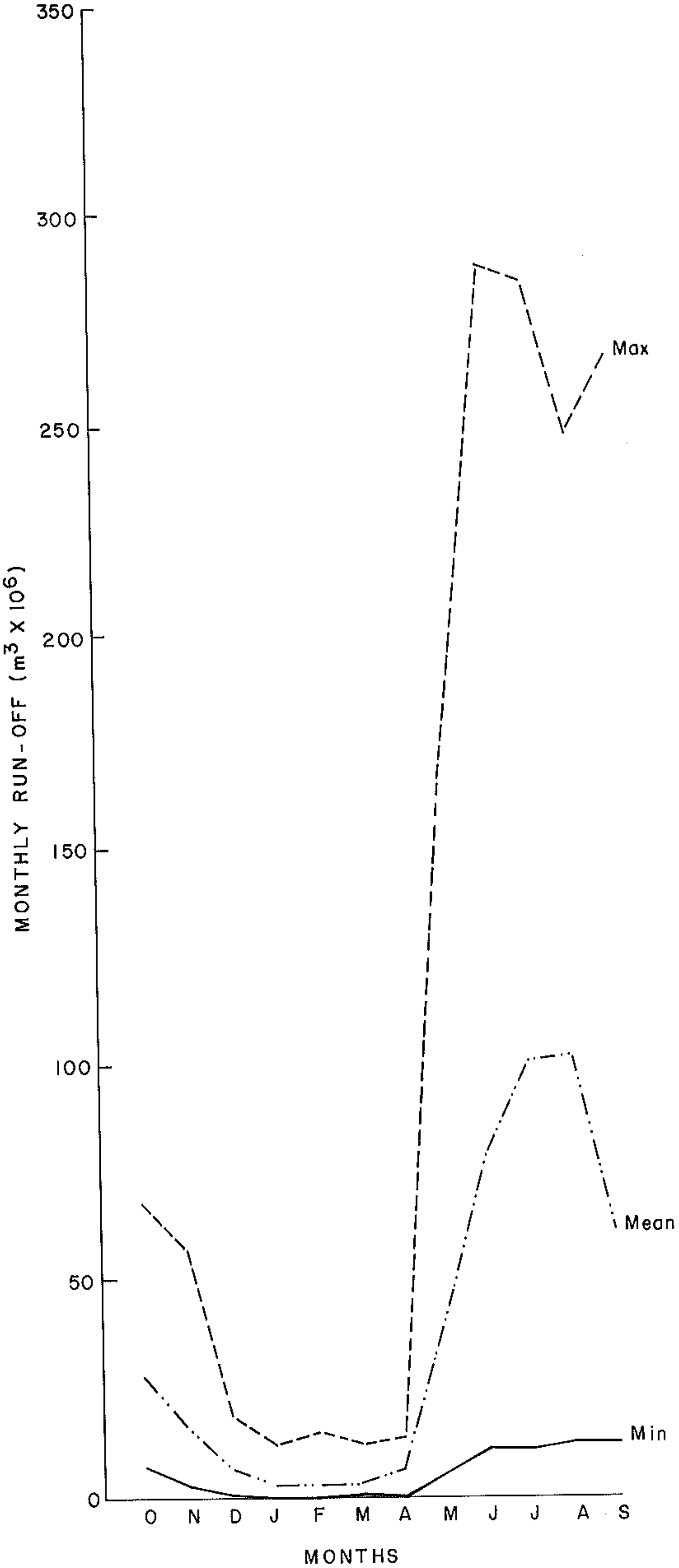


FIG. 3 : Olifants River: Monthly run-off for the period 1934 to 1960

(Clanwilliam Dam gauging station)

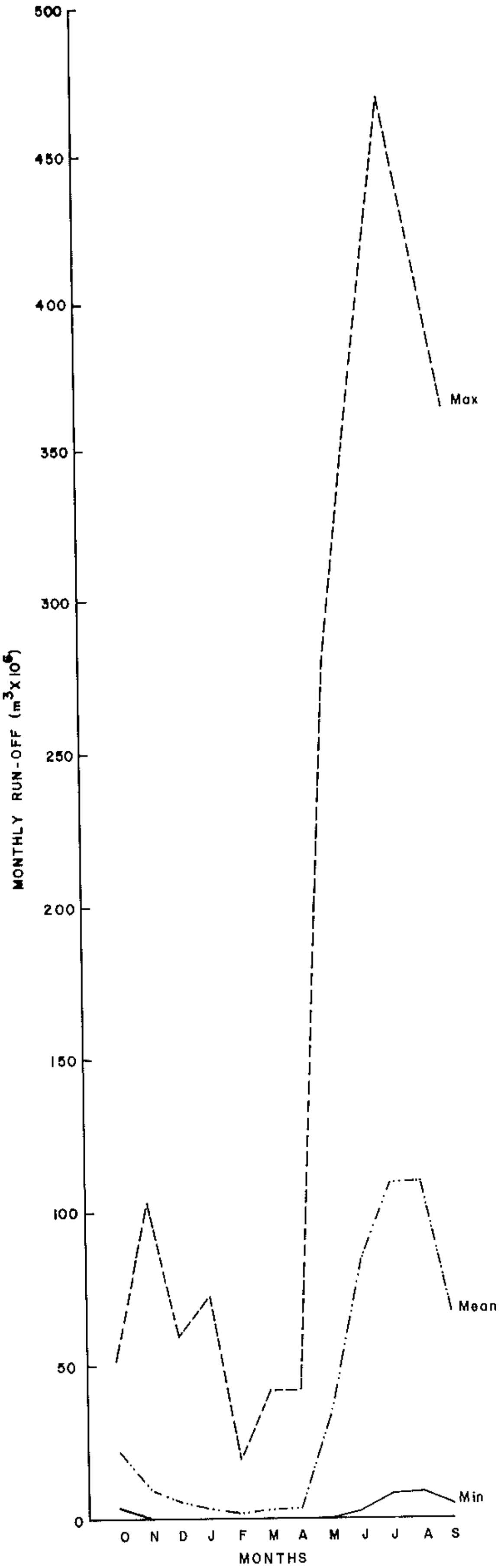


FIG. 4: Doring River: Monthly run-off for the period 1922 to 1960.

(Aspoort gauging station)

An important corollary of the Olifants River serving as the exit to the Orange River is the effect this would have had on the regional supply of diamonds from the continental interior to coastal Namaqualand. It has been established that diamonds are associated with river mouths (Gurney *et al.*, 1982). Present day mining occurs on Neogene coastal terraces and in the nearshore. Because of river gradient changes Dingle *et al.* (1983) have postulated coarse and heavy mineral sediment dumping up to 20km seaward of the present coastline during the late Oligocene to early Miocene low sea level. Thus the prospects for large diamondiferous deposits off the present Olifants River mouth seem promising.

3.1.4 Rainfall and Run-off

Rainfall

The south-western catchment, that is, the catchment of the Olifants River itself, lies within the winter rainfall region which has a Mediterranean climate (Schulze, 1965). The eastern portion of the catchment, that is, the Doring, Ongeluks and Tankwa rivers, lie in a rain shadow area which receives most of its rainfall in the winter months. However, this region can also receive considerable amounts of local rain in the form of thunderstorms during the summer. The eastern catchment is defined as having a semi-desert or poor steppe climate in which rainfall is unreliable and rarely exceeds an average of 250mm per annum (Schulze, 1965). The estuary also lies in an area of low rainfall almost all of which occurs in winter. Coastal fog is fairly common.

Run-off

The mean annual run-off (MAR) of the entire Olifants River catchment is 122 x 10^7 m^3 (Midgley and Pitman, 1969). The run-off pattern reflects the marked seasonality of the rainfall in the catchment (see above). Generally, there is little river flow in the summer while the highest flows occur during the period June to September (Figures 3 and 4). A notable feature is the extreme variability of the peak flow: in the Olifants River itself it can be as little as one-tenth of the average monthly run-off and as much as 2,5 times as great. The variation in flow of the Doring River is much greater: from one-tenth to 4,5 times the monthly flow rate in winter (Figure 4). This is a reflection of the erratic rainfall in the Doring catchment. Both the Olifants and Doring catchments have rapid run-off characteristics. In the case of the Olifants the water runs off the impervious Table Mountain Group sandstone and quartzite (see Section 3.1.3) while the rapid run-off in the Doring is a reflection of the sparse vegetation which is unable to retain much water and thereby attenuate flow.

3.1.5 Land Ownership/Uses

The catchment of the Olifants River system is almost entirely rural with farming being the most important activity. The farming varies from intensive, irrigated lands mainly along the lower reaches below the Bulshoek Dam, to low density sheep grazing in the Tankwa Karoo rain shadow region. There are two Proclaimed Mountain catchment areas in the source region of the Olifants River itself: the Groot Winterhoek (81 427ha) and the Koue Bokkeveld (96 348ha) (P G Reyneke, Directorate of Forestry, *in litt.)*. Besides the Proclaimed Catchments many of the higher mountain areas are under the control of the Directorate of Forestry as State Forests. Much of the Cedarberg is managed as a Wilderness Area with access by hikers strictly controlled to minimise human impact.

The area around Clanwilliam is famed for the production of Rooibos tea which is made from the leaves of an indigenous shrub, *Aspalathus linearis linearis*.

3.1.6 Obstructions

There are two major dams on the Olifants River: the Clanwilliam Dam, built in 1932 and raised in 1966, which has a capacity of 127 x 10^6m^3 and the 7,5 x 10^6m^3 capacity Bulshoek Dam, built in 1919 to act as a control barrage for the lower Olifants River irrigation scheme.

There are numerous bridges across the Olifants River and its tributaries. However, only the causeway across the Olifants River approximately 8km south of the upper end of the Clanwilliam Dam appears to have any effect on the river flow. At the time of the ECRU survey (83.08.08) river sand had blocked many of the spans on the eastern side. In times of flood, however, the water simply overtops the causeway temporarily rendering it impassable to traffic.

A natural rocky obstruction forms the head of tidal effect on the Olifants River at Lutzville. A causeway (the "low water" bridge) has been built across the river at this point (Figure 5).

Fig. 5: The "low water" bridge at Lutzville which marks the head of tidal effect in the Olifants River some 32 km from the sea (measured along the river course).

3.1.7 Siltation

The main silt load in the Olifants River system is carried by the Doring River which drains areas of relatively soft tillites and shales (see Section 3.1.3 above). The Olifants River proper carries very little silt and, in addition, passes through two major dams which act as silt traps. The silt supply to the estuary is, therefore, irregular being mainly delivered by winter floods.

However, summer floods, such as that of February 1981, do occur (colour aerial photograph, Job 376, February 1981). This photograph strikingly illustrates the massive contribution of sediment to the Olifants River system by the Doring River. This particular flood was the result of the same extreme rainfall event which devastated the Karoo town of Laingsburg. The Doring catchment lies immediately to the west of the catchment of the Grootrivier which passes through Laingsburg. In the estuary itself much of the sediment consists of very fine muds enriched with organic material from the extensive salt marshes.

3.1.8 Abnormal Flow Patterns

Winter floods occur whenever heavy rain falls in the catchment. For example, over a 32-year period the mean monthly run-off for June has been exceeded on 10 occasions, on four of which the mean monthly value was exceeded by an order of magnitude (Monthly Flow Records, 1964). Major flooding occurred in 1925 during which the estuary mouth assumed its present configuration.

Local flooding along the river banks occurs at times of high flow, but generally little serious damage is caused since the immediate riverine strip which is valuable agricultural land, contains few fixed structures. During the ECRU survey (08-12.08.83) flood debris was noted in the riverside vineyards at Vredendal. During the same survey a considerable amount of debris, mainly *Phragmites*, was seen along the north side of Die Eiland and on the southern shores of the estuary just inside the mouth.

3.2 Estuary

3.2.1 Estuary Characteristics

Human activity has had little impact on the Olifants Estuary which probably differs little from its original condition. The depth of water over the bar is about 0,6m and with no protection from the south-westerly swells, the breakers make entry by boat hazardous (South African Sailing Directions, 1979). Thus there has been little incentive to develop the estuary as a harbour.

The definition of the upper limit of the Olifants Estuary is not simple: saline water has been recorded 32km upstream at Lutzville (Eagle and Bartlett, 1984). The upstream limit of seawater penetration depends on the strength of river flow. In winter, after heavy rain in the catchment, the river breaks through to the sea and a red-brown plume extends several hundred metres offshore. Conversely, in summer, when there is little river flow the seawater ("blue water") penetrates as far as Ebenhaeser on occasions.

Duvenage (1983) chose a point 850m downstream from Soutpansklipheuwel, as marked on the 1:50 000 Topographic Sheet 3118 CA Papendorp, as the upper limit of the estuary for the purposes of determining its area. From Duvenage's arbitrary point to the mouth, the estuary is 10,5km long with its axis running almost exactly north-south. Opposite Papendorp the estuary is broadest, being 1,5km wide. However, the main channel running along the north side of Die Eiland is only approximately 0,5 km wide. The centre of the estuary basin is occupied by Die Eiland which is approximately 1km long and 0,5km wide. A blind inlet with extensive salt marshes (75ha) on either side lies between Die Eiland and Papendorp.

The mouth of the estuary is permanently open and its position is determined by the rocky platform and sill on its northern side (Heydorn and Tinley, 1980).

3.2.2 Geomorphology and Bottom Material

(Sections 3.2.2 and 3.2.3 were contributed by Dr G A W Fromme of the Sediment Dynamics Division, NRIO)

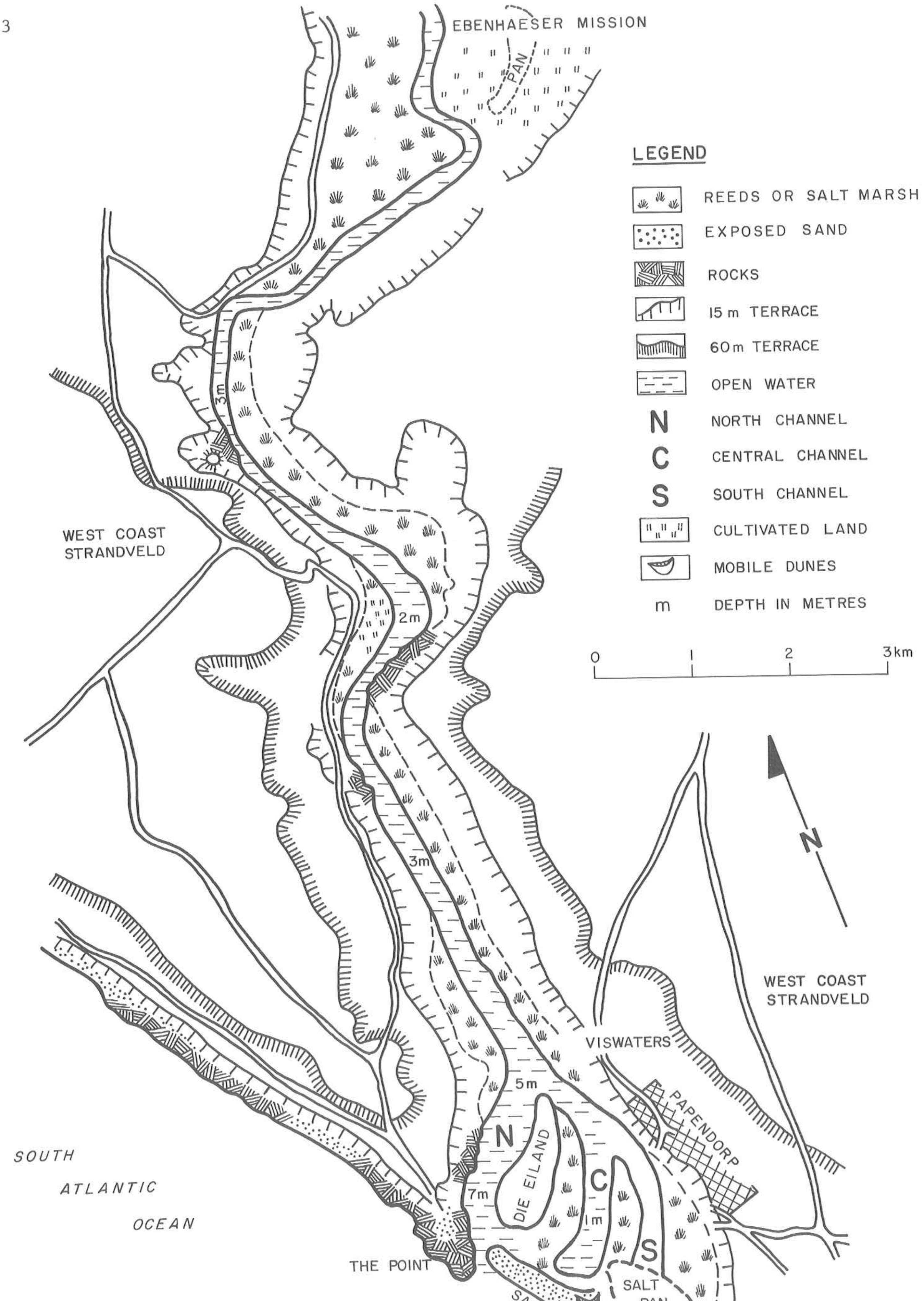


FIG. 6: OLIFANTS ESTUARY IN 1983
(after Coward, 1981)

The Olifants Estuary consists of two major geomorphological sections, the upper and the lower estuary. The upper estuary is a stretch of about 10km in length between Ebenhaeser and Viswaters (Figure 1, 1:50 000 Topographic sheet 3118 CA) where the river is confined in a deeply incised valley with an average width of 1km between the 15m contours, and 2,5km between the 60m contours. At Viswaters the estuary emerges onto a funnel-shaped coastal floodplain which is offset to the south, about 3km wide along the seashore, and 4,5km wide between the 60m contours.

The abovementioned contours (15m and 60m) mark the edges of two Pleistocene interglacial gravel terraces (Coward, 1981) which were deposited during hyperthermal interglacial periods between 1,5 million and 15 000 years B.P. During these interglacial periods marine transgressions occurred, caused by higher temperatures combined with local tectonics. High-level shorelines along which the gravel terraces in the lower Olifants valley were deposited were thus formed (Orme, 1975; Tankard, 1975; Truswell, 1977; Tankard and Rogers, 1978).

The lower Olifants valley (below Ebenhaeser) was cut more deeply into the surrounding plateau during the later Tertiary (Pliocene, 5 to 1,5 million years B.P.). The plateau consists of Table Mountain sandstone and of Malmesbury phyllite and Pre-Cambrian limestone, and is covered by superficial Tertiary to Quaternary deposits of limestone, sandstone and gravel. The plateau was shaped by wave erosion during a period of high sea level during the middle Tertiary (Miocene, 20 to 5 million years B.P.), followed by a low sea level during the Pliocene, after which the abovementioned incision by the Olifants River into the plateau began.

This erosional process was accentuated by the Pleistocene glacio-eustatic sea level regressions which caused "over-deepening" of the coastal valleys as a result of lowering of the base of erosion (sea level) by 130m below the present MSL. With the marine transgression at the end of the last Ice-Age (Flandrian Transgression, 15 000 to 5 000 B.P.), during which the sea level rose to 2,5m above the present MSL, these valleys were inundated and were filled by marine and fluvial sediments. It is these sediments which form the present-day surfaces of floodplains and beds of the Olifants and other South-African estuaries (Taljaard, 1949; McLachlan and McMillan, 1979; Truswell, 1977).

While the bed of the upper Olifants Estuary within the deep valley is relatively stable, the open lower estuary represents a dynamic zone, where estuary channels often change their course during floods. A large island (Die Eiland), encompassed by the two major (northern and central) estuary arms has formed in the estuary basin, while a third (southern) arm, which ends in the Papendorp salt pan, is dry at present (Figure 6).

During the ECRU survey (8-12 August 1983) bottom sediment samples were collected in the centre of the estuary channel for particle size analysis. The results are given in Table I.

The medium sand 13km upstream of the mouth indicates the fluvial component of the river, the fine sand in the upper estuary characterizes reduced flow, while the medium sand in the lower estuary originates from the influx of marine sediments.

Water depths in the upper estuary range from 2m to 3m, while the lower estuary is 5m deep at the separation of the northern and central arm, and 7m deep about 0,5km upstream of the estuary mouth (northern channel). The central arm carries water only during floods, during which the water depth is usually less than 1m.

Table I: Olifants Estuary: sand grain sizes of bottom material

Location (km upstream) of mouth)	Median sand size (mm)	Remarks
13	0,429	upper limit of estuary
7	0,221	upper estuary
0,75	0,358	lower estuary

3.2.3 Estuary Mouth Dynamics

The permanently open mouth of the Olifants Estuary, which is usually the outlet of the northern arm of the estuary, is situated between a large and very stable sand spit on the southern side, and the rocky bluff of Hartebeesklip or the "Point" on the northern side. The sand spit is 2,5km long and 250m wide, and is backed at its inner (landward) side by the floodplains of the lower estuary basin which are covered by saltmarsh vegetation and some mobile sand dunes.

The sand spit blocks the presently closed central and dried-out southern arm of the estuary, but a breach of the spit by the central arm was observed during a river flood in 1925 (Mr A Geustyn, resident of Papendorp, pers. comm.). During the ECRU survey in August 1983 the mouth (northern channel) was about 150m wide, but Coward (1981) reports a "narrow channel" of only 80m in width during the summer of 1980/81.

On both sides of the estuary a steep rocky shoreline, which consists of Malmesbury Group sandstone in the north, and of Malmesbury Group and Table Mountain Group sandstone in the south, rises up to a gravel terrace 27 m above sea level. The few small pocket beaches between the rocks are covered with black sand including high concentrations of heavy minerals (Figure 7).

Fig. 7: Concentrations of heavy minerals on the beach *ca.* one kilometre south of the Olifants Estuary mouth.

During the ECRU survey on 20 August 1983 the sand spit was investigated closely. The results of this are given in Table II.

The sand grain sizes on the beach along the sand spit range from fine at the big dune in front of the closed central channel to medium along the other sections of this beach, with the coarsest sand sizes at the mouth.

Table II: Olifants Estuary: characteristics of beach at sand spit

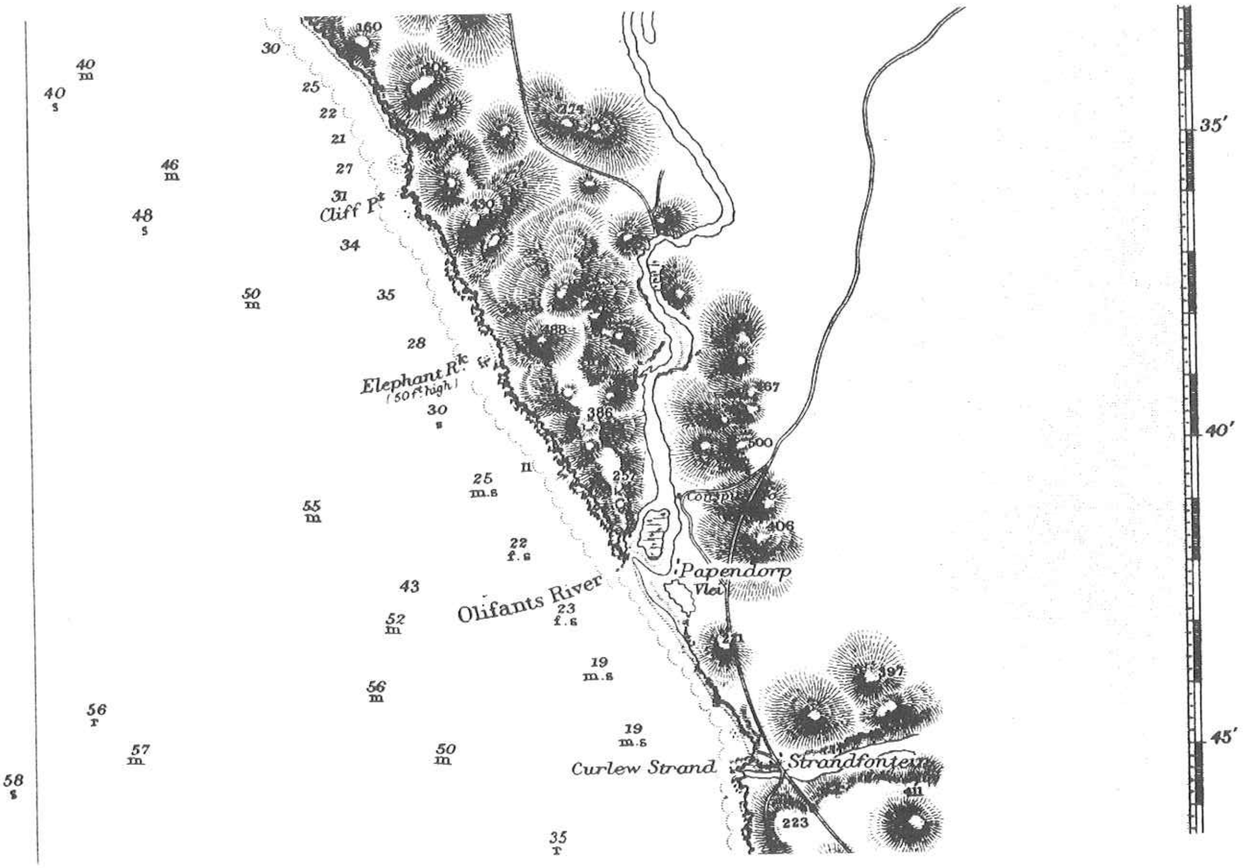
Location (relative to mouth)	Beach characteristics		Remarks
	Slope (°)	Median sand size (*) (mm)	
Mouth (south bank)	2 - 4	0,333	Black sand at HW-line much flood debris
0,5 km S	3	0,265	Steeper in troughs between cusps (high energy coast)
1 km S	1° 20′	0,230	In front of big dune
1 km S (Top of dune)	-	0,208	Dune in front of dead central channel, 12 m high
2 km S	2°	0,262	South end of sand spit beach (in front of dry southern channel)

(*) Composite of 5 samples between HWL and LWL

Normally the sand grain size is larger at the mouth of a river than on the shore adjacent to the mouth. The difference in rate of the decrease in sand size on either side of the mouth gives an indication of the predominant longshore drift. A slower decrease of sand size over a similar distance on one side of the mouth than on the other indicates that the predominant longshore drift is in that direction (Fromme, 1980). The wave regime at the Olifants River mouth indicates that the predominant longshore drift is in a north-westerly direction. The decrease in sand size to the south of the mouth in the case of the Olifants Estuary sand spit, is not so much an indication of a probable secondary longshore sand drift to the south, as of the remnant of a sedimentation period some 4 000 years ago. At that time the sea level was 2,5m above the present level and the estuary was wide open between the rocks to the north ("The Point") and the southern channel. During this time estuarine sediment of fairly uniform size was probably deposited over the entire area of this ancient grand estuary mouth (Fromme in Whitfield 1983).

3.2.4 Estuary Dynamics

(a) Estuary: Maps and charts from 1869 to 1972 show a large partially sandy and swampy island (Die Eiland) in the lower estuary basin, which is encompassed by two estuarine arms, one running along the rocky north bank and the other one in the centre of the basin. The two arms (in this report called the northern and the central arms or channels, see Figure 6) combine at the north bank of the estuary and have a common mouth to the sea (see Figure 8, showing a historical chart from



OLIFANTS RIVER MOUTH

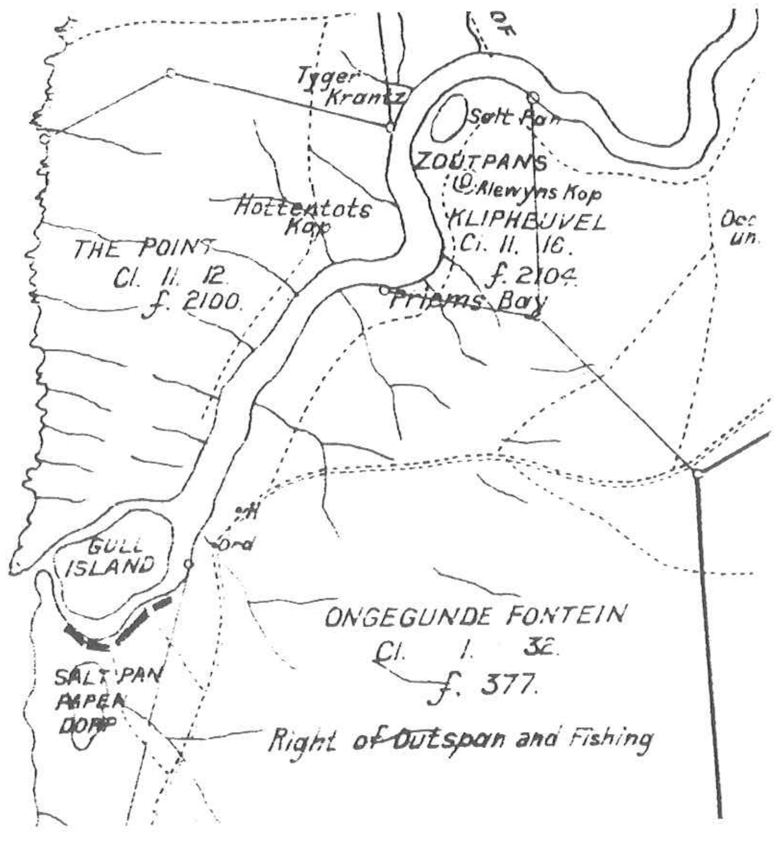


Fig. 8: Olifants Estuary, 1869/70 (top) and 1890/1900 (bottom).

Fig. 9: Olifants Estuary, 1958 (top) and 1981 (bottom).

1869/70 and a Divisional map from 1890/1900). Evidence of a third southern arm, which is not shown on the maps and charts, is given by seven sets of aerial photographs from 1942 to 1981 (see Figure 9, showing aerial photographs from 1958 and 1981).

Before the flood of 1925 both the northern and the central channels carried water. During the flood the central channel breached the sand spit approximately one kilometre south of the previously combined mouth of the northern and central channel. This second mouth remained open for two years. Because of the diversion of the flow from the connecting channel between the lower end of the central to the northern estuary arm (Figure 8) this channel became sanded-up. After two years of progressive influx of marine sand through the new mouth, and with reduced flow in the Olifants River, the new mouth of the central arm also became blocked, which led to a general shoaling of the central arm with an outflow connection to the northern arm only by seepage or little creeks through the silted-up previous connection area which is at present covered by saltmarshes (Messrs A Geusteyn and A Dittmer, both long-time residents of Papendorp, pers. comm.,).

The third (southern) arm is dried up at present. Only a few isolated salt marsh pools are indicative of a previous water coverage. The salt pan at the lower end of the southern arm is supplied with water via a small artificial channel from the central arm (Figure 10). As this southern arm is neglected on all the available maps from 1869 to 1972, but is visible on the aerial photographs from 1942 to 1981, and is still discernible *in situ* as a moist depression to-day, it may be concluded that, except for floods such as those of 1925, it has not functioned as a real estuary channel during the last 115 years. It must, therefore, have formed long before 1869, possibly during a strong flood. According to its configuration it might also have had a mouth at the far south end of the estuary basin, where a local depression exists behind the beach in this area (Figure 9, aerial photograph from 1958).

Fig. 10: The seawater supply channel connecting the Papendorp salt pan (in background) with the Olifants Estuary. Note the crude "control gate" consisting of a board and earth dam.

Comparison of all available evidence from maps, aerial photographs and the results of the ECRU survey in August 1983, indicate little variation in the channels, islands and sand banks. Hence it can be concluded that the Olifants Estuary is a relatively stable system. This might be due to the controlled and reduced discharge caused by the two irrigation dams in the upper stretches of the Olifants River which absorb most spate flows but not necessarily extreme ones. The last discernible changes in the estuary occurred during the flood in 1925, that is before the construction of the Clanwilliam Dam in 1932.

(b) Coast: Because waves are responsible for the generation of surf zone currents and littoral sediment movement, the wave conditions along the coast greatly influence the character and behaviour of an estuary mouth. Wave data from VOS ("Voluntary Observing Ships", Swart and Serdyn, 1984) were used for the determination of *deep-sea wave directions and heights*. Wave heights obtained from the Koeberg Waverider give an indication of the *wave heights in the nearshore areas* of the South African west coast (Coetzee, 1981 to 1983). Using the VOS-data the *median wave* heights for the various directions of wave incidence were also computed; they are given in the table below:

Wave direction (^{o})	150	180	210	240	270	300	330	Mean
Median wave height (m)*	2,2	2,3	2,1	2,3	2,0	1,8	1,6	2,0

* The median wave height is that wave height exceeded 50 per cent of the time.

The highest deep-sea waves recorded by VOS reach 8,2m, while the Koeberg Waverider gives 7m as maximum nearshore wave height.

The mean deep-sea median wave height of 2,0m as calculated for the west coast (VOS) appears to be moderate if compared with those for the south coast, that is, 2,4m for Struis Bay and 2,45m for the Sedgefield (Swartvlei) coast.

A wave rose (Figure 11) illustrates the wave directions at the Olifants Estuary mouth. A line drawn perpendicular to the coast to divide the half-circle of possible wave incidences into the two main sectors which control the direction of the longshore current and sediment transport, shows that 83,7 per cent of the nearshore wave incidence is from SW to S, and only 14,9 per cent is from WSW to NW. This indicates that a north-westward longshore drift will be dominant.

The configuration of the Olifants Estuary sand spit is in agreement with this, and as any further migration of the estuary mouth in this direction (NW) is checked by the rocky bank at the north-west side of the mouth, the present position of the mouth seems to be the terminal point of the evolution of this estuary mouth.

3.2.5 Land Ownership/Uses

The Olifants Estuary falls under the overall jurisdiction of the Cedarberg Divisional Council. The north bank consists of private farms while the south bank consists of the settlements of Papendorp and Ebenhaeser and their associated lands. Papendorp is owned by the Department of Community Development which leases properties and saltpan concessions to the present White residents (see Section 2.2 above. However, the leases are not being renewed as it is planned to transfer Papendorp to the Department of Internal Affairs (formerly Coloured Affairs) for integration with the Ebenhaeser Colony.

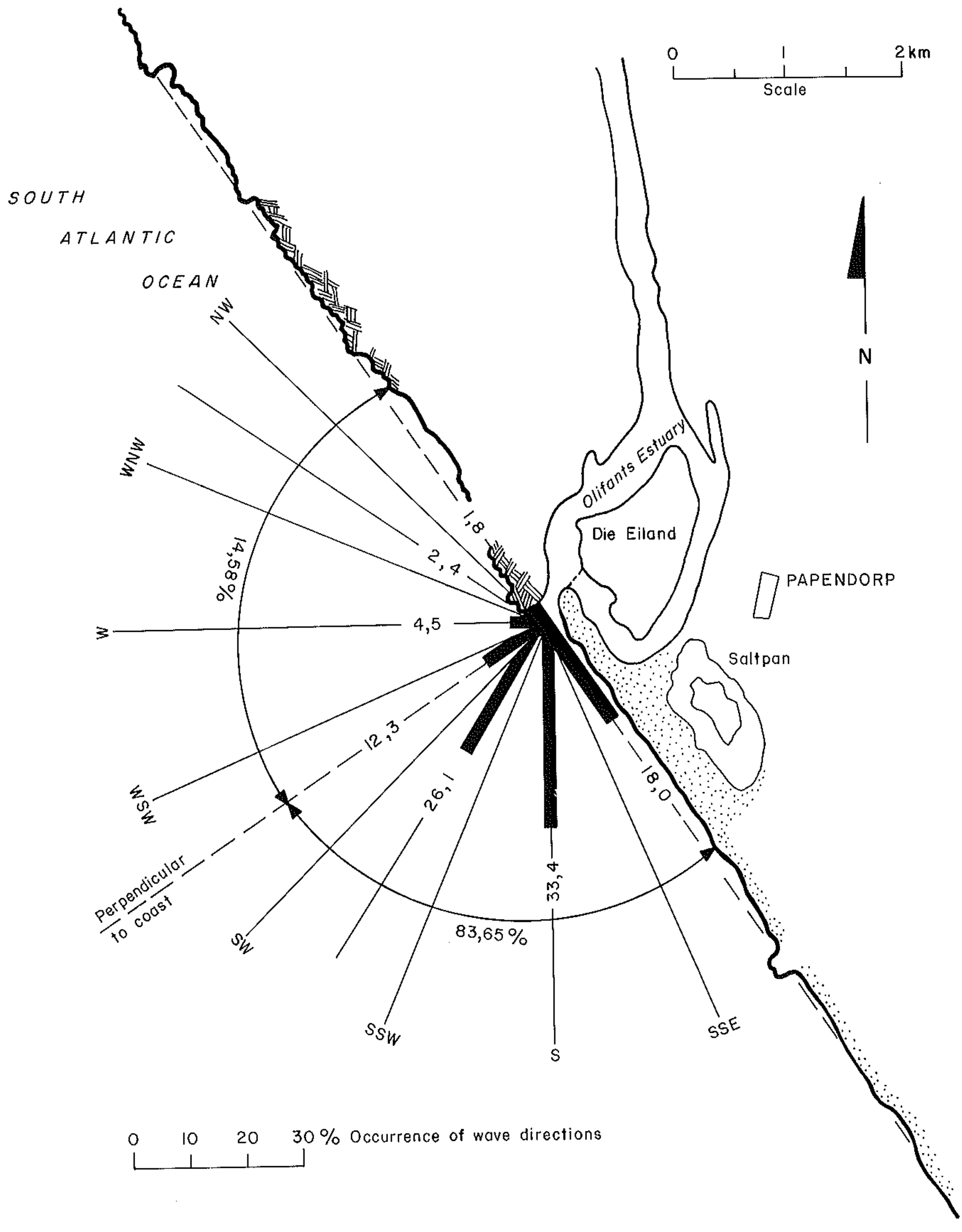


FIG. 11: Wave directions at Olifants Estuary mouth (percent occurrence) and predominant wave incidence from SW to S. (according to VOS)

The aridity of the area restricts agricultural activity to sheep and goat grazing except at Ebenhaeser where irrigation is undertaken with water from the lower Olifants River irrigation scheme. Marine diamond mining takes place along the sea coast of the farm "Die Punt" lying on the north bank and Strandfontein Minerale (Edms) Bpk holds the prospecting rights to Papendorp. There are a few diamond prospecting trenches on the south and east side of the Papendorp saltpan. The saltpan itself is leased to a number of persons who work the pan at a subsistence level. During spring tides saltwater is led via a narrow ditch from the estuary to the saltpan. The ditch is then blocked with planks and mud and the salt water in the pan allowed to evaporate and concentrate.

The estuary itself is used very occasionally as a harbour for small craft (less than 10 m in length) but the water over the bar at the mouth is shallow (0,6m) and the sea is usually rough with breakers (Africa Pilot II, 1977). To quote the South African Sailing Directions Volume II (1979):

> "small fishing craft can, on calm days, enter and leave the river, but it is a somewhat hazardous operation not to be undertaken lightly. The river itself inside the bar is deep and might provide a good harbour were it economically possible to dredge the entrance."

The estuary is unsuitable for recreational boating due to the strong tidal currents and, when in flood, the river current. Furthermore large areas either dry out or become very shallow at low tide. Zwamborn (1978), who states that "safe boating on the river would be possible under all but major flood conditions" and "the river is navigable for small craft for several kilometres upstream" clearly did not attempt to use a boat on the estuary and river. During the ECRU survey of 8-12 August 1983, when the river was in flood, the 3 metre dinghy ran aground a number of times between Ebenhaeser and the mouth, particularly in the big bend about 6 km from the sea. During the summer months the strong southerly winds in conjunction with the tidal currents can create very choppy conditions in the estuary making the use of small craft somewhat unsafe (M O'Callaghan, Botanical Research Institute, pers. comm.). Furthermore, access on the south bank is through saltmarshes and very glutinous mud rich in organic material. In view of the foregoing it seems unrealistic to consider developing the estuary for water sport.

Fishing, mainly for mullet ("harders") *Mugil* spp., by means of nets set on poles across the channels, is under permit from the Cape Department of Nature and Environmental Conservation (CDNEC). Currently there are 35 licence holders, eleven of whom may use 30 m x 2 m 51 mm stretched mesh commercial nets and the remaining 24 may use 10 m x 2 m 51 mm stretched mesh nets for personal purposes, that is, the catch may not be sold (E B du Biel, CDNEC, pers. comm.). During the ECRU survey (10 August 1983) CDNEC fisheries inspectors confiscated an illegal 200 m-long net which had been set in the river the previous night. The scale of poaching is not known, but in all probability poachers account for more fish than the licensed net owners.

3.2.6 Obstructions

There are no man-made obstructions in the estuary which impede water movement. On the south bank, at Viswaters, there is a small earth embankment extending about 25m into the salt marsh to facilitate the launching of small boats. Approximately 500 metres upstream from the mouth on the north side of the estuary there is a mooring occasionally used by small marine diamond mining craft.

3.2.7 Physico-chemical Characteristics

Four surveys of the physico-chemical regime of the Olifants Estuary have been undertaken to date. These are the summer 1976, winter 1977 and summer 1980 surveys by the NRIO Marine Pollution Monitoring Group (MPMG) and the winter 1983 survey by ECRU. The positions of the sampling stations are shown in Figure 12.

The physico-chemical regime of the Olifants Estuary shows strong seasonal variation. In winter saltwater penetration is limited by the strong riverflow. At times of flood the estuary is completely fresh and a large plume of sediment-laden water can extend a kilometre out to sea (colour aerial photo, Job 376, February 1981). During summer the river flow almost ceases with the result that seawater penetrates a considerable distance upstream. Saltwater ("blouwater") penetrates as far upstream as Ebenhaeser during a dry summer (Mr Hahn, Ebenhaeser Village Council, pers. comm.). The river is tidal as far upstream as the low water bridge at Lutzville 32 km from the sea although the tidal prism probably does not penetrate further than Ebenhaeser even at times of extremely low river flow.

pH

pH determinations were made during the surveys conducted by the MPMG in the summer of 1976 and winter of 1977 (Eagle and Bartlett, 1984). During the winter survey, when the river was flowing strongly, the pH values obtained (7,3-7,9) were marginally lower than those obtained in summer (7,32-8,52). However, these results are somewhat anomalous since lower values (*ca.* 7,3) were obtained at the estuary mouth than further upstream. As the pH of seawater ranges from 7,8 to 8,3 (Day, 1981), higher values would be expected from the mouth region and not *vice versa.*

Temperature

Temperature readings taken during the MPMG winter 1977 survey showed a high degree of uniformity along the estuary. Temperatures were in the range 9,3-10,3°C at low tide and 11,2-12,1°C at high tide. In summer 1976 temperature readings from the mouth were considerably lower than upstream. At low tide the temperatures ranged from 14,1°C at the mouth to 20,2°C upstream and at high tide from 10,0°C to 21,5°C. The low summer sea temperatures are the result of strong offshore winds causing the upwelling of very cold bottom water inshore. There is some evidence of thermal stratification in the estuary. This is limited because the estuary is shallow and generally well-mixed. Furthermore the surveys have all been undertaken when either the river or the sea have been almost completely dominant (MPMG surveys in summer 1976, winter 1977, summer 1980 and ECRU survey winter 1983). Surveys in spring and autumn, when neither the sea nor the river is likely to be dominant, may present a different picture.

Transparency

Transparency measurements have only been undertaken during one survey (ECRU, winter 1983). The river water, carrying sediment in suspension, was light brown in colour and severely restricted light penetration (Secchi disc values of 0,3-0,4 m). On the other hand the seawater was blue green in colour and moderately transparent (Secchi disc: 1,6 m). This difference in water colour highlighted the interface between the fresh river water and the seawater.

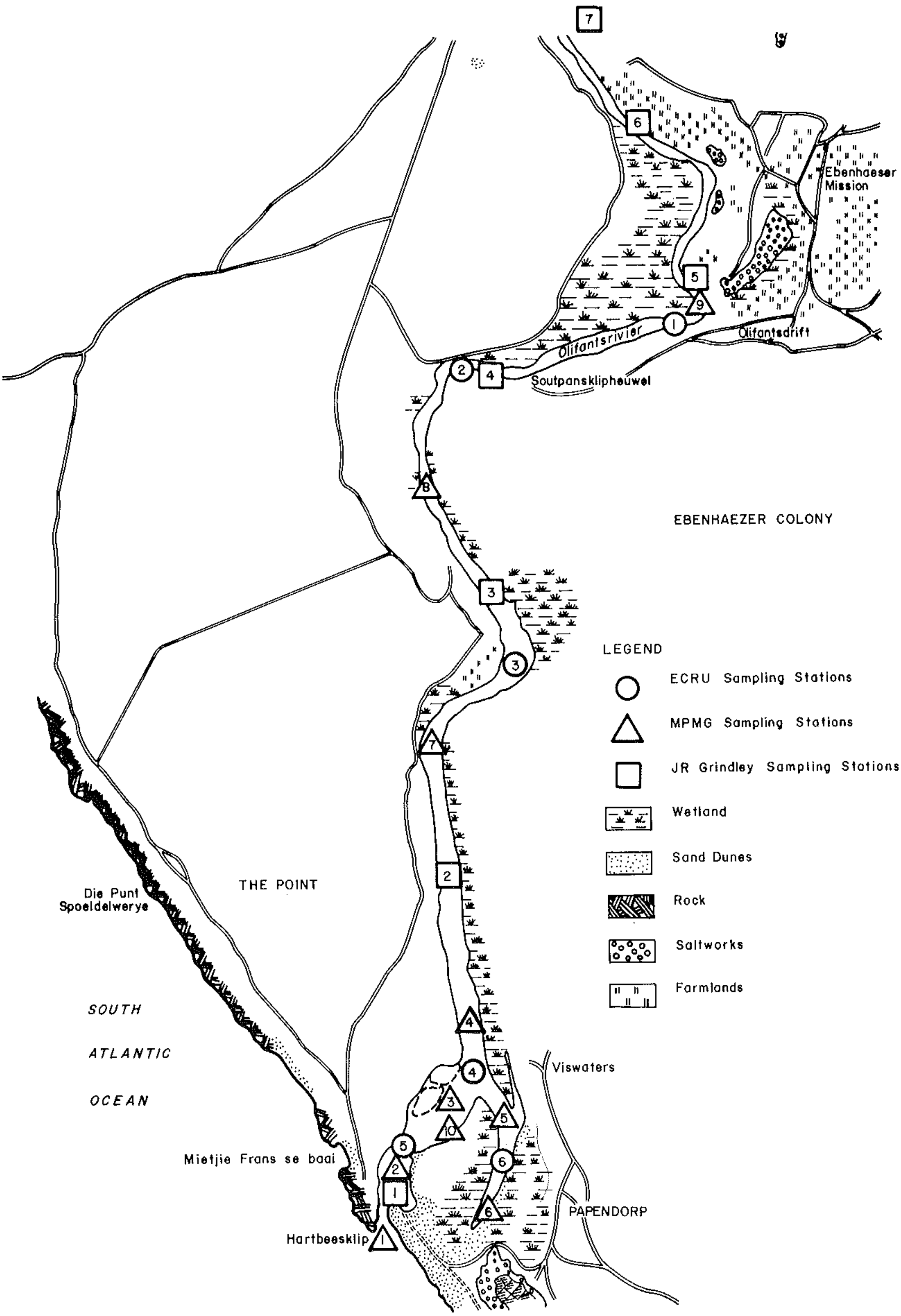


FIG. 12: Olifants Estuary: physico-chemical sampling stations.

Salinity

As can be expected the salinity within the estuary varies with the state of the tide and the strength of the freshwater inflow. Generally, in winter, the river dominates the estuary and seawater penetration either does not occur (MPMG winter 1977) or is very limited (ECRU winter 1983). During the latter survey salinity stratification occurred in the blind southern arm (ECRU Station 6) where a reading of 6 parts per thousand was obtained from the surface and 32 parts per thousand from the bottom. Stratification also occurred at ECRU Station 4 in the main channel, where the surface water was fresh (0 parts per thousand) and the bottom water (the salt wedge) saline (30 parts per thousand). During the summer, the saltwater progressively penetrates further and further upstream as the riverflow decreases. Salinities of 10-20 parts per thousand (MPMG, 1980) and 3-20 parts per thousand (MPMG, 1976) were recorded respectively 5 km and 8 km from the mouth. If additional dams are built on the Olifants and Doring rivers, summer river flow will be further attenuated and greater seawater penetration will occur. This could affect the lower-lying irrigation lands at Ebenhaeser where a salination problem already exists. The problem is compounded by the river water itself being saline during the summer. During the 1980 MPMG summer survey the salinity at Klawer (83km from the mouth) was 2,1 parts per thousand. The sodium/calcium ratio of 1,6:1 indicated that the salinity was not of marine origin (seawater sodium/calcium ratio = 24:1) but rather land-derived having been leached from the substrate.

Dissolved oxygen

During both the summer and the winter surveys the dissolved oxygen concentrations approached the theoretical saturation values for the prevailing salinity and temperature. However, during the MPMG summer 1980 survey there was a drop in dissolved oxygen concentration around the middle reaches (MPMG Stations 8 and 9). In this region the substratum consists of an organic-rich fine sediment which probably supports numerous bacteria which would have the effect of lowering the oxygen concentration. Another possible cause for the reduced oxygen concentration in the mid-estuary is mortality and decomposition of marine phytoplankton coming into contact with fresh river water.

Nutrients

A marked difference between the summer and winter nitrate and phosphate levels is evident from the surveys conducted by the MPMG. The differences in levels probably are the result of the marked seasonality of the run-off: there is almost no precipitation during the summer. Very high nitrate values (*ca.* 50 μ mol/ℓ) were obtained at Stations 8 and 9 during the summer 1980 survey. Some of the nitrate may have been released by decomposing organisms but the bulk is probably derived from agricultural fertilizers. Similarly elevated phosphate levels were found at MPMG Stations 8 and 9 during the summer 1980 survey.

Since the estuary is permanently open, thus allowing regular tidal interchange, there is little danger that the system will suffer from eutrophication. However, if the scale of fertilizer utilization in the Olifants River valley were to increase, problems with eutrophication of the river, particularly in summer, could occur and might have a deleterious effect on the estuary.

3.2.8 Pollution and Public Health Aspects

There is no industry and the general level of development is minimal between Lutzville and the sea. Consequently the estuary is unpolluted by industrial effluents. However, there must be a not inconsiderable input of agricultural chemicals leached from the agricultural lands (see Section 3.1.5) in the catchment and bordering the river. Further, there is a possibility that a certain amount of sewage seepage from Ebenhaeser and Papendorp enters the estuary but as the estuary is large and regularly flushed by tidal action and the human population density is low there is no cause for concern. However, if Papendorp was developed as a resort, consideration would have be given to providing a properly reticulated sewage system in order to avoid pollution of the estuary.

4. BIOTIC CHARACTERISTICS

4.1 Flora

(This section was contributed by Mr M O'Callaghan of the Botanical Research Institute)

Figure 13 shows the spatial distribution of the mapping units recognized at the Olifants River while Appendix I lists some of the species present in, and physical features of, each unit. These data were collected during November 1982 and August 1983.

According to Acocks (1975), this river valley is the only area where karroid scrub (Veld Type 31, Succulent Karoo) reaches the coast. Along the rest of this coastline, the coastal flats are covered with strandveld vegetation. Although this may be the general case, the vegetation around the Olifants Estuary consists rather of mixed associations. Unfortunately, this report does not allow detailed description of these vegetation types, nor can full credit be given to the great variety of plants in this area. More detailed vegetation studies of this area would be necessary before any further development affecting this vegetation takes place.

4.1.1 Phytoplankton/Diatoms

The phytoplankton of the Olifants Estuary has not been studied. However, diatoms were recorded in several zooplankton samples collected by J R Grindley in December 1979 and were found to be abundant at his Station 5, in the middle reaches of the estuary.

4.1.2 Algae

Day (1981) reports numerous marine algae from the rocks near the mouth of this river. These include *Porphyra capensis, Chaetangium* spp. and *Chaetomorpha* sp. He also reports luxuriant growths of *Ulva* sp. to the west of 'Die Eiland' while *Enteromorpha* sp. is found in the marshes, both here and further upstream.

4.1.3 Aquatic Vegetation

According to Edgcumbe (1980), *Zostera capensis* is not found west of the Berg River. However, Day (1981) reports large *Z. capensis* beds to the north-east of 'Die Eiland' with patches as far upstream as Rhebokbaai.

Although small amounts of *Potamogeton* sp. (possibly *P. pectinatus)* were collected near Ebenhaeser, the growth of this plant is probably restricted by the turbidity of the water and by the dense reeds lining the banks of the river.

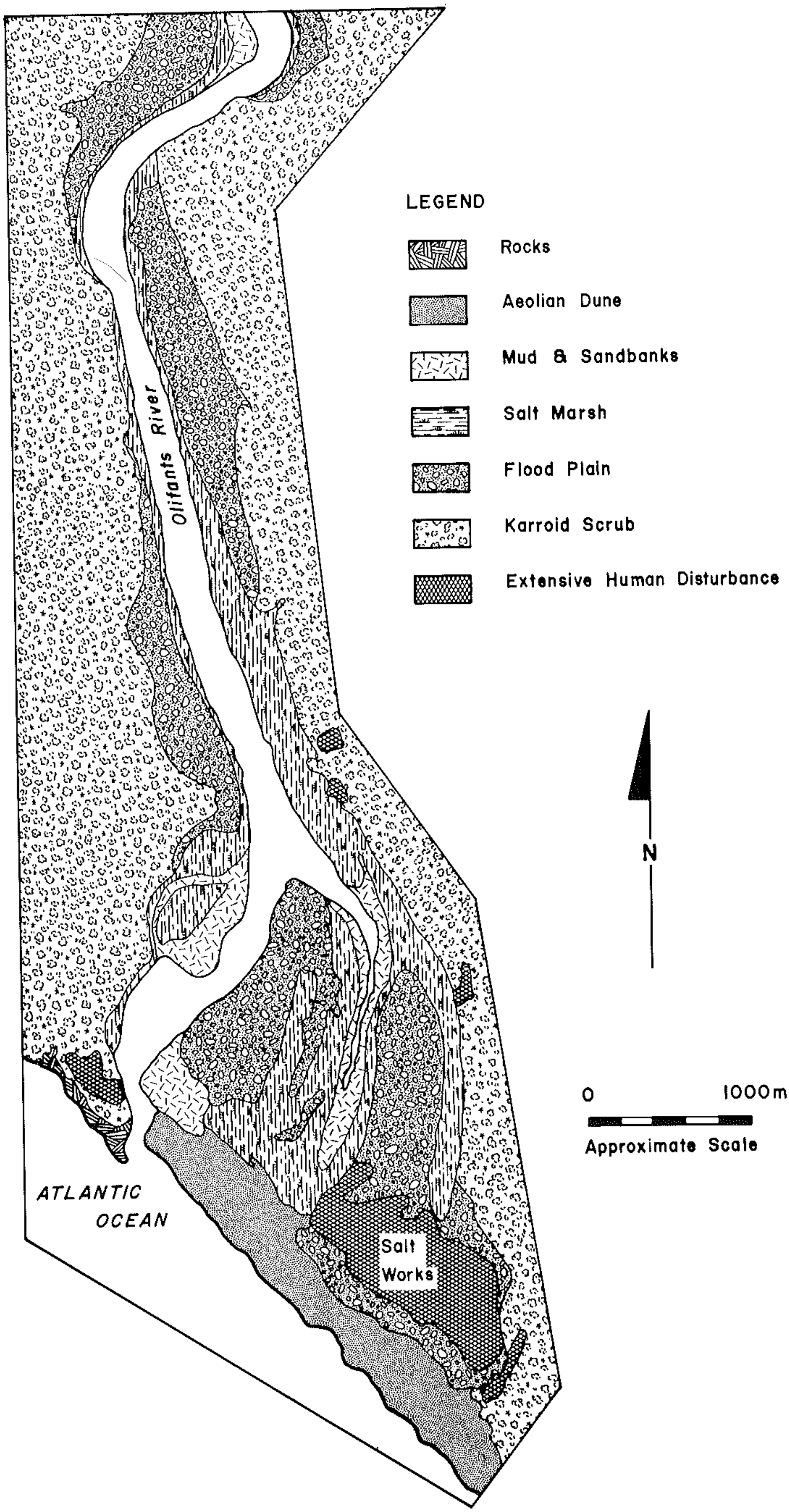


FIG. 13: The vegetation of the lower Olifants Estuary.

4.1.4 Semi-aquatic Vegetation

These vegetation types cover relatively large areas nearer the mouth and, due to the steep slope of the river valley, become restricted further upstream.

(a) The salt marshes are well stratified with *Sarcocornia perennis* at the lower levels, followed by *Triglochin striata* and *Cotula coronopifolia*. *S. natalensis* (possibly var. *affine*) is also found on the edge of the channels. The upper limit of the salt marsh is usually indicated by *Limonium scabrum, Sporobolus virginicus* and *Chenolea diffusa*.

Some of the tidally inundated mud flats south-west of 'Die Eiland' are barely vegetated, but may support *Zostera capensis* and large communities of invertebrates (Grindley, 1979).

(b) The flood plain vegetation occurs on the river terraces above the salt marshes and is only inundated occasionally. It is dominated by *Sarcocornia pillansiae* and *Salsola* sp. However, numerous species with more terrestrial affinities are also found here. For example, *Atriplex bolusii* and *Lycium horridum* are found near the beach while, further inland, numerous Mesembryanthemaceae are also found on the flood plain.

(c) Reed beds, consisting predominantly of *Scirpus littoralis* and *Phragmites australis*, line the banks of the river upstream from Olifantsdrif.

4.1.5 Terrestrial Vegetation

On the aeolian sand near the coast, numerous psammophilous (sand loving) pioneers such as *Eragrostis cyperoides, Arctotheca populifolia* and *Tetragonia decumbens* occur. Further inland, shrubs such as *Nylandtia spinosa, Blackiella inflata* and *Myrica cordifolia* are found with numerous karroid plants.

The karroid scrub consists mainly of succulents such as *Euphorbia mauritanica, E. hamata*, small shrubs, e.g. *Lycium horridum*, and numerous Mesembryanthemaceae. After spring rains, the veld is ablaze with flowers such as *Oxalis depressa, Homeria miniata, Lapeirosia jaquini* and numerous others.

The vegetation of this area has become degraded. The extensive flood plains are criss-crossed by animal and vehicle tracks which damage this vegetation type irreparably. The terrestrial vegetation has been drastically over-grazed in places and unsightly prospecting ditches deface some areas.

It is suggested that the passage of vehicles and pedestrians be severely restricted, especially on the floodplains and salt marshes. Grazing by livestock should be controlled as the denudation of the vegetation is causing erosion.

4.2 Fauna

4.2.1 Zooplankton

J R Grindley (University of Cape Town) investigated the zooplankton of the estuary and recorded 25 taxa but not all were identified to species level (Appendix II). He found a mean biomass of 26,5 mg dry weight/m^3 and 35 taxa. The number of taxa is greater than that recorded in any of the other west coast estuaries except the Orange. However, even greater diversities were recorded in open west coast bays including Saldanha Bay, Langebaan Lagoon and Sandwich Harbour. Dry biomass values in those systems were higher with a maximum of over 500 mg dry weight/m^3 while in some pans biomass was as low as 1,8 mg dry weight/m^3.

Grindley sampled zooplankton from the mouth through to beyond Ebenhaeser in fresh water in the fluvial zone. Salinities ranged from 34,5°/oo at the mouth to 0°/oo above Ebenhaeser with intermediate values at intervening sampling stations. Mean biomass estimates for each of the zones were:

Mouth (Station 1)	34,7 mg DW/m^3
Channel (Station 2)	6,7 mg DW/m^3
River (Station 3)	13,2 mg DW/m^3
River (Station 7)	5,9 mg DW/m^3
(DW = dry weight)	

(The locations of the sampling stations are shown in Figure 12.)

While zooplankton biomass is often significantly higher in the upper reaches of estuaries (Grindley, 1981) where species diversity is low and estuarine species predominate, the biomass was greatest at the mouth in the Olifants Estuary during the sampling on 5 December 1970.

4.2.2 Aquatic Invertebrates: Soft Substrates

Some 45 species of aquatic invertebrates have been recorded from the Olifants Estuary (Appendix III). This list is not exhaustive since very little detailed work at the Olifants Estuary has been undertaken since the original survey by Professor J H Day of the University of Cape Town in 1949. *Enteromorpha* and the aquatic macrophytes *Zostera* and *Sarcocornia perennis* provide shelter for the invertebrate fauna. Amongst these are the marine amphipods *Hyale grandicornis, Melita zeylanica, Atylus guttatus* and *Paramoera capensis,* which are not only found in the marine algae at the mouth but also in the *Zostera* and *Enteromorpha* further upstream (Brown, 1969). The razor clam or pencil bait *Solen capensis,* occurs in the soft sand along the north shore of Die Eiland.

The sand prawn *Callianassa kraussi* and the mud prawn *Upogebia africana* both occur in the estuary. *Callianassa* is dominant in the lower sandy reaches whereas *Upogebia* is more common in the upper muddy reaches. The two species are not, however, mutually exclusive and a considerable degree of overlap occurs. Gaigher (1979), whose sampling was restricted to the intertidal zone, recorded *Callianassa* densities of 43-302/m^2 (5 sampling sites) and for *Upogebia,* densities of 248-347/m^2 (2 sampling sites). Both *Callianassa* and *Upogebia* play an active role in working the sediments in which they live and probably make a significant contribution to the estuarine ecosystem. However, the role of *Callianassa* and *Upogebia* in the Olifants Estuary in assisting the oxygenation of the sediments appears to be less than in some east coast estuaries. Brown (1969) states that *Callianassa* burrows in the Olifants Estuary extend down into the black, anaerobic mud which lies only a few centimetres below the surface, whereas in the east coast Kleinemonde Estuary the reduced (anaerobic) layers lie up to a metre below the burrows. Possibly an examination of the sediment particle size would provide an explanation for this difference: better oxygenation would be expected in coarser-grained sediments.

On the large sandflat to the south-west of Die Eiland near the mouth a distinct, thin layer of microalgae including diatoms was noted in association with *Callianassa* burrows. The small gastropod snail *Assiminea globulus* appeared to be feeding on this microalgal film as were Lesser Flamingos *Phoeniconaias minor* (ECRU survey 8-12 August 1983). Day (1981) reports that the population density of *Assiminea* on these sandflats averages 380/m^2.

4.2.3 Aquatic Invertebrates: Hard Substrates

The fauna on the rocks at the mouth is typical of Cape west coast rocky-shores whereas these forms are almost entirely absent from the rocks within the estuary (Brown, 1969). Probably the high turbidity and low salinity associated with the winter floods are the most important factors precluding colonization of the estuarine rocks by marine species.

4.2.4 Fish

Eight marine and one freshwater species of fish have been recorded from the Olifants Estuary (Appendix IV). Of the marine species only the White steenbras *Lithognathus lithognathus* and the southern mullet *Liza richardsoni* are of importance to the fishermen who operate in the estuary. As mentioned above in Section 3.2.4 there are 35 fishermen who are permitted to use nets in the Olifants Estuary of whom 11 have commercial status. Most of the fish are sold locally either fresh or dried as bokkoms (E B du Biel, CDNEC, pers. comm.). The Cape Department of Nature and Environmental Conservation proposes to introduce a closed season for fishing between 1 April and 30 September each year (A du Biel, pers. comm.). Although the Olifants River contains 10 species of freshwater fish of which 8 are endemic (Scott, 1982) only the sawfin or "freshwater snoek" *Barbus serra* appears to tolerate any salinity. Specimens of *B. serra* have been collected below the weir at Lutzville and as far downstream as Olifantsdrif approximately 15 km from the mouth (Day, 1981).

4.2.5 Amphibians and Reptiles

A L de Villiers *(in litt.)* of the Cape Department of Nature and Environmental Conservation has produced a checklist (compiled from Branch, 1983; FitzSimons, 1943; Greig and Burdett, 1976 and Poynton, 1964) of the amphibians and reptiles occurring in the area covered by the 1:50 000 topographic map 3118 CA Papendorp. Five species of frogs and toads, two species of tortoise, 17 species of snakes and 19 species of lizards are considered likely to occur in the area (Appendix V).

4.2.6 Birds

One hundred and twenty-five bird species have been recorded at the Olifants Estuary and in its environs (Appendix VI). The avifauna of the quarter-degree square (1:50 000 topographical Sheet 3118 CA Papendorp) surrounding the estuary reflects the three main habitat components namely, marine, estuarine and the arid surrounding land. The estuary has been identified as one of the ten coastal wetlands of major importance as wader habitats in the south-western Cape (Cooper and Summers, 1976).

The Kelp Gull *Larus dominicanus* feeds on the white mussel *Donax serra* which is abundant along the beaches north and south of the estuary mouth. The Kelp Gull and other marine species such as the Cape Cormorant *Phalacrocorax capensis*, White-breasted Cormorant *P. carbo*, Crowned Cormorant *P. coronatus*, Common Tern *Sterna hirundo*, Arctic Tern *S. paradisaea* and Sandwich Tern *S. sandvicensis* mainly use the estuary as a roost and as a shelter in rough weather. Within the estuary numerous flamingos (see Section 4.2.2 above) and Palaearctic and resident waders (Charadrii) feed extensively on the sand and mud flats exposed at low tide. At high tide these birds move into the *Sarcocornia* marshes adjacent to Viswaters and Papendorp ("Die Dam", Figure 1). During the ECRU survey of 8-12 August 1983 numerous flocks (totalling approximately 2 000 birds) of Curlew Sandpipers *Calidris ferruginea* were encountered along the river between Ebenhaeser and Viswaters.

Since none of the surveys reported in Summers *et al.* (1976) and Underhill and Cooper (1983) (Appendix VII) covered the section of river upstream of Viswaters, it is probable that the value of the Olifants Estuary to waders, particularly Palaearctic migrants, has been greatly underestimated.

Red-knobbed Coot *Fulica cristata* make extensive use of the *Sarcocornia* marshes for forage both in summer and in winter (Underhill and Cooper, 1983, ECRU survey 8-12 August 1983). The White Pelican *Pelecanus onocrotalus,* which breeds on Dassen Island, is a regular visitor to the Olifants Estuary where flocks may be seen fishing in the main channel.

The Olifants Estuary is of considerable ornithological interest and serious consideration should be given to giving the estuary nature reserve status. South Africa is poorly endowed with wetlands, thus every effort should be made to protect wetland habitats. Cooper and Summers (1976) estimated that there has been a 40 per cent decline in wader numbers in the environs of Cape Town in the 20 years up to publication of their paper. This decline has been caused by habitat degradation (dredging and dumping), marina development and general urban encroachment.

4.2.7 Mammals

The species of mammals likely to occur in the environs of the Olifants Estuary are listed in Appendix VIII. Only four species actually have been recorded from the area covered by the 1:50 000 topographical sheet 3118 CA Papendorp and a further nine species from immediately adjacent areas. No systematic mammal survey of the area has been undertaken (P H Lloyd, CDNEC, *in litt.)* and the list could be extended by a further 69 species including 11 Cetaceans (Appendix VIII).

5. SYNTHESIS

The Olifants Estuary is in an almost pristine state and human activity in the area has had little impact on it. In fact the sole activity that has a direct effect is fishing and even this is on a small scale (see Section 4.2.4). At present, activities in the catchment probably have a greater effect on the estuary than those in its immediate environs. The flow pattern of the Olifants River proper has been modified by the Clanwilliam and Bulshoek Dams which have the effect of smoothing most flood peaks except in extremely wet years. Furthermore these dams have reduced the period in which the estuary receives fresh water. There are plans to construct a further dam on the headwaters of the Olifants River which could result in a greater attenuation of flow, that is, even less fresh water will reach the estuary. There has probably been an increase in the sediment load carried by the Doring River. This river drains an arid catchment (see Section 3.1.4) which is used mainly for sheep grazing. Consequently the vegetation cover has been reduced and soil erosion increased. The overall effect of damming the Olifants and overgrazing the Doring catchment has been to increase the amount of sediment reaching the estuary and to decrease the water flow available to scour the estuary. However, there is a strong tidal scour which reduces the tendency for the estuary to silt up.

Proposed developments at the estuary are strongly orientated towards the needs of the Coloured people. Consideration is being given to the development of the Olifants Estuary as a holiday resort for the Coloureds of Namaqualand. The estuary itself is unsuitable for water-based recreation particularly for people with little or no experience of the sea. The shores are muddy and the tidal currents strong (see Section 3.2.4). Any development should therefore be focussed on the sea itself. Currently a number of campers use the dune area to the south west of the saltpan and spend their time on the adjacent beach swimming and fishing. Clearly the beach area should be preferred for any holiday resort development. Amenities could be built on the "platform" and on the low north-facing scarp at the south end of the saltpan. However, a major prerequisite for any development is the provision of an adequate freshwater supply. The small brackish springs at Papendorp are completely inadequate for supplying a major resort development. The Olifants River might provide the necessary water if a surplus, to the present requirements of the riparian farmers and towns along the river, were available. Attention would also have to be given to sewage disposal. Septic tanks may be adequate if the scale of development is very small. However, any large, more permanent, resort would require a proper sewage treatment system. It is imperative that an adequate sewage system is installed from the start as an integral feature of any development rather than as a *post hoc* palliative measure. Discharge of the treated effluent into the estuary would require careful study in order to select a site where the effluent would be rapidly diluted and flushed into the sea thereby avoiding eutrophication and a public health hazard.

Indiscriminate driving, particularly by trail motorcycles, over the dunes and through the saltmarsh areas must be prohibited. A properly surfaced, fenced road should be built between the camping area and the estuary mouth. The road should run between the saltpan and the dunes more or less following the alignment of the existing track. Control of off-road vehicles is essential to prevent destruction of fragile habitats, disturbance of birds and the generally peaceful atmosphere. Except for the peak summer holiday period, the remote peacefulness and the wildlife of the estuary are the main features drawing visitors to the area. In spring, after good winter rains, the wildflowers draw many tourists from the Western Cape and further afield. Consideration should be given to including suitable hotel or holiday bungalow accommodation in any development scheme.

The operation of the existing subsistence saltworks can be allowed to continue as it has little impact on the area. However, should expansion of this activity be considered, a detailed economic feasibility study should be undertaken to establish whether these saltworks could be upgraded from the present subsistence industry. Evaporation ponds built on the saltpan would have little visual impact on the area. Any buildings should be built on the east side of the pan and should be designed to harmonize with the surroundings.

The entire Ebenhaeser/Papendorp area should be placed under a single management authority so that conservation, management and development can be co-ordinated. Only if such a co-ordinated approach is adopted can the long-term quality and viability of the Olifants Estuary and its environs be assured. Grindley and Cooper (1979) proposed that the Olifants Estuary should be proclaimed a reserve with their Category A status, that is, the estuary should be rigidly protected with limited access by permit only. It may, however, be more practical to give consideration to establishing an Olifants Estuary National Park in terms of Schedule 5 of the National Parks Act (Act No. 57 of 1976) or as a Lake Area. Such a National Park could be roughly triangular in shape with its apex at Ebenhaeser and its base running along the coast from Robeiland in the north to Strandfontein in the south. The exact boundaries would have to be determined after a detailed environmental survey. National Park status would provide the area with the expertise to manage both the terrestrial and aquatic components, thus ensuring its continued ecological viability. National Park status would also attract tourists, particularly in the spring flower season, and thus provide sorely needed direct and indirect sources of income for the local population.

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Aerial Photographs

Date	Job	Strip/No.	Scale 1:	Type	Source
1942	11/42	489, 493	30 000	b/w	Trig. survey
1958	409	23-6760	36 000	b/w	Trig. survey
1966	567	C2/1160	50 000	b/w	Trig. survey
11.01.1976	764	10/0506	50 000	b/w	Trig. survey
11.05.1979	326	4/117, 118	10 000	colour	Univ. Natal
01.04.1980	66	348	20 000	b/w	Trig. survey
Feb. 1981	375	439 to 441	10 000	colour	Univ. Natal

7. GLOSSARY OF TERMS USED IN PART II REPORTS

ABIOTIC: non-living (characteristics).

AEOLIAN (deposits): materials transported and laid down on the earth's surface by wind.

ALIEN: plants or animals introduced from one environment to another, where they had not occurred previously.

ALLUVIUM: unconsolidated fragmental material laid down by a river or stream as a cone or fan, in its bed, on its floodplain and in lakes or estuaries, usually comprised of silt, sand or gravel.

ANAEROBIC: lacking or devoid of oxygen.

ANOXIC: the condition of not having enough oxygen.

AQUATIC: growing or living in or upon water.

ARCUATE: curved symmetrically like a bow.

BARCHANOID (dune): crescent-shaped and moving forward continually, the horns of the crescent pointing downwind.

BATHYMETRY: measurement of depth of a water body.

BENTHIC: bottom-living.

BERM: a natural or artificially constructed narrow terrace, shelf or ledge of sediment.

BIMODAL: having two peaks.

BIOGENIC: 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 gastro-intestinal tract.

COMMUNITY: a well defined assemblage of plants and/or animals clearly distinguishable from other such assemblages.

CONGLOMERATE: a rock composed of rounded, waterworn pebbles 'cemented' in a matrix of calcium carbonate, silica or iron oxide.

CUSP: a sand spit or beach ridge usually at right angles to the beach formed by sets of constructive waves.

"D" NET: a small net attached to a "D" shaped frame riding on skids and pulled along the bottom of the estuary, used for sampling animals on or near the bottom.

DETRITUS: organic debris from decomposing plants and animals.

DIATOMS: a class of algae with distinct pigments and siliceous cell walls. They are important components of phytoplankton.

DYNAMIC: relating to ongoing and natural change.

ECOLOGY: the study of the structure and functions of ecosystems, particularly the dynamic co-evolutionary relationships of organisms, communities and habitats.

ECOSYSTEM: an interacting and interdependent natural system of organisms, biotic communities and their habitats.

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^{o}, 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.

References:

DAY, J.H. (ed.)(1981). Estuarine ecology with particular reference to Southern Africa. Cape Town, A.A. Balkema.

SOUTH AFRICAN TIDE TABLES (1980). Retreat C.P. The Hydrographer. South African Navy.

APPENDIX I: Species composition and physical features of the mapping units identified at the Olifants River mouth

	Area (ha)	% of area studied	Cover (%)	Height (m)
Salt marshes	196,79	12,50	100	0,20
Flood plains	284,90	18,10	40	0,70
Dune and dune scrub	88,64	5,63	20	0,80
Karroid scrub	708,04	44,98	30	0,50
Mud and sand banks	55,92	3,56		
Water	164,08	10,43		
Rocks	5,80	0,38		
Extensive human disturbance	69,64	4,42		
Total	1 574,36			

Salt Marshes

Chenolea diffusa (1); *Cotula coronopifolia* (2); *Limonium scabrum* (+); *Sarcocornia natalensis* (2); *S. perennis* (4); *Sporobolus virginicus* (+); *Triglochin striata* (1).

Flood Plains

Lycium horridum (+); *Monochlamys albicans* (+); *Salsola* sp. (2); *Sarcocornia pillansiae* (1).

Dune Scrub

Atriplex bolusii (2); *Conicosa* cf. *pugioniformis* (+); *Crassula umbellata* (+); *Eragrostis cyperoides* (1); *Ferraria* sp. (r); *Grielium humifusium* (+); *Hypertelis salsoides* (+); *Lebeckia cineria* (+); *Lycium horridum* (1); *Mesembryanthemum crystichum* (+); *Nylandtia spinosa* (1) (+); *Pelargonium carnosum* (r); *Polygonum maritimum* (1); *Ruschia crassuloides* (+); *R. namaquana* (+); *Salsola* sp. (1); *Tetragonia decumbens* (+); *Zaluzianskya villosa* (+); *Zygophyllum morgsana* (+).

Karroid Scrub

Aloe sp. (+); *Aridaria* sp. (+); *Asparagus capensis* var. *capensis* (+); *Berkheya fruticosa* (+); *Blackiella inflata* (1); *Bulbine tuberosa* (+); *Crassula tomentosa* (+); *Didelta carnosa* +); *Dimorphotheca sinuata* (+); *Doreanthus* sp.(+); *Drosanthemum curtophyllum* (1); *D. marinum* (+); *Euphorbia hamata* (+); *E. mauritanica* (+); *Gasteria* sp. (+); *Grielium grandiflorum* (+); *Halolepis nodulosa* (+); *Helichrysum asperum* (r); *Hermannia cuneifolia* (+); *Homeria miniata* (+); *Lampranthus* sp. (+); *Lapeirousia jaquini* (+); *Lycium horridum* (1); *Melephora crassa* (+); *Mesembryanthemum crystichum* (1); *Osteospermum microcarpum* (1); *O. oppositifolium* (+); *O. pinnatum* (+); *Oxalis depressa* (+); *Pentzia suffrucosa* (r); *Psilocaulon* sp. (+); *Pteronia glabrata* (r); *Ruschia bolusiae* (+); *R. nana* (+); *R. tribracta* (+); *Salsola* sp. (+); *Senecio* sp. (1); *Spergularia media* (+); *Sutera campanulata* (1); *Tetragonia fruticosa* (+); *Vanzijlia rostella* (+); *Zaluzianskya villosa* (+).

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

r - 1/few individuals, cover less than 0,1% of area
+ - occasional plants, cover less than 1% of area
1 - abundant, cover 1 - 5% of area
2 - any number, cover 6 - 26% 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.

APPENDIX II: Catalogue of zooplankton species collected from the Olifants Estuary by J.R. Grindley (see section 4.2.1).

Organisms recorded include: COELENTERATA, Hydroid medusae including *Obelia*. NEMATODA, Nematoda indet. POLYCHAETA, Polychaete larvae. CHAETOGNATHA, *Sagitta friderici*. OSTRACODA, Ostracoda indet. COPEPODA, *Calanoides carinatus, Centropages brachiatus*, Cyclopoid, *Diaptomus capensis, Harpacticus gracilis* and other harpacticoids, *Hemicyclops, Oithona similis, Oncaea* sp., *Paracalanus crassirostris, Paracartia africana, Paracartia longipatella*, parasitic copepod, *Porcellidium* sp., *Pseudodiaptomus hessei, Saphirella* sp., *Tortanus capensis*. CIRRIPEDIA, Nauplius and cypris larvae. MYSIDACEA, *Gastrosaccus brevifissura, Mesopodopsis slabberi*. CUMACEA, *Iphinoe truncata*. ISOPODA, *Cirolana hirtipes, Paridotea ungulata*. AMPHIPODA, *Atylus guttatus, Austrochiltonia subtenuis*. DECAPODA, *Hymenosoma orbiculare*, Megalopa larvae, Mysis larvae, Zoea larvae. MOLLUSCA, Gastropod larvae, lamellibranch larvae. INSECTA, Chironomid larvae. PISCES, Fish larvae and lamellibranch larvae. INSECTA, Chironomid larvae. PISCES, Fish larvae and fish eggs.

In addition to this list the shrimp *Palaemon pacificus* was collected by J.R. Grindley in January 1979.

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

APPENDIX III: Catalogue of invertebrate species collected from the Olifants Estuary by J H Day *(in litt.)*.

HYDROZOA, *Obelia dichotoma*. ANTHOZOA, *Bunodactis reynaudi*. CTENOPHORA, *Pleurobrachia* sp. POLYCHAETA, *Boccardia* cf. *ligerica, Capitella capitata, Ceratonereis erythraeënsis, Glycera* sp., *Nephthys* sp. *Perinereis nuntia* v. *vallata, Platynereis dumerilii, Orbinia* sp., *Fabricia* sp. CIRRIPEDIA, *Balanus algicola, Tetraclita serrata*. AMPHIPODA, *Austrochiltonia subtenuis, Ericthonius brasiliensis, Hyale grandicornis, Hyale hirtipalma, Hyperia galba* (pelagic species), *Melita zeylanica, Atylus guttatus, Paramoera capensis, Orchestia rectipalma*. ISOPODA, *Deto echinata, Eurydice longicornis, Exosphaeroma hylecoetes, Exosphaeroma laeviusculum, Ligia dilatata* v. *gracilior*. MYSIDACEA, *Mesopodopsis slabberi*. DECAPOD CRUSTACEA: MACRURA, *Palaemon pacificus*. ANOMURA, *Callianassa kraussii, Upogebia africana*. BRACHYURA, *Cyclograpsus punctatus, Hymenosoma orbiculare, Thaumastoplax spiralis*. MOLLUSCA: PELECYPODA, *Choromytilus meridionalis, Solen capensis*. GASTROPODA, *Assiminea globulus, Helcion dunkeri, Littorina knysnaensis, Nassarius kraussianus, Oxystele variegata, Patella granularis, Thais dubia, Assiminea (Hydrobia) isosceles*.

APPENDIX IV: Fish species collected from the Olifants Estuary. J H Day *(in litt.)*.

FRESHWATER

Common name	Scientific name
Sawfin or "freshwater snoek"	*Barbus serra*

MARINE

Common name	Scientific name
Cape silverside	*Hepsetia breviceps*
West coast sole	*Austroglossus microlepis*
Estuarine round-herring	*Gilchristella aestuarius*
Barehead goby	*Gobius nudiceps*
Southern mullet	*Liza richardsoni*
White steenbras	*Lithognathus lithognathus*
Pipefish	*Syngnathus acus*
Cape gurnard	*Trigla capensis*

Note: Nomenclature follows Smith (1975).

APPENDIX V: Amphibians and Reptiles which are likely to occur in the area covered by the 1:50 000 topographic sheet 3118 CA Papendorp (A L de Villiers *in litt.*).

CLASS AMPHIBIA (Frogs and Toads)

Common name	Scientific name
Common Platanna	*Xenopus laevis*
Namaqua Rain Frog	*Breviceps namaquensis*
Sand Rain Frog	*Breviceps rosei*
Cape Sand Frog	*Tomopterna delalandii*
Cape Rana	*Rana fuscigula*

CLASS REPTILIA

ORDER CHELONIA (Tortoises)

Common name	Scientific name
Angulate Tortoise	*Chersina angulata*
Namaqualand Tent Tortoise	*Psammobates tentorius trimeni*

ORDER SQUAMATA

SUB-ORDER SERPENTES (OPHIDIA) (Snakes)

Common name	Scientific name
Pink Earth Snake	*Typhlops lalandei*
Brown House Snake	*Lamprophis fuliginosus*
Spotted House Snake	*Lamprophis guttatus*

APPENDIX V: (Cont.)

ORDER SQUAMATA

SUB-ORDER SERPENTES (OPHIDIA) (Snakes) (Cont.)

Common name	Scientific name
Mole Snake	*Pseudaspis cana*
Rhombic Skaapsteker	*Psammophylax rhombeatus*
Western Beaked Snake	*Dipsina multimaculata*
Whip Snake	*Psammophis notostictus*
Leighton's Sand Snake	*Psammophis leightoni namibensis*
Cross-marked Sand Snake	*Psammophis crucifer*

Common name	Scientific name
Spotted Dwarf Garter Snake	*Homoroselaps lacteus* (Broadley, 1983)
Southern Shovel-snout	*Prosymna sundevallii sundevallii*
Boomslang	*Dispholidus typus*
Common Egg-eating Snake	*Dasypeltis scabra*
Coral Snake	*Aspidelaps lubricus*
Cape Cobra	*Naja nivea*
Western Black Spitting Cobra	*Naja nigricollis woodi*
Many-horned Adder	*Bitis cornuta cornuta* (Broadley, 1983)

SUB-ORDER LACERTILIA (Lizards)

Common name	Scientific name
Bibron's Gecko	*Pachydactylus bibronii*
Austen's Gecko	*Pachydactylus austeni*
Rough-scaled Gecko	*Pachydactylus rugosus formosus*
Lineated Gecko	*Phyllodactylus lineatus*
Namaqua Dwarf Chameleon	*Bradypodion occidentale*
Rock Agama	*Agama atra*
Cape Spiny Agama	*Agama hispida*
Knox's Ocellated Sand Lizard	*Meroles knoxii*
Ocellated Sand Lizard	*Eremias lineoocellata pulchella*
Striped Namaqua Blindworm	*Acontias lineatus*
Cuvier's Blindworm	*Typlosaurus caecus*
Kasner's Didactyle Sand Skink	*Scelotes kasneri*
Gronovi's Monodactyle Skink	*Scelotes gronovii*
Cape Three-striped Skink	*Mabuya capensis*
Cape Speckled Skink	*Mabuya homalocephala*
Koppie Skink	*Mabuya sulcata*
Common Variegated Skink	*Mabuya variegata*
Karoo Girdled Lizard	*Cordylus polyzonus*
Large-scaled Girdled Lizard	*Cordylus macropholis*
Namaqua Plated Lizard	*Gerrhosaurus typicus*

APPENDIX VI: Checklist of birds recorded in the quarter-degree square 3118 CA Papendorp compiled from Hockey and Underhill, (1983), Underhill and Cooper (1983), Summers *et al* (1976) and ECRU field survey of 8-12 August 1983

Roberts No.	Common name
4	Great Crested Grebe
6	Little Grebe
42	White Pelican
47	White-breasted Cormorant
48	Cape Cormorant
50	Reed Cormorant
51	Crowned Cormorant
52	Darter
54	Grey Heron
55	Black-headed Heron
57	Purple Heron
59	Little Egret
61	Cattle Egret
69	Night Heron
72	Hamerkop
81	Sacred Ibis
85	Spoonbill
86	Greater Flamingo
87	Lesser Flamingo
89	Egyptian Goose
90	South African Shelduck
94	Cape Shoveller
95	Black Duck
96	Yellow-billed Duck
97	Red-billed Teal
123	Rock Kestrel
130	Black-shouldered Kite
167	African Marsh Harrier
192	Crowned Guineafowl
197	Water Rail
208	Purple Gallinule
210	Moorhen
212	Red-knobbed Coot
218	Ludwig's Bustard
225	Black Korhaan
231	Black Oystercatcher
232	Turnstone
233	Ringed Plover
235	White-fronted Sandplover
236	Chestnut-banded Sandplover
237	Kittlitz's Sandplover
238	Three-banded Sandplover
241	Grey Plover
242	Crowned Plover
245	Blacksmith Plover
250	Ethiopian Snipe
251	Curlew Sandpiper
253	Little Stint
254	Knot
255	Sanderling

Roberts No.	Common name
287	Kelp Gull
288	Grey-headed Gull
289	Hartlaub's Gull
290	Caspian Tern
291	Common Tern
294	Arctic Tern
296	Sandwich Tern
298	Swift Tern
299	Little Tern
304	White-winged Black Tern
307	Namaqua Sandgrouse
311	Rock Pigeon
314	Red-eyed Turtle Dove
316	Turtle Dove
317	Laughing Dove
318	Namaqua Dove
385	Little Swift
394	Pied Kingfisher
397	Malachite Kingfisher
418	Hoopoe
461	Karoo Lark
463	Thick-billed Lark
475	Long-billed Lark
488	Red-capped Lark
493	European Swallow
495	White-throated Swallow
502	Greater Striped Swallow
506	Rock Martin
509	African Sand Martin
522	Pied Crow
658	Capped Wheatear
575	Ant-eating Chat
576	Stone Chat
581	Cape Robin
583	Karoo Scrub Robin
604	Cape Reed Warbler
609	African Sedge Warbler
619	Rufous-eared Warbler
622	Bar-throated Apalis
629	Fantail Cisticola
646	Le Vaillant's Cisticola
651	Karoo Prinia
663	Chat Flycatcher
686	Cape Wagtail
707	Fiscal
722	Bokmakierie
733	European Starling
745	Red-winged Starling
746	Pied Starling
751	Malachite Sunbird

APPENDIX VI: (Cont.)

Roberts No.	Common name
256	Ruff
258	Common Sandpiper
259	Green Sandpiper
262	Marsh Sandpiper
263	Greenshank
266	Bar-tailed Godwit
267	Curlew
268	Whimbrel
269	Avocet
270	Stilt
274	Water Dikkop
275	Cape Dikkop
760	Lesser Double-collared Sunbird
784	House Sparrow
786	Cape Sparrow
799	Cape Weaver
803	Masked Weaver
808	Red Bishop
810	Cape Widow
843	Common Waxbill
857	Cape Canary
866	Yellow Canary
873	Cape Bunting
950	Feral Pigeon

APPENDIX VII: Counts of bird at the Olifants Estuary

Roberts No.	Species	Underhill & Cooper 1983 23.01.80	Underhill & Cooper 1983 27.12.80	Summers *et al.* 1976 (Waders only) 03.11.75	Summers *et al.* 1976 (Waders only) 01.12.75
4	Great Crested Grebe	2	-	*	*
6	Little Grebe		10	*	*
42	White Pelican	1	64	*	*
47	White-breasted Cormorant	29	183	*	*
48	Cape Cormorant	86	52	*	*
50	Reed Cormorant	1	-	*	*
54	Grey Heron	17	23	*	*
55	Black-headed Heron	1	-	*	*
57	Purple Heron	-	2	*	*
59	Little Egret	25	33	*	*
61	Cattle Egret	-	7	*	*
69	Night Heron	-	1	*	*
85	African Spoonbill	12	35	*	*
86	Greater Flamingo	109	321	*	*
87	Lesser Flamingo	48	2 728	*	*
89	Egyptian Goose	-	2	*	*
90	South African Shelduck	10	3	*	*
94	Cape Shoveller	5	58	*	*
96	Yellow-billed Duck	-	37	*	*
97	Red-billed Teal	1	3	*	*
98	Cape Teal	5	14	*	*
167	African Marsh Harrier	-	1	*	*
208	Purple Gallinule	-	2	*	*
212	Red-knobbed Coot	65	992	*	*
231	Black Oystercatcher	7	2	-	2
232	Turnstone	16	11	-	35
233	Ringed Plover	180	83	25	48
235	White-fronted Sandplover	47	60	12	47
237	Kittlitz's Sandplover	55	63	3	14
238	Three-banded Sandplover	8	2	0	2
241	Grey Plover	147	330	17	40
245	Blacksmith Plover	-	19	-	-

APPENDIX VII: (Cont.)

Roberts No.	Species	Underhill & Cooper 1983 23.01.80	Underhill & Cooper 1983 27.12.80	Summers *et al.* 1976 (Waders only) 03.11.75	Summers *et al.* 1976 (Waders only) 01.12.75
251	Curlew Sandpiper	1 932	5 362	765	744
253	Little Stint	395	213	22	137
254	Knot	182	161	18	72
255	Sanderling	109	234	96	246
256	Ruff	-	6	-	-
257	Terek Sandpiper	3	4	5	2
258	Common Sandpiper	1	1	0	5
259	Green Sandpiper	7	11	-	-
262	Marsh Sandpiper	-	-	0	3
263	Greenshank	107	183	28	56
266	Bar-tailed Godwit	21	22	2	2
267	Curlew	37	96	0	27
268	Whimbrel	48	66	3	14
269	Avocet	182	487	176	162
270	Black-winged Stilt	6	14	1	1
275	Cape Dikkop	1	-	-	-
287	Kelp Gull	9	64	*	*
288	Grey-headed Gull	1	-	*	*
289	Hartlaub's Gull	139	184	*	*
290	Caspian Tern	-	5	*	*
291/294	Common/Arctic Tern	12 013	3 157	*	*
296	Sandwich Tern	14	28	*	*
298	Swift Tern	23	56	*	*
299	Little Tern	-	3	*	*
304	White-winged Black Tern	23	62	*	*
394	Pied Kingfisher	3	3	*	*
686	Cape Wagtail	36	26	*	*
	Unidentified			825	410
	Total migrants			1 806	1 871
	Total waders			1 998	2 099

APPENDIX VIII: Mammal species which occur or are like to occur in the environs of the Olifants Estuary (P H Lloyd, CDNEC, *in litt.)*

Species recorded as occurring in the area covered by the 1:50 000 topographic sheet 3118 CA Papendorp	Other species recorded from areas adjacent to that covered by the 1:50 000 topographic sheet 3118 CA Papendorp
CHIROPTERA *Tadarida aegyptiaca* RODENTIA *Parotomys brantsii* *Malacothrix typica* PINNEPEDIA *Arctocephalus pusillus*	CHIROPTERA *Rhinolophus capensis* RODENTIA *Otomys unisulcatus* *Mystromys albicaudatus* *Gerbillurus paeba* *Desmodillus auricularis* CARNIVORA *Otocyon megalotis* *Ictonyx striatus* *Cynictis penicillata* *Suricatta suricatta*

Species which may occur in but not yet recorded from the Olifants Estuary area (species with a high probability of occurrence marked with an asterisk)

INSECTIVORA
- *Myosorex varius*
- **Sunus varilla*
- *Crocidura flavescens*
- **Crocidura cyanea*
- **Chrysochloris asiatica*
- RDB *Cryptochloris zyli*
- RDB *Cryptochloris wintoni*
- RDB *Eremitalpa granti*
- *Macroscelides proboscideus*
- *Elephantulus rupestris*
- *Elephantulus edwardi*

CHIROPTERA
- *Miniopterus schreibersii*
- *Eptesicus hottentotus*
- *Eptesicus melckorum*
- *Eptesicus capensis*
- *Myotis tricolor*
- RDB *Myotis lesueuri*
- *Sauromys petrophilus*
- *Tadarida pumila*
- *Nycteris thebaica*
- *Rhinolophus clivosus*

PRIMATES
- *Papio ursinus*

TUBULIDENTATA
- RDB *Orycteropus afer*

HYRACOIDEA
- *Procavia capensis*

ARTIODACTYLA
- *Sylvicapra grimmia*
- *Antidorcas marsupialis*
- **Raphicerus campestris*
- *Raphicerus melanotis*
- *Pelea capreolus*

LAGOMORPHA
- *Lepus saxatilis*
- *Lepus capensis*

APPENDIX VIII: (Cont.)

Species which may occur in but not yet recorded from the Olifants Estuary area (species with a high probability of occurrence marked with an asterisk)

CARNIVORA
**Vulpes chama*
Canis mesomelas
RDB *Mellivora capensis*
Aonyx capensis
Genetta genetta
Herpestes pulverulentus
**Atilax paludinosus*
RDB **Proteles cristatus*
**Felis lybica* (sic)
Felis caracal

CETACEA (records incomplete)
Mesoplodon mirus (?)
Hyperoodon planifrons (?)
Kogia breviceps (?)
Grampus griseus (?)
Globicephala melaena (?)
**Delphinus delphis*
Stenella coerulealba (?)
Tursiops aduncus
Balaenoptera acutorostrata (?)
Balaenoptera edeni (?)
**Eubalaena glacialis australis* (?)

RODENTIA
Otomys irroratus
Otomys saunderseae
Dendromus melanotis
Dendromus mesomelas
RDB *Tatera afra*
Rhabdomys pumilio
RDB *Acomys subspinosus*
Aethomys namaquensis
Mus minutoides
(Mus musculus)
RDB *Praomys verreauxi*
(Rattus rattus)
RDB *Graphiurus ocularis*
**Hystric africaeaustralis*
Bathyergus suillus
Cryptomys hottentotus
Georychus capensis

RDB = Species listed in the South African red data book - small mammals (Meester, 1976)

APPENDIX IX: Guide to available information

ESTUARY / RIVERMOUTH / LAGOON: OLIFANTS (Estuary)

Guide to available information

Group	Topic	Acocks	Africa Pilot	Axelson	Branch	Broadley	Brown	Bulpin	Burman	Coetzee	Cooper and Summers	Coward	Day	Dingle and Hendey	Dingle *et al*	Du Plessis	Du Toit	Duvenage	Eagle and Bartlett
YEAR (DATE OF INFORMATION)		1975	1977	1973	1981	1983	1969	1980	1970	1977–1982	1976	1981	1981	1984	1983	1973	1910	1983	1984
MANAGEMENT	Historical			*				*	*							*			
MANAGEMENT	Conservation/Utilization																		
MANAGEMENT	Management/Planning																		
MANAGEMENT	Legislation																		
MANAGEMENT	Water																		
BIOTIC	Food webs/Ecosystems																		
BIOTIC – Fauna	Mammals																		
BIOTIC – Fauna	Birds										*								
BIOTIC – Fauna	Reptiles				*	*													
BIOTIC – Fauna	Amphibians																		
BIOTIC – Fauna	Fish												*						
BIOTIC – Fauna	Molluscs												*						
BIOTIC – Fauna	Crustaceans						*												
BIOTIC – Fauna	Other aquatic invertebrates						*												
BIOTIC – Fauna	Terrestrial invertebrates																		
BIOTIC – Fauna	Zooplankton																		
BIOTIC – Flora	Terrestrial vegetation	*																	
BIOTIC – Flora	Semi-aquatic vegetation																		
BIOTIC – Flora	Aquatic vegetation												*						
BIOTIC – Flora	Algae												*						
BIOTIC – Flora	Phytoplankton																		
BIOTIC	Microbiology																		
ABIOTIC – Chemistry	Pollution																		
ABIOTIC – Chemistry	Eutrophication																		
ABIOTIC – Chemistry	General Chemistry																		*
ABIOTIC	Salinity																		
ABIOTIC – Physics	Circulation and mixing																		
ABIOTIC – Physics	Hydrology / Flood regime																		
ABIOTIC – Physics	Oceanography		*							*									
ABIOTIC – Physics	Climate																		
ABIOTIC – Geology	Sedimentology													*	*				
ABIOTIC – Geology	Palaeoenvironment													*	*		*		
ABIOTIC – Geology	Geology											*		*	*				
ABIOTIC – Physiography	Morphology																	*	
ABIOTIC – Physiography	Dams/Obstructions																		
ABIOTIC – Physiography	Catchment characteristics																		

Sources of information

APPENDIX IX: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: OLIFANTS (Estuary)

Guide to available information	Edgcumbe	FitzSimons	Fromme	Gaigher	Greig and Burdett	Grindley	Grindley and Cooper	Gurney *et al*	Heydorn and Tinley	Hockey and Underhill	Howell and Bourlière	Jubb	Jubb	McLachlan & McMillan	Meester	Midgley and Pitman	Monthly Flow Records	Noble and Hemens
YEAR (DATE OF INFORMATION)	1980	1943	1980	1979	1976	1981	1979	1982	1980	1983	1963	1964	1965	1979	1976	1969	1964	1978
MANAGEMENT																		
Historical																		
Conservation/Utilization							*		*									
Management/Planning							*		*									
Legislation																		
Water																		
BIOTIC																		
Food webs/Ecosystems																		
Fauna: Mammals															*			
Fauna: Birds										*								
Fauna: Reptiles		*			*													
Fauna: Amphibians																		
Fauna: Fish											*	*	*					
Fauna: Molluscs																		
Fauna: Crustaceans				*														
Fauna: Other aquatic invertebrates																		
Fauna: Terrestrial invertebrates																		
Fauna: Zooplankton						*												
Flora: Terrestrial vegetation																		
Flora: Semi-aquatic vegetation																		
Flora: Aquatic vegetation	*																	
Flora: Algae																		
Flora: Phytoplankton																		
Microbiology																		
ABIOTIC																		
Chemistry: Pollution																		
Chemistry: Eutrophication																		
Chemistry: General Chemistry																		
Salinity																		
Physics: Circulation and mixing																		
Physics: Hydrology / Flood regime																*	*	
Physics: Oceanography																		
Physics: Climate																		
Geology: Sedimentology			*					*										
Geology: Palaeoenvironment								*						*				
Geology: Geology								*										
Physiography: Morphology																		
Physiography: Dams/Obstructions																		
Physiography: Catchment characteristics																		*

APPENDIX IX: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: OLIFANTS (Estuary)

Sources of information			Orme	Parkington	Poynton	Schulze	Scott	Smith	South African (National Parks Act)	South African Sailing Directions	Strassberger	Summers *et al*	Swart and Serdyn	Taljaard	Tankard	Tankard and Rogers	Truswell	Underhill and Cooper	Waterhouse	Whitfield *et al*
YEAR (DATE OF INFORMATION)			1975	1976	1964	1965	1982	1975	1976	1979	1969	1976	1984	1949	1975	1978	1977	1983	1932	1983
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																		

APPENDIX IX: (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: OLIFANTS (Estuary)

Guide to available information

Category	Group	Item	Zwamborn	AL de Villiers (*in litt.*)	PH Lloyd (*in litt.*)	PG Reyneke (*in litt.*)	WJ van Ryssen (*in litt.*)	A Dittmer (pers. comm.)	EB du Biel (pers. comm.)	A Geustyn (pers. comm.)	Mr Hahn (pers. comm.)	M O'Callaghan (pers. comm.)
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				*						
YEAR (DATE OF INFORMATION)			1978									

Sources of information

PLATE I:

Viswaters: the access channel through the salt marshes used by small-boat fishermen (ECRU, 84-03-20).

PLATE II:

View north along southern sandspit to the estuary mouth which is bounded by rocks and a low bluff on its northern side (ECRU, 83-08-10).

PLATE III:

Brine concentration ponds at the Papendorp subsistence salt works. Note the pink colouration caused by the presence of halophilic bacteria (ECRU, 84-03-20).

LIST OF REPORTS PUBLISHED BY ECRU TO DATE

Estuaries of the Cape Part I. Synopsis of the Cape Coast. Natural features, dynamics and utilization. A E F Heydorn and K L Tinley. CSIR Research Report 380.

Estuaries of the Cape Part II. Synopses of available information on individual systems. Editors A E F Heydorn and J R Grindley.

Report No.	Estuary Name	CSIR Research Report No.
		400
1	Spoeg	401
2	Buffels	402
3	Groen	403
4	Swartlintjies	404
5	Holgat	405
6	Bitter	406
7	Gamtoos	407
8	Rooiels	408
9	Uilkraals	409
10	Kowie	410
11	Hartenbos	
	(Buffels Wes, Elsies, Sir Lowry's Pass)	411
12	(Steenbras, Buffels Oos)	412
13	Silvermine	413
14	Sand	414
15	Zeekoe	415
16	Eerste	416
17	Lourens	417
18	Bot	418
19	Groot (Wes), Sout	419
20	Groot Brak	420
21	Breë	421
22	Swartvlei	423
24	Onrus	424
25	Heuningnes	425
26	Olifants	426
27	Wildevoëlvlei	427
28	Rietvlei/Diep (in prep.)	428
29	Houtbaai (in prep.)	429
30	Knysna (in prep.)	430
31	Keurbooms/Bitou/Piesang	