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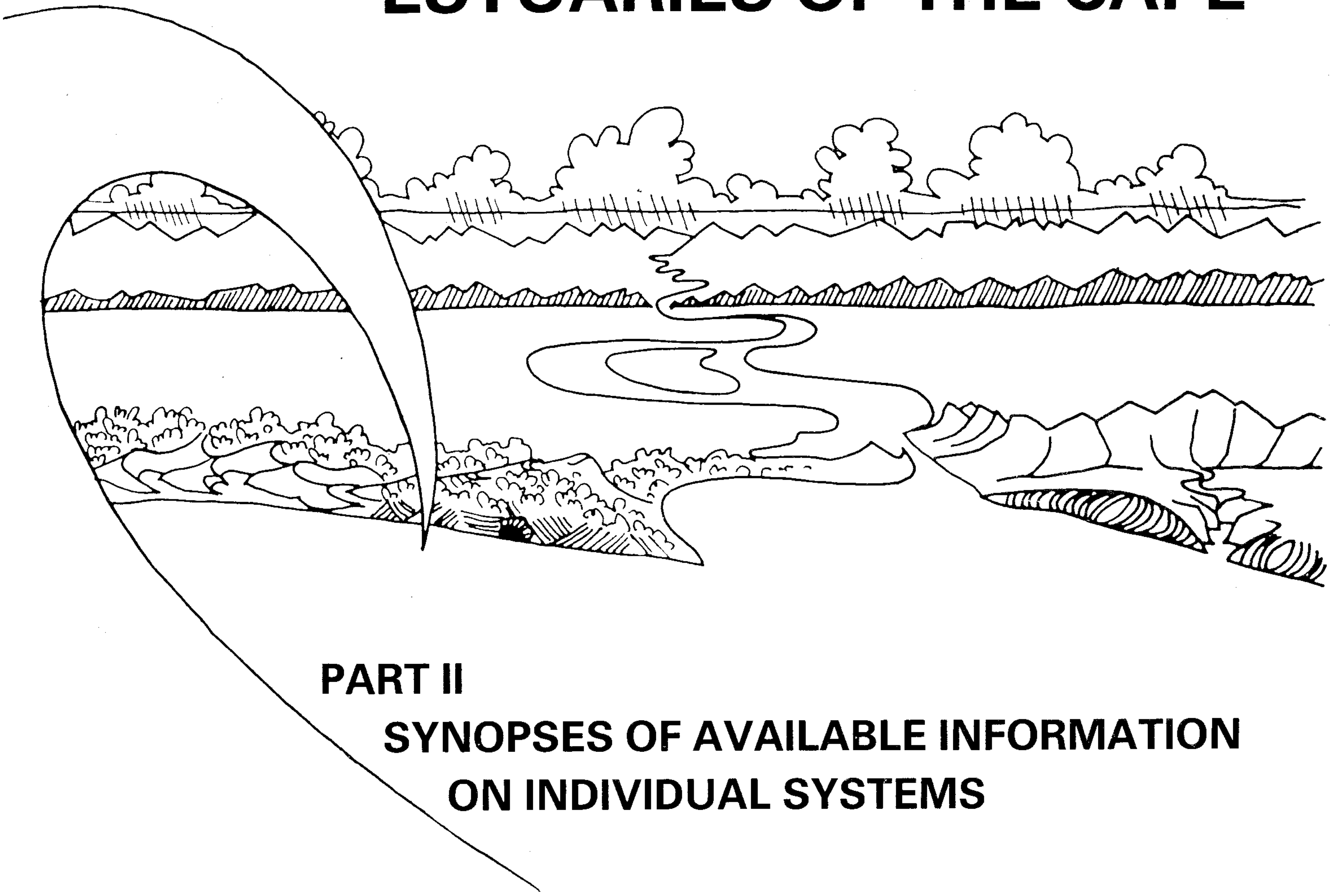
ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 33

KROM (CMS 45), SEEKOEI (CMS 46) AND KABELJOUS (CMS 47)

CSIR RESEARCH REPORT 432

Stellenbosch, South Africa
April 1988

ESTUARIES OF THE CAPE

PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS:
A E F HEYDORN and P D MORANT
Division of Earth, Marine and Atmospheric Science and Technology,
CSIR, Stellenbosch

FRONTISPIECE: KROMME ESTUARY – ALT. 450 m, ECRU 79-10-16

REPORT NO. 33: KROM (CMS 45), SEEKOEI (CMS 46) AND KABELJOUS (CMS 47)

(CMS 45, 46 and 47 – CSIR Estuary Index Numbers)

BY: I B BICKERTON* AND S M PIERCE**

*ESTUARINE AND COASTAL RESEARCH UNIT
**BOTANY DEPARTMENT, UNIVERSITY OF CAPE TOWN

ESTUARINE AND COASTAL RESEARCH UNIT – ECRU
DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY
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PREFACE

The Estuarine and Coastal Research Unit was established by the National Research Institute for Oceanology 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 from the Kei to 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 undertake investigations 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 "Estuaries of the Cape, Part I - Synopsis of the Cape Coast. Natural Features, Dynamics and Utilization" (by Heydorn and Tinley, CSIR Research Report 380). The report 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 "Estuaries of the Cape, Part II". These reports summarize, in language understandable to the layman, all available information on individual estuaries. 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, 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.

On 1 April 1988 the National Research Institute for Oceanology was incorporated into the new Division of Earth, Marine and Atmospheric Science and Technology (DEMAST) of the CSIR. In the process of restructuring, the Estuarine and Coastal Research Unit (ECRU) ceased to exist as an entity. However, the tasks undertaken by the ECRU continue to be performed by the Coastal Processes and Management Advice Programme of DEMAST.

D H SWART
MANAGER, COASTAL PROCESSES AND MANAGEMENT ADVICE PROGRAMME
DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY

CONTENTS

SECTION		PAGE NO.

FIGURES

FIGURES | PAGE NO.

TABLES

APPENDICES

APPENDICES PAGE NO.

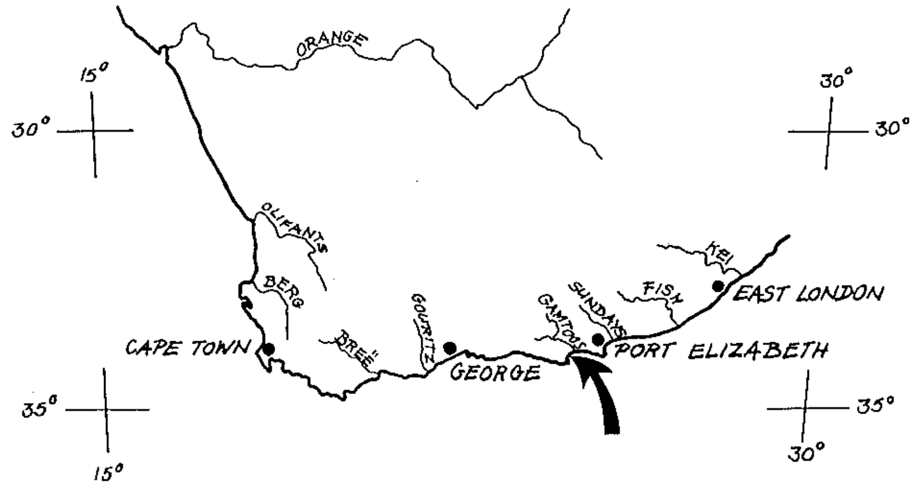
PLATES

KROM, SEEKOEI AND KABELJOUS

1. LOCATION

According to the 1:50 000 Topographical Sheet 3424 BB Humansdorp, the mouths of the Kromme, Seekoei and Kabeljous estuaries have the following approximate co-ordinates:

Kromme	34°08'S; 24°51'E
Seekoei	34°05'S; 24°54'E
Kabeljous	34°00'S; 24°56'E



1.1 Accessibility

The township of St Francis Bay is accessible from Humansdorp via an 18 km tarred road. This road crosses the lower reaches of the Kromme approximately 3 km from the mouth (Figures 1 and 6). The southern side of the mouth of the Kromme is accessible by various roads from St Francis Bay Township to Marina Glades (a marina on the southern bank just upstream of the mouth).

Both the northern and southern banks of the Seekoei Estuary are easily accessible. Access to the southern side is via an 11 km gravel road from the old Humansdorp/Port Elizabeth main road to Paradise Beach holiday township which is situated on the southern bank. The turn-off to this gravel road is approximately 7 km from Humansdorp (1:50 000 Sheet 3424 BB Humansdorp). Access to the northern bank is via a 4 km tar road which runs from Jeffreys Bay Township to the holiday township of Aston Bay situated on the northern bank. A privately constructed causeway across the Seekoei is used by residents of Paradise Beach as a short cut to Aston Bay and Jeffreys Bay.

The old main road between Humansdorp and Port Elizabeth crosses the Kabeljous approximately 2 km upstream of the mouth of the estuary. Access to the southern bank of the estuary is via Kabeljous-on-Sea which is situated just to the north of Jeffreys Bay Township. Kabeljous-on-Sea is accessible via the northern turn-off to Jeffreys Bay from the old main road. It is situated approximately 1 km from the turn-off which is approximately 16 km from Humansdorp.

1.2 State, Provincial and Local Authorities

The estuaries and catchment areas of the Kromme, Seekoei and Kabeljous rivers all lie within the boundaries of the Humansdorp Divisional Council.

St Francis Bay, situated on the southern bank of the Kromme, was established as a Local Area under the Township Ordinances of the Province in December 1976. An active Ratepayers Association works in close co-operation with the Divisional Council. The St Francis/Kromme Trust (which plays an environmental "watchdog" role) was inaugurated in 1981 under the auspices of the St Francis Bay Ratepayer's Association (Articles on the St Francis Bay ..., 1985). The area covered by the Trust encompasses both banks of the Kromme River up to the Elandsjagt Dam, the estuary and the coast westwards through St Francis Bay and Cape St Francis up to and including Thysbaai (Articles on the St Francis Bay ..., 1985).

On the southern bank of the Seekoei Estuary lies Paradise Beach which is a residential/holiday township and is classified as a Local Area. The residential/holiday township of Aston Bay is situated on the northern bank of the Seekoei and falls under the jurisdiction of Jeffreys Bay Municipality. The Seekoei River Nature Reserve, controlled by the CPA Department of Nature and Environmental Conservation, comprises the upper part of the northern bank and a triangle of land at the confluence of the Swart and Seekoei rivers.

Jeffreys Bay Municipality stretches from the northern bank of the Seekoei (Aston Bay) to the southern bank of the Kabeljous (Kabeljous-on-Sea) (CPA Report No. 2, 1973).

2. HISTORICAL BACKGROUND

2.1 Synonyms and Derivations

KROM

KROMME — Originates from the Dutch name on a map prepared in 1752 by Van de Marsch (Articles on the St Francis Bay ..., 1985). This name was also used on a map by surveyor Friderici in 1789 (McDonald, 1985). It is also the name used in various scientific publications (e.g. Hecht, 1973; Baird *et al.* 1981; Melville-Smith 1981; Watling and Watling, 1982a; Hanekom, 1982; The Kromme Estuary, 1984). As the name Kromme is now the most commonly used name and also because it has already been used in previous CSIR reports, it is hereafter used in this report.

CROMME — The name used on a map by surveyor Wentzel in 1776 (McDonald, 1985).

CROME — The name used on a map prepared by surveyor Leisten in 1779 (from journal of Governor Van Plettenberg 1778; in McDonald, 1985).

KROM — The name used on a Royal Navy Hydrographic Office chart dated between 1855 and 1867 and also on orthophoto and topographical maps (1:50 000 Sheet 3424 BB Humansdorp, 1:250 000 Topographical Sheet 3324 Port Elizabeth and 1:10 000 Orthophoto 3424 BB 12). Krom is the name used on the cover and title pages of this report according to the ECRU convention of using the names as given on 1:50 000 topo-cadastral sheets.

SEEKOEI

ZEEKOE — The name as given on early Divisional maps of Humansdorp (Cape Archives M3/2032, 1890; Cape Archives M4/1574, 1921).

SEEKOEI — The name used on orthophotos and topographical maps (1:50 000 Sheet 3424 BB Humansdorp, 1:250 000 Topographical Sheet 3324 Port Elizabeth, 1:10 000 Orthophoto 3424 BB 8 and 1:10 000 Orthophoto 3424 BB 9) and hereafter used in this report.

KABELJOUS

KABELJOU — The name used on a Royal Navy Hydrographic Office map dated between 1855 and 1867.

KABELJOUWS — The name used on the 1:275 000 Humansdorp Topo-cadastral Map of *c*. 1900 (S.A. Library, Cape Town, Reg. Act 1888, 918/751).

KABELJAAW — The name used on a Royal Navy Hydrographic Office Chart dated between 1948 and 1953.

KABELJOUS — The name used on orthophoto and topographical maps (1:50 000 Sheet 3424 BB Humansdorp, 1:250 000 Topographical Sheet 3324 Port Elizabeth and 1:10 000 Orthophoto 3424 BB 4) and hereafter used in this report.

According to Bulpin (1980) the Kromme gets its name from its crooked course. No information on the derivations of the names Seekoei and Kabeljous could be found. However, the former is probably associated with the earlier occurrence of hippopotamuses in the areas and the latter with the kob, *Argyrosomus hololepidotus*. The Afrikaans name for this fish is kabeljou.

2.2 Historical Aspects

In 1575 the Portuguese explorer Manuel Perestrello gave St Francis Bay its name by calling it Baia de San Francisco (McDonald, 1985). It was originally named Golfo dos Pastores by Bartholomeu Dias in 1488 and was also known as Golfo dos Vaqueiros (Raper, 1987).

Jeffreys Bay had its beginning as a trading store in 1849. In the days before the opening of the narrow gauge railway line from Port Elizabeth to Humansdorp, the beach in front of the store was used for landing and off-loading cargo. According to Bulpin (1980) the bay was named after the senior of the two partners in the trading store venture: Messrs J A Jeffrey and Glendinning. Raper (1987) however states that the Jeffreys after whom the bay was named, is variously identified as a trader, a ship-wrecked ship's captain who survived by building a hut from the wreckage and a whaler from St Helena who opened the first commercial house there.

Bulpin (1980) goes on to say that for many years, Cape St Francis was very difficult to reach, its only access being a sandy track through the dunes. A turning point in the history of St Francis Bay was the arrival in 1954 of Mr L B E Hulett and his family.

Mr Hulett was the driving force behind the development of Sea Vista Marina and surrounding township of St Francis Bay on the southern bank of the Kromme. Cape St Francis (as the resort was known in earlier days) gained real fame in 1961 when Canadian film producer and surfing enthusiast Bruce Brown produced his surfing film "Endless Summer" (Bulpin, 1980) much of which was made there. The film lauded Cape St Francis as having the most perfect wave in the world.

St Francis Bay Township was proclaimed in 1965 (Gerryts, 1985). The Township was initially named Cape St Francis, then Sea Vista and since the beginning of January 1979 it has been designated as St Francis Bay (McDonald, 1985).

According to Bulpin (1980), the coasters serving the trade at Jeffreys Bay vanished soon after the narrow gauge railway line from Port Elizabeth to Humansdorp was established, but the beaches there were soon discovered by holidaymakers. Jeffreys Bay became a municipality in January 1968 and is growing rapidly as real estate developers cover the landscape with seaside homes (Bulpin, 1980). In recent times local as well as international surfers have discovered the quality of the waves of St Francis Bay and "Supertubes Point" at Jeffreys Bay is one of the finest surfing areas in the world.

2.3 Archaeology

The following description was extracted from Binneman (1985).

Stone tools of prehistoric man dating back between 200 000 to 1 000 000 years ago can be found at Thysbaai to the west of Seal Point and also in the vast inland dune systems in the vicinity of St Francis Bay and Oyster Bay. During the last 10 000 years the area was inhabited by two distinct cultural groups, the San (Bushmen) and Khoi (Hottentot) peoples as is evident from the many shell middens which occur in the area. Their archaeological remains are represented by big piles of shells found along the coast adjacent to rocky outcrops. These middens were made by the San and Khoi over the last 10 000 years. The Khoi people only inhabited the area from 1 700 years ago.

Most archaeological remains in the St Francis Bay/Santareme Bay areas have been or are soon to be destroyed by increasing development. It should therefore be noted that all archaeological features are protected by law and middens should not be disturbed.

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Catchment Characteristics

KROMME

Area

The catchment area of the Kromme is given as 1 125 km^2 (Heydorn and Tinley, 1980), 1 085 km^2 (Noble and Hemens, 1978; Day, 1981; Pitman *et al.*, 1981 and Jezewski and Roberts, 1986) and 936 km^2 (Reddering and Esterhuysen, 1983).

River length

The total length of the Kromme River, from its origin near Krugerskraal in the Tsitsikamma Mountains to the mouth is approximately 95 km (Reddering and Esterhuysen, 1983). This was also the distance measured on the 1:250 000 Topographical Sheet 3324 Port Elizabeth. Jezewski and Roberts (1986) give the length as 105 km.

Tributaries

There are many unnamed tributaries of the Kromme River as seen from the 1:250 000 Topographical Sheet 3324 Port Elizabeth. The major tributary is the Geelhoutboomrivier which flows into the Kromme approximately 9 km upstream of the mouth. From the upper catchment down to the mouth, the other named tributaries are as follows:

The Dwarsrivier joins the Kromme approximately 8 km downstream of the source of the latter. The Witels joins the Kromme as it flows past Hudsonvale. Downstream of the Churchill Dam, the Dieprivier (which has Die Laagte and the Salieboomlaagte rivers as tributaries) joins the Kromme as does the Leeubosrivier further downstream. Other than the Geelhoutboomrivier, the Kleinrivier (11,6 km upstream of the mouth), the Boskloof (5,2 km upstream of the mouth), the Sandrivier (2 km upstream of the mouth) and the Huisrivier (1 km upstream of the mouth) flow into the Kromme Estuary (see Figure 1).

SEEKOEI

Area

The catchment area of the Seekoei is given as 502 km^2 (Noble and Hemens, 1978), 312 km^2 (Heydorn and Tinley, 1980; Esterhuysen, 1982), 262 km^2 (Hydrological/ Hydraulic Study, 1986b) and 250 km^2 (Jezewski and Roberts, 1986). The last-named figures are probably the most accurate.

River length

The total length of the Seekoei from its source inland of Humansdorp to the mouth is approximately 30 km (Esterhuysen, 1982). A distance of 35 km was measured on the 1:250 000 Topographical Sheet 3424 Port Elizabeth. Jezewski and Roberts (1986) give the length as 36 km.

Tributaries

The main tributary of the Seekoei is the Swartrivier which joins it approximately 1 km upstream of the mouth. A tributary of the Swartrivier is the Rondebosrivier which joins it in its upper catchment. Just upstream of the Aloe Ridge causeway crossing, the Kansta River and Soutvlei drain into the Seekoei River. There are several unnamed water courses indicated on the 1:250 000 Topographical Sheet 3324 Port Elizabeth.

KABELJOUS

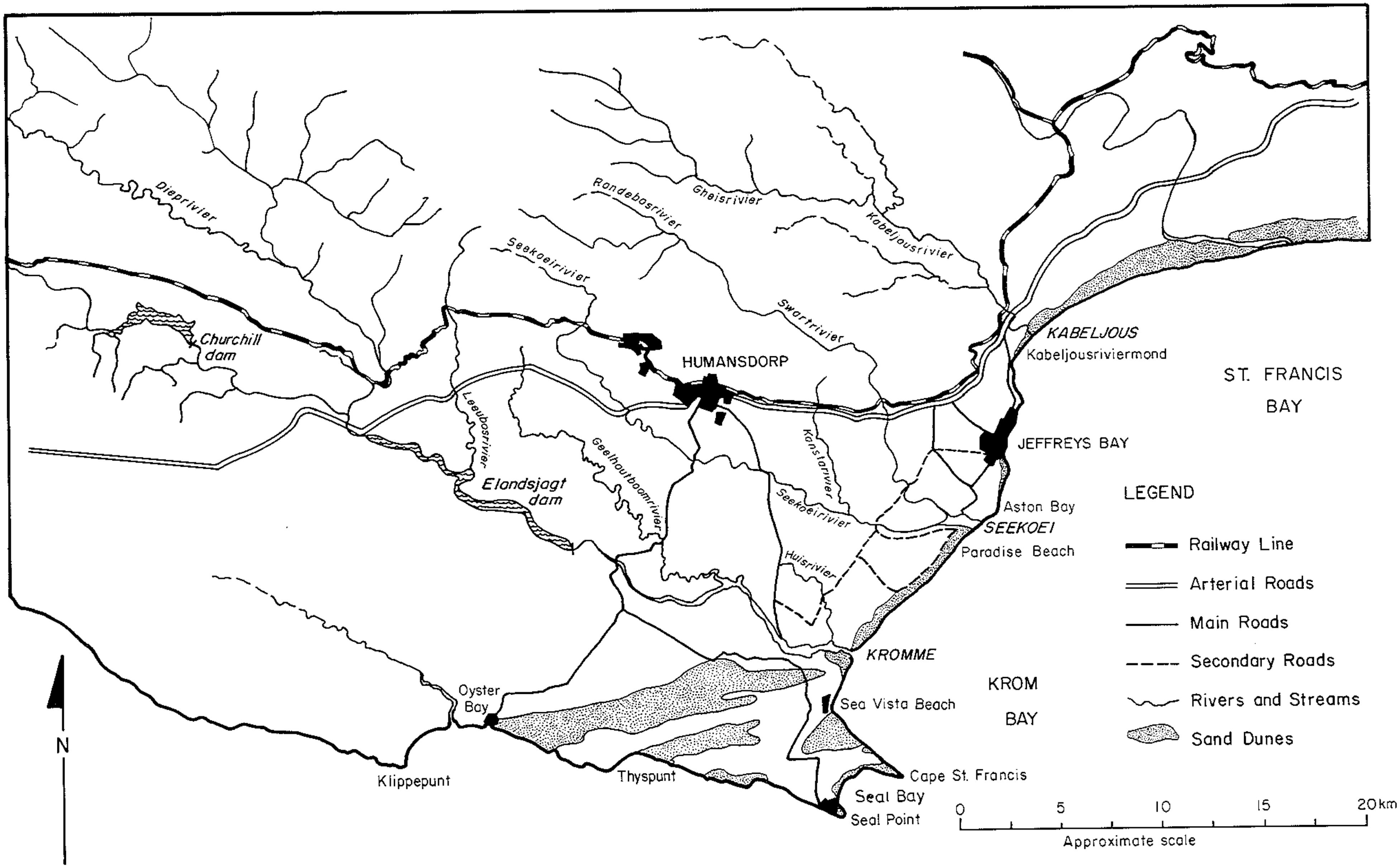
Area

The catchment area of the Kabeljous is given as 502 km^2 (Noble and Hemens, 1978), 312 km^2 (Heydorn and Tinley, 1980), 262 km^2 (Jezewski and Roberts, 1986) and 238 km^2 (Reddering and Esterhuysen, 1984; Hydrological/Hydraulic Study, 1986a). The last-mentioned figures are probably the most accurate.

River length

The total length of the Kabeljous from the origin of its tributary, the Gheisrivier, to the mouth is approximately 30 km as measured on the 1:250 000 Topographical Sheet 3324 Port Elizabeth. Reddering and Esterhuysen (1984) give the river length as 25 km whereas Jezewski and Roberts (1986) give a figure of 33 km.

FIG. I: Map showing Kromme, Seekoei and Kabeljous estuaries, and the lower reaches of their catchments
(Drawn from 1: 250 000 Topographical Sheet 3324)



Tributaries

The main tributary of the Kabeljous is the Gheisrivier (1:250 000 Topographical Sheet 3324 Port Elizabeth). According to the 1:50 000 Sheet 3324 DD Hankey, the Dieprivier runs into the Gheisrivier. There are several unnamed water courses which drain into the Kabeljous and the Gheisrivier (1:250 000 Topographical Sheet 3324 Port Elizabeth).

3.1.2 Geology

KROMME

The Kromme rises in the Table Mountain Group sandstones of the Tsitsikamma Mountains in the Langkloof Valley east of Joubertina (1:1 000 000 Geological Map of SA, Gravity Edition). According to Reddering and Esterhuysen (1983) the upper and middle reaches of the Kromme River are situated on an east/west trending Bokkeveld Group Shale syncline which stretches from 20 km east of Joubertina to near the tidal head of the estuary. Resistant quartzite of the Table Mountain Group forms the adjacent anticlinal ridges.

In its middle reaches the Kromme meanders through the low hilly foreland south of the Kouga Mountains near Humansdorp, consisting of over-lying soft argillaeceous sandstones and shales of the Bokkeveld Group and underlying coarse friable sandstones and quartzites with thick intercalating bands of hard mudstone belonging to the Table Mountain Group as described for the site of the Elandsjagt Dam (South Africa (Republic), Department of Water Affairs, 1977).

Hecht (1973) describes the geology of the Kromme Estuary as follows: On the northern bank quartzites, sandstone and shales of the Bokkeveld Group persist from the head of the estuary to just upstream of the mouth. The sand of the north bank of the mouth of the estuary is classified as drift sand of the late Tertiary.

On the southern bank Bokkeveld Group quartzites sandstones and shales are found from the head of the estuary to its middle reaches. From here alluvium of the late Tertiary extends downstream to approximately 3 km from the mouth. Between this point and the mouth, consolidated sand, also of the late Tertiary is found (Hecht, 1973).

Initially, the valley of the Kromme estuary was incised during the Tertiary into a tectonically uplifting coastal terrace, 40 to 100 m in altitude, which consists of mid-Palaeozoic Bokkeveld shales and sandstones. When the base of erosion was lowered by 100-120 m by glacio-eustatic sea level regressions during the Pleistocene Ice Age (1,5 million to 12 000 years B.P.) the valley became over-deepened, but was subsequently drowned and filled with marine and fluvial sediments when the sea level rose to about MSL + 3 m during the post-glacial hyperthermal (Flandrian Transgression, 12 000 to 4 000 years B.P.). It is these sediments which basically form the present estuary bed and adjacent floodplains. The present configuration of the estuary, its sand banks, the sandspit and the front barrier dune have taken shape during the period of retreat of the sea from its high holocene (Flandrian) to its present level during the past 4 000 years (Fromme and Badenhorst, 1987).

SEEKOEI

According to Esterhuysen (1982) and the 1:1 000 000 Geological Map of SA, Gravity Edition, the upper reaches of both the Seekoei and Swart rivers traverse

Palaeozoic Table Mountain Group quartzite. The lower reaches of both rivers are characterized by Bokkeveld Group shales.

The geological evolution of the Seekoei Estuary is similar to that of the Kromme Estuary, the only difference being that the plateau surrounding the Seekoei Estuary is much lower in altitude (20 to 40 m) than that at the Kromme. Generally, the sediments of the estuary bed and adjacent floodplains were deposited during the Flandrian Transgression (12 000 to 4 000 years B.P.), but the sand banks in the lower section of the estuary must have formed between 4 000 years B.P. and present. According to their appearance and as far as can be discerned from aerial photographs from 1942 to 1987 they must be very young as they show active increase during this period.

KABELJOUS

Reddering and Esterhuysen (1984) give a brief description of the geological structure of the Kabeljous catchment. It consists of an anticline with Table Mountain Group quartzite at the core and Bokkeveld Group slate on the flanks. To the south-east this succession is unconformably overlain by Cretaceous conglomerate and sandstone of the Mesozoic Gamtoos Basin.

3.1.3 Rainfall and Run-off

Rainfall over the catchments of the Kromme, Seekoei and Kabeljous rivers occurs throughout the year with maxima in autumn and spring. The months of lowest rainfall are January and February. The bulk of the three catchments lie between the 500 mm and 1 000 mm isohyets (Heydorn and Tinley, 1980) but the rainfall pattern varies both seasonally and annually giving rise to erratic run-off regimes. This is borne out by the high variation in the monthly run-off figures given by Hydrological/Hydraulic Study, (1985, 1986a and 1986b). These figures were derived from the simulated monthly run-off data for virgin conditions given by Pitman *et al.* (1981) and reflect the unpredictable nature of flooding in the three systems. In the case of the Kromme the run-off into the estuary has been radically changed by the construction of two major dams.

KROMME

The mean annual precipitation in the Kromme catchment ranges from 700 mm to 1 200 mm (Reddering and Esterhuysen, 1983). Pitman *et al.* (1981) give the mean annual precipitation for the upper catchment of the Kromme as 764 mm and that for the lower catchment as 636 mm.

The mean annual run-off for the Kromme is given as 105 x 10^6 m^3 (Noble and Hemens, 1978; Heydorn and Tinley, 1980), 105,5 x 10^6 m^3 (Reddering and Esterhuysen, 1983) and 123 x 10^6 m^3 (Pitman *et al.*, 1981). However, these figures reflect the run-off from the entire catchment and do not take the effects of the Churchill Dam (completed in 1943) and Elandsjagt Dam (completed in 1982) on the run-off into the estuary into account. Figure 2 shows the variation in mean monthly run-off for the Kromme catchment. The data plotted in Figure 2 were obtained from Hydrological/Hydraulic Study (1985). These data were obtained by adjusting the simulated run-off data for virgin conditions from 1924 to 1980 as given by Pitman *et al.* (1981), to account for the impoundment of run-off by the Churchill Dam from 1943 onwards. The trends in Figure 2 show the autumn and spring peaks and summer and winter lows in rainfall and run-off which are typical of rivers entering the sea in St Francis Bay. The wettest months are normally those of August and September with the driest being January and February. The mean annual run-off as adjusted for the effects of the Churchill Dam

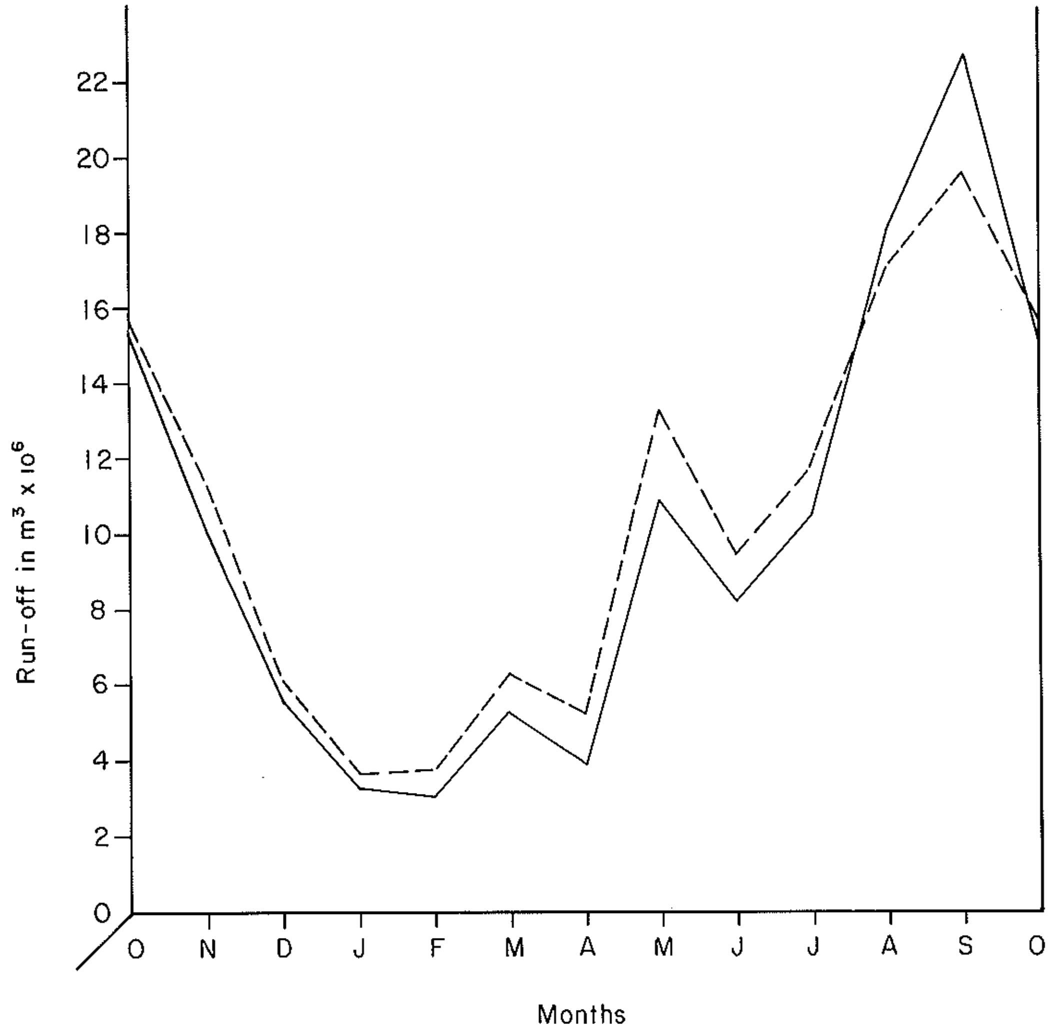


FIG. 2: Mean simulated monthly run-off for the Kromme catchment. The simulated run-off adjusted for the impoundment and release of water by the Churchill Dam (after Hydrological/Hydraulic Study, 1985) is shown by the continuous line. The simulated run-off for virgin conditions (after Pitman *et al.* (1981) is shown by the broken line.

and based on the simulated run-off data given by Pitman *et al.* (1981) for the period 1924 to 1980, is 116,8 x 10^6 m^3 which is approximately 95 percent of the unadjusted figure (122,9 x 10^6 m^3). No data are available to determine the effects of the recently completed Elandsjagt Dam but some water is released downstream.

SEEKOEI

The mean annual precipitation over the Seekoei catchment is given as 570 mm (Esterhuysen, 1982) and 599 mm (Pitman *et al.*, 1981).

The mean annual run-off for the Seekoei is given as 27 x 10^6 m^3 (Noble and Hemens, 1978) and 16,77 x 10^6 m^3 (Hydrological/Hydraulic Study, 1986b). The former figure was quoted by Heydorn and Tinley (1980) and Esterhuysen (1982). The variation in mean monthly run-off calculated from the simulated run-off data given by Pitman *et al.* (1981), shows a trend similar to that for the Kromme (see Figure 2).

KABELJOUS

The mean annual precipitation over the Kabeljous catchment is given as 450 mm (Reddering and Esterhuysen, 1984) and 599 mm (Pitman *et al.*, 1981).

The mean annual run-off for the Kabeljous is given as 27 x 10^6 m^3 (Noble and Hemens, 1978) and 15,23 x 10^6 m^3 (Hydrological/Hydraulic Study, 1986a). The former figure was quoted by Heydorn and Tinley (1980) and Reddering and Esterhuysen (1984). The variation in mean monthly run-off as calculated from the simulated run-off data given by Pitman *et al.* (1981) shows a trend similar to that for the Kromme and Seekoei (see Figure 2).

3.1.4 Land Ownership/Uses

The catchments of the Kromme, Seekoei and Kabeljous rivers consist largely of privately-owned farmland. In the upper parts of the catchments extensive sheep farming is practised whereas closer to the coast natural grazing by cattle and sheep is alternated with wheat. To the south-west of the Kromme Estuary the sandy terrain is used for the grazing of stock (F Weitz, Agricultural Technical Services, pers. comm.).

In the upper catchment of the Kromme, The Churchill Dam has a net assured yield of 26,31 x 10^6 m^3 per year whilst that projected for the Elandsjagt Dam in 1977 was 32,09 x 10^6 m^3 per year (South Africa (Republic) Department of Water Affairs, 1977). Both dams supply water to Port Elizabeth.

3.1.5 Obstructions

KROMME

The major obstructions to the flow of water in the Kromme River are the Churchill and Elandsjagt dams. The Churchill Dam is situated 50 km upstream of the mouth of the Kromme and was completed in 1943 (Hydrological/Hydraulic Study, 1985). It has a capacity of 33,3 x 10^6 m^3 (Noble and Hemens, 1978) and is managed by the Municipality of Port Elizabeth (South Africa (Republic) Department of Water Affairs, 1977).

The Elandsjagt Dam is situated 4 km above the tidal reach of the Kromme (Hydrological/Hydraulic Study, 1985) was completed in 1982 (The Kromme Estuary, 1984) and has a capacity of 100 x 10^6 m^3 (South Africa (Republic) Department of Water Affairs, 1977). At present it supplies 32,1 x 10^6 m^3 per annum to the Port Elizabeth Metropolitan Area (Van Veelen and Stoffberg, 1987). The Elandsjagt Dam is managed by the Directorate of Water Affairs. Approximately 3,5 km downstream of the dam wall a concrete causeway (Hecht, 1973) carrying the secondary road between Humansdorp and Oyster Bay, crosses the Kromme (1:250 000 Topographical Sheet 3324 Port Elizabeth).

Damping of floods by the Churchill and Elandsjagt dams can be expected, especially when the dams are not full at the time of minor floods. However, with bigger floods (e.g. 1 in 30 years and more), the dams will have less effect on the flow of water in the river.

There are also numerous small farm dams situated on tributaries of the Kromme which restrict the flow of water. Other obstructions include several minor road crossings in the catchment. The N2 National Road traverses the head of the Elandsjagt Dam (1:50 000 Sheet 3424 BB Humansdorp).

SEEKOEI

Farm dams have been shown to have a severe effect in catchments with low run-offs, particularly during dry years (Maaren and Moolman, 1986).

Obstructions in the catchment of the Seekoei consist of many small farm dams situated on the various minor tributaries. The Port Elizabeth/Humansdorp narrow-gauge railway line, the old National Road and the new N2 National Road, all cross the Swart and Seekoei rivers in their upper catchments but cannot be considered as significant obstructions to the normal flow of water. The Humansdorp/Oyster Bay and Humansdorp/St Francis Bay roads cross the Seekoei River in its upper catchment. A secondary road crosses the reed-filled Seekoei River via a low-lying bridge at Aloe Ridge approximately 5 km upstream of the mouth of the estuary and also the Swart River approximately 4,5 km upstream of the estuary mouth (1:50 000 3424 BB Humansdorp).

KABELJOUS

There are many small farm dams on minor tributaries of the Kabeljous (1:50 000 sheet 3324 DD Hankey). The Port Elizabeth/Humansdorp narrow-gauge railway-line and the old National Road cross the Kabeljous at the head of the estuary approximately 2 km upstream of the mouth. The new N2 National Road traverses the Kabeljous approximately 500 m further upstream of the old National Road bridge.

3.1.6 Siltation

Rooseboom and Coetzee (1975) categorized the potential fluvial sediment yields for the Kromme, Seekoei and Kabeljous catchments as being 150 tons per year per km^2, which is a relatively low yield and comprises mostly mud from Bokkeveld slates (Fromme and Badenhorst, 1987).

KROMME

According to Reddering and Esterhuysen (1983) the fluvial sediment yield of the Kromme is small and consists mainly of mud weathered from Bokkeveld slates. The sand input is also small because its quartzitic source resists weathering and erosion. Furthermore the Churchill and Elandsjagt dams probably stop most of the fluvial sediment input into the estuary, although some mud and to a lesser extent sand still enters from the Geelhoutboom River.

In the lower reaches of the Kromme, the Sand River constitutes a minor source of sand input into the lower estuary.

SEEKOEI

Fluvial sediment, consisting mainly of fine-grained clay particles, is deposited in the upper regions of the Seekoei (Esterhuysen, 1982). It appears that the construction of the low-lying rubble embankment across the Seekoei is inhibiting the scouring action due to fluvial floods which is important for removal of sediments which accumulate in the estuary.

KABELJOUS

Reddering and Esterhuysen (1984) describe the sedimentation of the Kabeljous Estuary. Two sources contribute land-derived sediment to the estuary. Fluvially derived pebbles and mud enter the tidal head of the estuary. From there this material is distributed into the estuary mainly by fluvial floods. Secondly locally derived storm water containing suspended clay, floats on the saline estuary water and is dispersed over the whole estuary by wind.

3.1.7 Abnormal Flow Patterns

KROMME

The flow in the Kromme River is erratic and floods can occur in almost any month from March to October. This can be seen from flow records for the gauging station K9R01 which is situated at the Churchill Dam (Monthly Flow Records, 1968; River Flow Data, 1978 and Directorate of Water Affairs, unpublished data).

Analysis of the above-mentioned flow records and also the simulated run-off data adjusted for the effects of the Churchill Dam (Hydrological/Hydraulic Study, 1985) shows that major floods occurred at the following times:

March	1928	October	1956
September	1932	June	1968
May	1935	August/September	1971
May	1944	August	1979
October	1953	July	1983

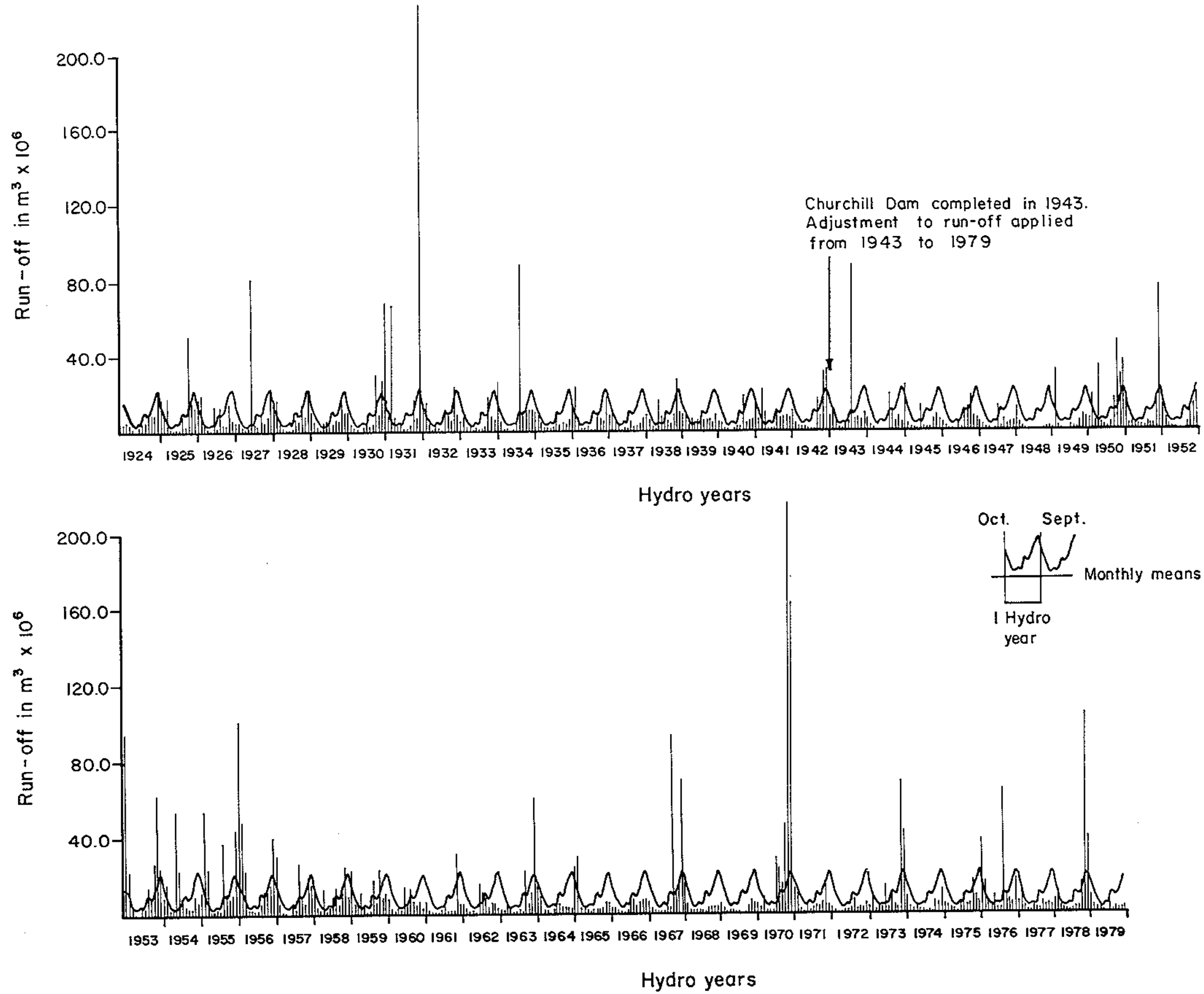
Flood peaks for the above-listed times can also be seen in the plot of the simulated monthly run-off, adjusted for the effects of the Churchill Dam, for the period 1924 to 1980 shown in Figure 3. (Note: The hydro years in Figure 3 commence in October of that year and end in September of the following year, e.g. the hydro year labelled as 1927 begins in October 1927 and ends in September 1928).

The natural run-off in the Kromme River has been changed by the construction of the previously mentioned Churchill and Elandsjagt dams. At present, run-off into the Kromme Estuary depends largely on the amount of water released from the Elandsjagt Dam which is only a few kilometres upstream of the head of tidal reach. At present water is released into the Kromme Estuary according to flow figures prescribed by the Scientific Services Branch of the Directorate of Water Affairs (C P R Roberts, Directorate of Water Affairs, pers. comm.). The release policy is such that more water is released during summer months than winter months. This is to compensate for the increased evaporative loss from the estuary in summer. However, the design of the Elandsjagt Dam precludes the release of artificial floods which could be used to scour sediment from the estuary.

At present, run-off into the estuary also occurs when the Elandsjagt Dam is full and flood waters cause overtopping of the spillway.

Jezewski and Roberts (1986) in a report dealing with the freshwater requirements of South African estuaries, give figures for the Kromme, Seekoei and Kabeljous estuaries. The freshwater requirement of each estuary was derived as the sum of the evaporative requirement and the flooding requirement. The evaporative requirement of the estuary was based on the mean annual net evaporation from the area of the estuary together with its associated wetlands. For the flooding requirement it was assumed that a single annual flooding release from a storage reservoir having similar flow characteristics to the two-year flood, would meet the criteria for flooding of estuarine wetlands and for opening the estuary mouth, as well as flushing out accumulated sediment. The figures given are, however, generalized and are subject to revision following more specific studies of the requirements of the individual estuaries.

<u>FIG. 3:</u> Simulated monthly run-off for the Kromme catchment, adjusted for the effects of the Churchill Dam – 1924 to 1979. The data plotted were obtained by adjusting the simulated run-off data for virgin conditions as given by Pitman *et al.* (1981), for the impoundment and release of water by the Churchill Dam (Figure from Hydrological/Hydraulic Study, 1985)



The total freshwater requirement of the Kromme Estuary has been calculated to be 10,982 x 10^6 m^3 per annum, which is 8,9 percent of the mean annual run-off (Jezewski and Roberts, 1986). Of this total, 2,372 x 10^6 m^3 is for evaporative water loss and 8,610 x 10^6 m^3 for flooding requirements.

SEEKOEI AND KABELJOUS

As there are no gauging stations on either the Seekoei or Kabeljous rivers, no flow records are available. However, simulated run-off data given by Hydrological/Hydraulic Study, (1986a and 1986b) which were derived from Pitman *et al.* (1981) suggest that floods in both the Seekoei and Kabeljous occurred at the same time as those in the Kromme.

Jezewski and Roberts (1986) calculated the freshwater requirements of the Seekoei and Kabeljous estuaries to be as follows:

Seekoei - total requirement of 1,992 x 10^6 m^3 per annum which is 12,7 percent of the mean annual run-off. Of the total requirement 0,892 x 10^6 m^3 is for evaporative water loss and 1,100 x 10^6 m^3 is the flooding requirement.

Kabeljous - total requirement of 1,925 x 10^6 m^3 per annum which is 11,8 percent of the mean annual run-off. Of the total requirement, 0 789 x 10^6 m^3 is for evaporative water loss and 1,140 x 10^6 m^3 is the flooding requirement.

3.2 Estuary

3.2.1 Estuary Dynamics

This section is partly based on a detailed report by the Sediment Dynamics Division of NRIO (Fromme and Badenhorst, 1987).

In order to be able to describe the dynamics of the three estuaries it is necessary to consider some of the physical processes taking place in St Francis Bay.

Wind, waves, littoral currents and sediment transport in St Francis Bay

Fromme and Badenhorst (1987) give VOS (Voluntary Observing Ships) wind recordings compiled from ship-borne anemometer readings. The data are summarized in Table 1 below.

As can be seen from Table 1, the predominant winds blow from the west (24,4 percent), east (14,2 percent) and west-south-west (13,1 percent). Such strong and frequent winds must play a major role in the sediment dynamics of St Francis Bay, especially in the south, where large mobile dune fields are present in the hinterland of Sea Vista Beach and the lower Kromme Estuary.

In evaluating the wave conditions in St Francis Bay two factors are significant:

Firstly, the predominant deep-sea wave direction is south-west (Table 2). Associated with this direction are the greatest wave heights and longest wave periods.

Secondly, the coast of St Francis Bay is protected against direct approach of these waves by Cape St Francis. St Francis Bay is a half-heart bay typical of the Cape south coast: the beaches in the south are the most sheltered, but as the coastline emerges from the shelter towards the more open stretches in the

TABLE 1: Summary of VOS wind recordings made from the offshore area between 34-35°E. The values were reduced by a factor of 0,6 to be representative of coastal winds

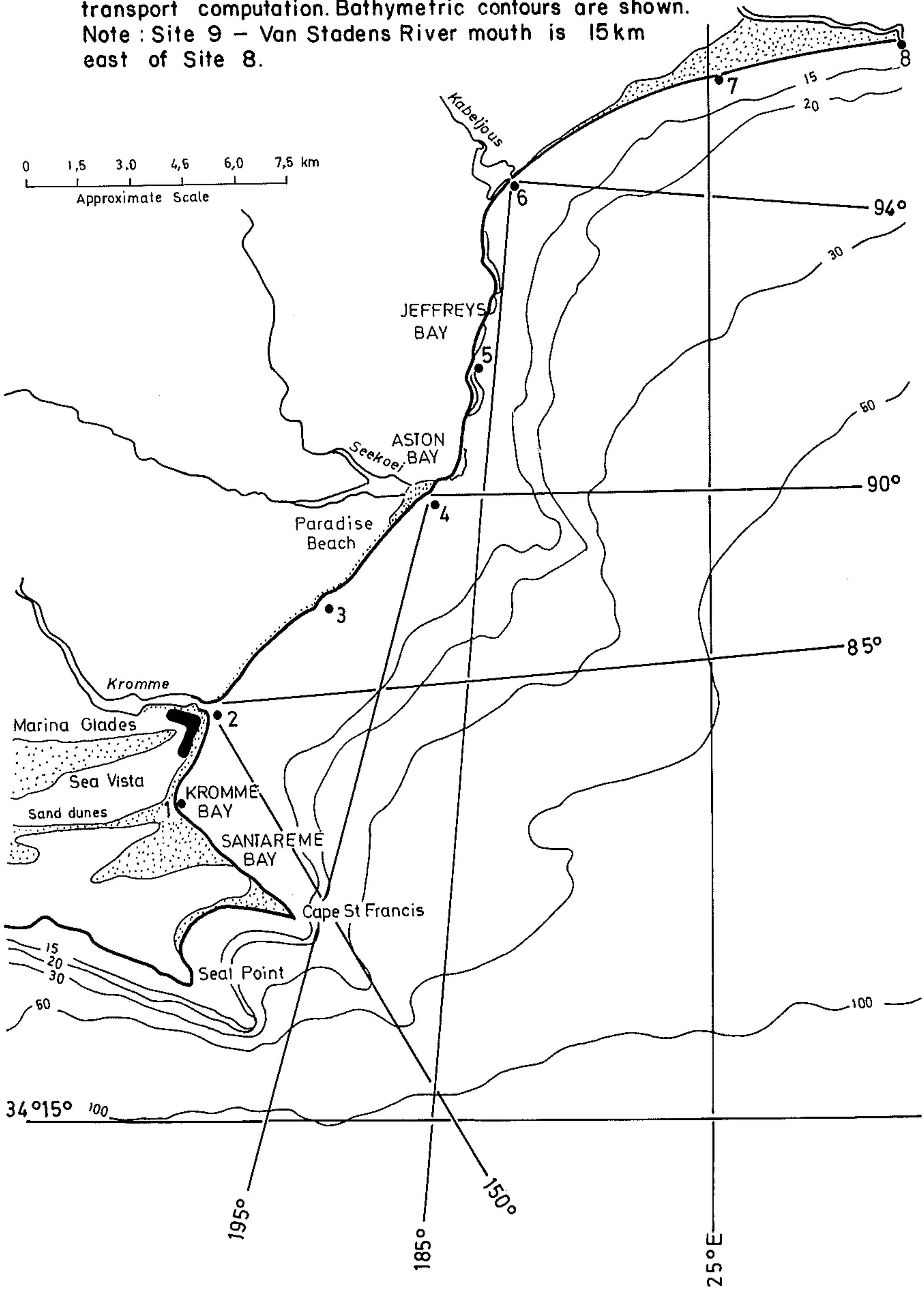
Direction	Percentage occurrence	Speed (m/s)		Direction	Percentage occurrence	Speed (m/s)	
		Average	Maximum			Average	Maximum
N	7,4	3	36	S	3,8	3	18
NNE	1,4	3	15	SSW	3,1	3	36
NE	3,4	6	15	SW	6,4	6	18
ENE	6,5	6	36	WSW	13,1	6	36
E	14,2	6	36	W	24,4	6	36
ESE	3,8	6	15	WNW	4,1	6	18
SE	2,9	3	18	NW	1,8	3	15
SSE	2,4	3	18	NNW	1,1	3	12

TABLE 2: Deep-sea wave conditions - St Francis Bay* 1960-1979 (VOS, Swart and Serdyn, 1981)

Wave directions		Frequency (percent)	Significant wave	
Degrees	General		Height (m)	Period (s)
80- 90-100	E	9,7	2,75	12,7
110-120-130	ESE-SE	6,0	2,55	13,0
140-150-160	SE-SSE	5,0	2,70	13,2
170-180-190	S	9,9	2,90	13,8
200-210-220	SSW-SW	23,5	3,45	13,9
230-240-250	SW-WSW	24,0	3,25	13,7
All possible directions		78,1	mean = 2,9	mean = 13,4
Other directions & calms		21,9		

* Average values of VOS taken from the areas between Lat. 34°-35°S, Long. 25°-26° E and Lat. 34°-35°S, Long. 24°-25°E.

FIG. 4 : St. Francis Bay, wave incidence and sites of longshore transport computation. Bathymetric contours are shown. Note : Site 9 – Van Stadens River mouth is 15 km east of Site 8.



north-east (Seekoei and Kabeljous estuary mouths), the wave energy increases. The reason for this lies in the fact that deep-sea waves from the south and south-west, reach St Francis Bay only after being heavily diffracted and refracted. These processes bend the wave crests around the promontory, dampen wave height and energy and tend to align the crests of the shoaling waves parallel to the coast.

The impact of the predominantly south-westerly waves striking the coast in St Francis Bay at an angle will force the water in the surf zone to move from south to north. However, wave diffraction behind Cape St Francis tends to cause a longshore current from north to south by means of differential wave set-up in the surf zone (that is, incidence of higher wave energy in the outer, less sheltered, than in the inner, more sheltered sections of the bay). The two mechanisms often work against each other, but in most half-heart shaped bays of the South African south coast, the energy of oblique wave incidence overrules the effect of wave set-up.

According to a computation of the longshore current energy spectra by Schoonees (1986) using an analytical computer method, the net longshore transport at nine sites (Figure 4) along the coast of St Francis Bay is with one exception, north-going. Site 3 was found to be the exception with 42 percent of the longshore sand drift north-going and 52 percent south-going.

In addition to the longshore movement, the on/offshore transport of water and sand caused by wave incidence parallel to the shore influences the beaches. In this case losses of beach sand by offshore transport during severe sea conditions are compensated for by onshore transport during calmer conditions. However, these short-term processes can lead to progradation or erosion, depending on the site and its configuration coupled with the long-term longshore transport processes.

Physiographic features and sediment dynamics of the Kromme Estuary and adjacent shoreline

Discharging into the south of St Francis Bay the Kromme River forms a large estuary which is 14 km long and has a highly variable but permanently open tidal inlet, with an average width of 80 m and an average depth of 2,5 m at low water ordinary spring tide. A massive sandspit about half a kilometre long, extends from the south bank and has a tendency to push the mouth channel northwards so that it periodically reaches the sea at the north-side of the mouth.

The tidal area of the Kromme Estuary is about 3 km^2 and the greatest width of the tidal zone is 175 m, that is, inside the mouth, behind the sandspit (Figure 6).

Analysis of the sediment distribution in the Kromme (Reddering and Esterhuysen, 1983) showed a gradation in substrate particle size from medium sand in the lowest 5 km to more angular fluvial sand particles, with smaller grain sizes and a higher organic content, upstream of 5 km from the mouth. The sediment distribution demonstrates the flood tide dominated character of the Kromme Estuary.

The input of sediments of terrestrial origin into the Kromme is minimal. Furthermore, the sediment-retaining effect of the Churchill and Elandsjagt dams prevents the bulk of the sediments carried by the river from entering the estuary.

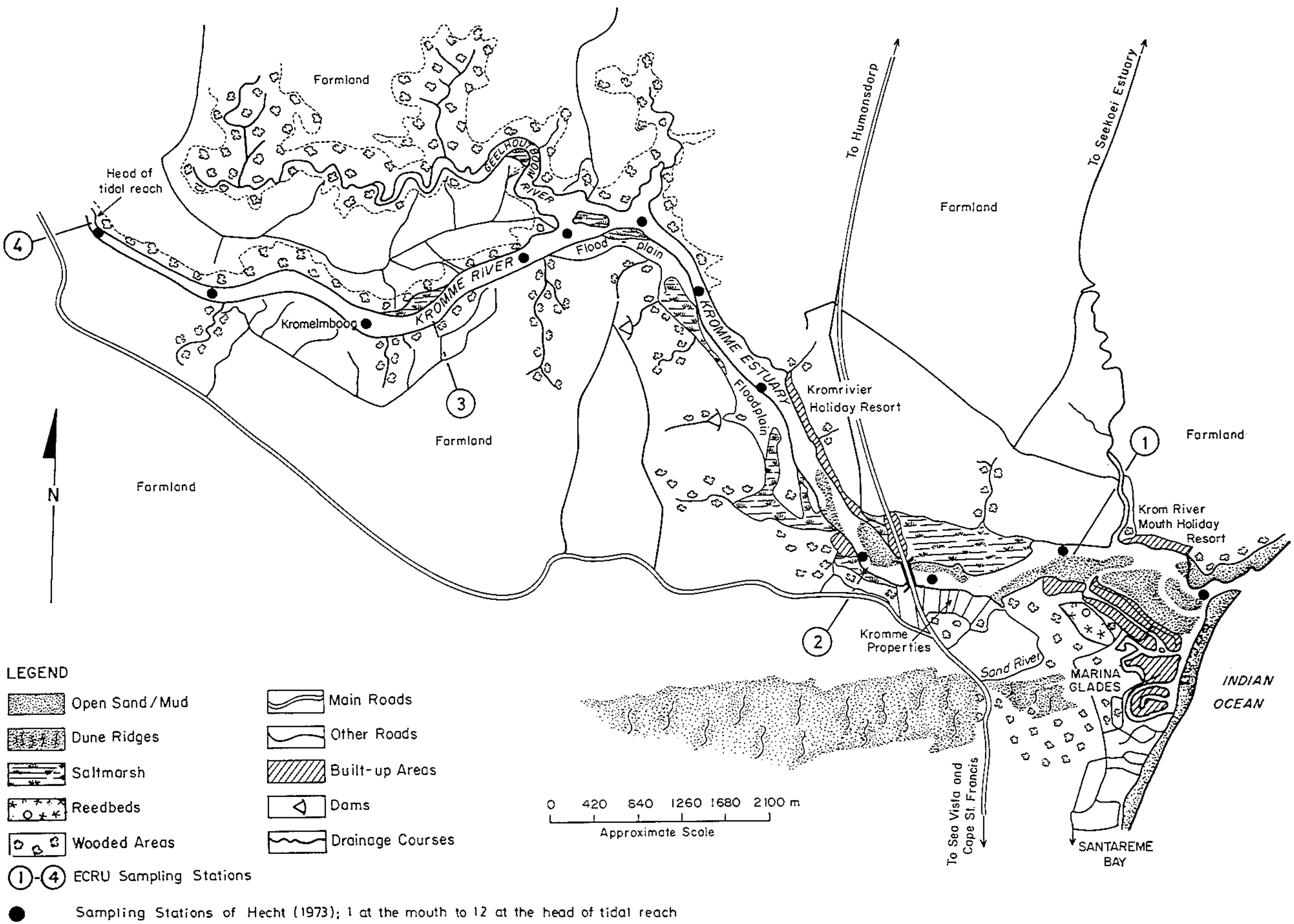
FIG. 5: The Kromme Estuary mouth showing St Francis Bay Township, Marina Glades and Sea Vista beach to the south of the mouth. The massive sandspit on the southern bank can be seen in the centre of the photograph with the Santareme Bay dunes in the left background. (Photo: Fisheries Development Corporation : 81-12-08).

Another possible source of terrestrial sand is the episodically flowing Sand River which enters the Kromme approximately 2 km upstream of the mouth. The Sand River drains the extensive dunefields which lie to the south-west of the mouth of the Kromme. It appears, however, that sand is carried into the Kromme by the Sand River, only during strong flood flows. According to the CSIR Report: The Kromme Estuary (1984), cartographic evidence from 1785, suggests that the ancient Sand River at one time opened directly into St Francis Bay and later into the present marshlands on the south bank of the mouth. In more recent times, however, these original outlets have been blocked by stabilized dunes and the Marina Glades development.

Historical maps and recent cartographic evidence suggest that the mouth of the Kromme Estuary has never been closed. However, moderate sedimentation of the lower reaches of the Kromme is taking place (Reddering and Esterhuysen, 1983). This is caused mainly by the influx of marine sand through the flood tide dominated tidal inlet, while terrestrial sediment yield from the catchment is negligible with the possible exception of the Sand River being a minor sand source. As a result of the reduced freshwater discharge, due to the Churchill and Elandsjagt dams, the marine sedimentation rate can be expected to increase (Reddering and Esterhuysen, 1983).

The implication of the net north-going longshore sediment transport is that sand is eroded in the south and is moved and deposited northwards along the coast. This is indicated by the increase in beach widths and a decrease in beach slopes from the south end of Sea Vista Beach towards the mouth of the Kromme Estuary. Northward of the mouth the situation appears to be reversed, that is, increasing beach widths and decreasing beach slopes from north to south. In earlier times before development took place, sand used to be supplied to the Kromme Bay beaches via the dunefields lying to the west and south-west of Sea Vista.

FIG. 6 : The Kromme Estuary



There have been allegations that Sea Vista Beach is losing sand which cannot be replenished from the drift sand dunefields to the south-west of Sea Vista. The blocking of the aeolian sand supply from these dunes is, however, not only due to the general dune stabilization activities carried out by the Directorate of Forestry. Comparison of aerial photography from 1942 to 1981 shows that about two-thirds of the contact zone between the dunefield and the shoreline (Santareme Bay) has been blocked by the southern section of the Sea Vista development.

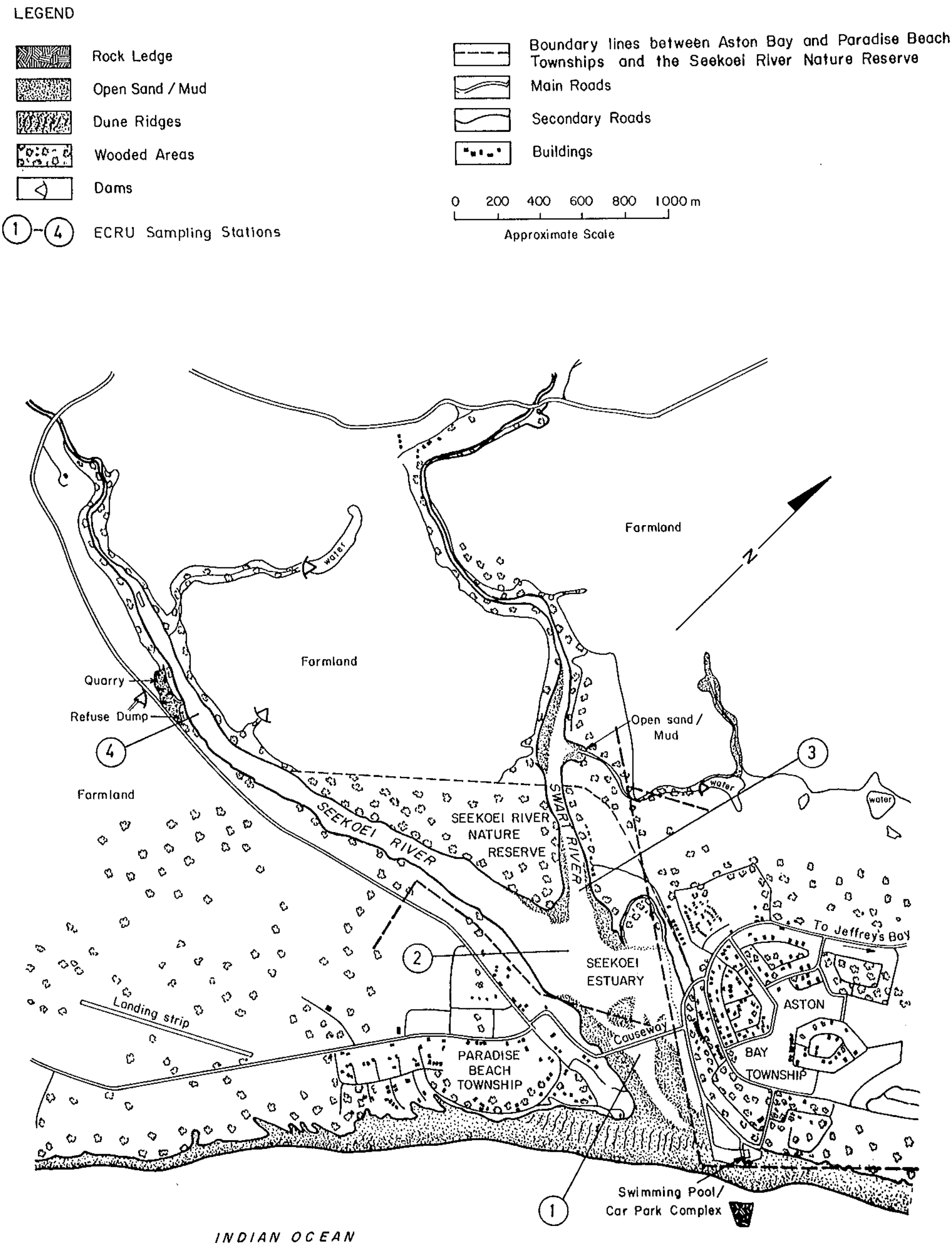
Historical evidence suggests that the sand dunes were still vegetated at the beginning of this century and could therefore only have supplied sand to the beach between 1921 (when the dune vegetation was destroyed) and 1960. It is concluded that Sea Vista Beach must have grown abnormally during that period and is now returning to its pre-1921 condition. The loss of beach was accentuated by beach erosion during an equinoctial storm in September 1978, after which there was very slow beach restoration.

Another possible source of beach replenishment is the Kromme Estuary. However, due to its flood tide dominated character and the fact that 73 percent of the sand at the mouth is moved away to the north by longshore current, the sand supply from this source is considered to be a minor but important one.

FIG. 7: The Kromme Estuary with Cape St Francis and Cape Seal in the background. The driftsand dunefields which extend from Oyster Bay in the west (to the right of the photo) to Sea Vista and Marina Glades (in the centre left of the photo) can be seen clearly. (ECRU: 85-06-17).

In conclusion, it is clear that the net north-going longshore current and sand transport along the Kromme Bay beaches will cause progressive depletion of these beaches because the aeolian sand supply from the dunes to the west of the bay has been cut off by stabilization works and housing developments. This may, however, simply be a return to the original situation before the dunes were depleted of their vegetation cover at the beginning of the century. Because it is sheltered against the predominant south-westerly deep-sea waves by Cape St

FIG. 8 : The Seekoei Estuary (Drawn from aerial photograph No. 221/4 of Job 391, 1981)



Francis, the coast of Kromme Bay is a low-energy coast which retards the erosion process. If it is found necessary to replenish the losses of sand from the beach, the pumping of sand from the dunes in the Sand River could be considered.

To implement this, a sandpump system could be established on the Sand River with a pipeline which could be laid along the slope to exit as near to the corner (between Santereme Bay and Sea Vista Beach) as possible (K L Tinley, *in litt.*). Alternatively the trucking of sand could be considered.

Although the predominant north-going longshore sand drift makes it unlikely that any substantial sand supply to the Kromme Bay beaches from the Kromme Estuary mouth can be expected, this limited source is nevertheless an important one.

The main influx of sediment into the estuary comes from the sea, whereby the constricted but permanently open mouth is instrumental in causing flood-tide domination which is responsible for a net deposition of marine sand as far as 5 km upstream in the estuary.

The Sand River is a secondary source of sediment which may contribute to the sanding-up of the lower estuary. Two kilometres upstream of the mouth, at the southern bank, the Sand River sheds a small delta into the Kromme estuary. From this delta, which is periodically fed by erratic river outbreaks, sand is spread by the tidal currents up- and downstream in the estuary.

Physiographic features and sediment dynamics of the Seekoei Estuary and adjacent shoreline

At the mouth of the Seekoei River a small but recreationally valuable closed estuary or coastal lagoon is impounded behind a massive beach bar which grows from the south bank (Paradise Beach) and joins the north bank at Aston Bay. The estuary consists of two arms, the main arm being formed by the Seekoei River, and a secondary arm formed by the Swart River (Figure 8). The estuary extends to about 3,5 and 2,5 km in both rivers, while their confluence is about 1,4 km upstream of the mouth. The widest section of about 400 m is situated just below this confluence.

The sandbar at the mouth is breached only during rare major floods. The driving force for the build-up of sand and bar movement from south to north is the predominant north-going longshore current and sand transport. A lower section in the bar along the north bank (Aston Bay) forms a connection between the estuary and the sea where overwash occasionally takes place during very high springtides. Effective tidal exchange only takes place when the bar is breached and the channel is scoured well below high-tide level.

Of morphological and hydraulic significance is a rock sill (Figure 9), the landward base of which is usually overlain by beach sand, but which outcrops and forms a small promontory at the northern end of the sandbar causing a wider beach (in this case sandbar) to the south of it, whereas the beach north of the sill is much narrower.

Westerly winds predominate and Fromme and Badenhorst (1987) showed that sand is mainly blown from the estuary towards the sea. However, about 5 000 m^3/year (9 500 m^3/km/year over a stretch of about 500 m) of sand is blown towards the estuary and it can be expected that most of this is trapped in the estuary.

Prior to 1969 the Seekoei Estuary drained over the landward part of the rocky sill where the swimming pool and car-park are now located (Figure 9). The sill inhibited incursion of marine sands and prevented complete drainage of the system during low tide and periods of low river flow. Following the construction of the car-park (1969) and swimming pool (1973) the mouth/drainage channel was forced southwards to an area without a rock sill. Consequently the estuary drained completely during low tide. In an effort to prevent this a causeway was built across the estuary 700 m upstream of the mouth in 1973. The causeway, inadequately designed and crudely constructed, has severely disrupted the natural function of the estuary. It is, however, important to note that as early as 1968, the water level behind the rocky sill was considered too low for the developers of Paradise Beach and a weir was built on the rocky sill in the mouth channel.

The past and present dynamics of the Seekoei Estuary have been described by Wooldridge and Wallace (1977), Rust (1979), Esterhuysen (1982), Fromme and Badenhorst (1987) and Bickerton and Badenhorst (1987). The following summary is based largely on Fromme and Badenhorst (1987):

(1) The outcrop of the rock sill at the northern end of the sandbar at the original mouth position played a pivotal role in the (sediment) dynamics of the system in that:

(a) it prevented further northward migration of the mouth, permitting tidal exchange over the rock sill while limiting the influx of sediment into the estuary so that the mouth remained open for longer periods;

(b) it limited the level to which the water could fall following a breaching of the sandbar, that is, the estuary never drained completely after a flood-induced breaching.

(2) The disruption of the mouth dynamics of the Seekoei Estuary started in 1969 with the construction of the protective embankment and parking area (followed by the swimming pool complex in 1973). The course of the mouth channel was deflected southwards towards the centre of the sandbar where the rocky sill lies deeper under the sand. This resulted in the estuary having a deeper mouth through which it drained almost completely at low tide and through which large amounts of sediment are transported into the estuary during incoming tide. In addition, after a breaching and subsequent reclosure, the reduced height of the bar now permits greater quantitities of sand to be transported into the estuary by overwash than was the case hitherto.

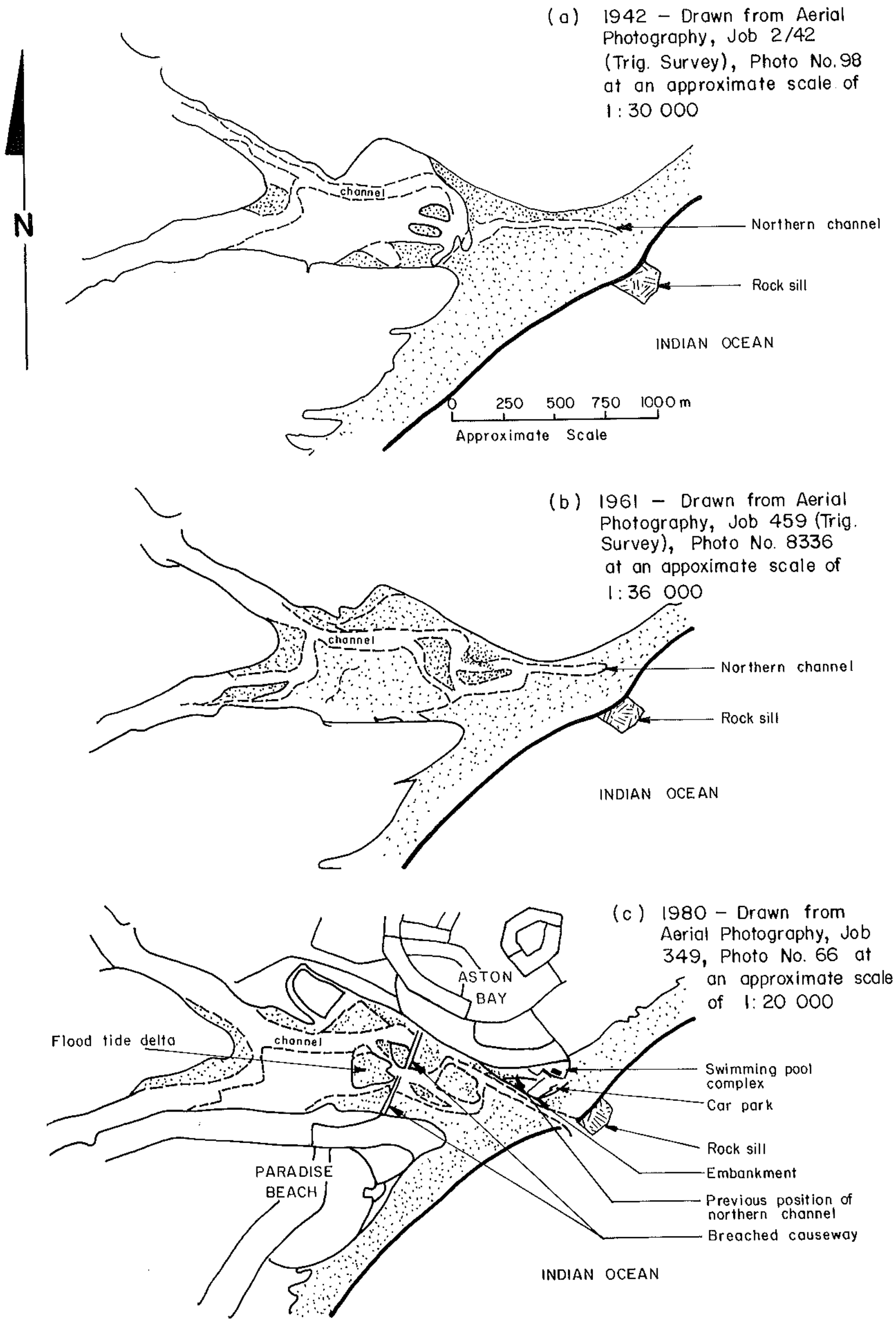
(3) Because the artificial deviation of the mouth caused the estuary to drain, the causeway was constructed some 700 m upstream of the mouth in 1973 (It is notable that, as early as 1968, a crude weir had been constructed on the rock sill as shown by aerial photographs). The aim was to ensure that adequate water levels were maintained in the estuary above the causeway but, as a result of inadequate design, the following problems have arisen:

(a) The openings provided in the causeway are totally inadequate to cope with flood flows, with the result that the water is dammed upstream of it where the silt load, previously flushed out to sea, is deposited.

(b) The damming-up of the water upstream of the causeway retards the flushing effect of the flood flow, with the result that very little sand is flushed from the estuary during floods, thereby contributing to the sedimentation process.

(c) The causeway is damaged during flood flows and the material is spread in the estuary downstream of the causeway.

FIG. 9 : Changes in configuration of the Seekoei Estuary Mouth
(All maps drawn to same scale using a Stereo Zoom Transferscope)



(d) The water level upstream of the causeway is kept at a level of MSL +0,29 m, which means that the mud flats which were naturally exposed from time to time are now "unnaturally" kept under water.

(e) The causeway is too low for safe vehicular traffic when the upper estuary is full. Consequently requests are made for the mouth to be opened whenever the water level is high.

An advantage of the causeway is that it acts as a trap to the increased ingress of marine sand into the estuary from the sea as a result of the artificial southward deviation of the mouth. However, in the aerial photograph taken in 1980 sandbanks consisting of marine sand were already visible upstream of the causeway thereby indicating the serious nature of this problem.

FIG. 10: The Seekoei Estuary showing the townships of Aston Bay to the left and Paradise Beach to the right of the estuary mouth and the Seekoei River Nature Reserve in the foreground. The causeway and marine sediment downstream of it can be seen clearly. (Alt. 400 m, ECRU: 86-01-22).

In the long term, the accumulation of marine sand between the causeway and the sea may cause the build-up of such a massive sandbar that the estuary will be cut off from the sea more effectively than it is at present.

Possible remedial measures

In considering possible remedial measures the following points should be borne in mind:

(1) The area in which the mouth of the Seekoei used to open (in the north-east) and where the swimming pool/car-complex was built, is privately owned and the Seashore Act of 1935 cannot be enforced.

(2) A large part of the lower reaches of the bed of the Seekoei (where the causeway crosses the lagoon) is zoned as "Public Open Space" and falls within the jurisdiction of the local authorities (Jeffreys Bay Municipality and Humansdorp Divisional Council).

(3) Proposals to remove the causeway and build an artificial sill (Rust, 1979) in the existing mouth to try to reinstate the original mouth dynamics are impracticable because of the dynamic nature of the mouth area.

(4) The removal of the existing causeway will probably result in the Seekoei draining completely during low tide after flood flows. Because of artificial changes in the mouth the sedimentation rate has been increased. Furthermore, because the estuary is flood-tide dominated, sediment will quickly move up the estuary.

(5) Previous debates on the issue of the Seekoei causeway have indicated that there is local objection to its removal largely because of its present function as an access route. As local authorities have jurisdiction over the bed of the lagoon in its lower reaches, this is an important consideration.

Hence, taking the above considerations into account, the solution would appear to be to attempt restoring the natural processes by upgrading the Seekoei causeway, thereby improving tidal exchange over the whole area of the estuary. This would require more culverts with a lower sill or even no sill, which would mean that when the mouth is closed the water level would be lower than at present. The upgrading of the causeway would allow flood discharge to flush more sediment from the estuary, thereby creating a larger mouth area which would keep the mouth channel open for longer periods and improve tidal exchange.

FIG. 11: The weir/causeway across the Seekoei Estuary with Paradise Beach Township in the background. The impact of the causeway is clearly evident. (Photo: ECRU: 83-05-16).

The NRIO has suggested that the causeway be raised to the level of the permanent roads on the Aston Bay side, at the same time providing enough culverts to allow floods to pass through unaffected (Bickerton and Badenhorst, 1987). The bottom level of the culverts must be such that a sill is formed to prevent large-scale sedimentation upstream of the causeway while still allowing fairly good tidal exchange when the mouth is open. The culverts should also be placed in the main channel on the Aston Bay side of the estuary and not in the present position. The height of the sill or elevation of the culvert bases can be determined by studying tidal exchange through the existing culverts. It should be of the order of +0,25 m MSL which is the approximate level of the previous naturally occurring rocky sill.

It must, however, be remembered that the main problem that will have to be faced by those responsible for the management of the estuary is the influx of sediment through the open mouth or by washover over the sandbar. The possibility that future floods will not be able to scour the mouth to a size large enough to allow tidal exchange must be kept in mind. To prevent the estuary from thus becoming a freshwater lagoon with negative ecological consequences and, as next step, a marshland, dredging may have to be considered.

These factors could be optimized by means of a hydraulic model study to determine the optimum height of the weir and thus ascertain the desired degree of drainage and tidal exchange.

Physiographic features and sediment dynamics of the Kabeljous Estuary and adjacent shoreline

The Kabeljous Estuary consists usually of a wide shallow coastal lagoon which is on average 0,5 m deep and an upstream converging appendix-shaped channel section 1,7 km in length with water depths of 1,6 to 2,3 m (ECRU Survey, November 1984). At the head of the channel an old causeway marks the tidal limit approximately 2,25 km upstream of the sea. On the north-eastern side of the lagoon a lateral valley about 0,5 km wide, drains towards the Kabeljous via a one kilometre long winding creek.

The 34 ha lagoon is separated from the sea by a massive sandbar which stretches 800 m across the mouth area and is 100 to 200 m wide. This sandbar forms part of the wide sandy beach which runs from Jeffreys Bay in the south to the mouth of the Gamtoos River in the north-east. It blocks river discharge and tidal exchange effectively for most of the year. Being breached alternatively at the south or north bank during floods, the Kabeljous has the characteristics of a lagoon with occasional estuarine phases.

The characteristics of the sandbar (as found during the ECRU survey of 22 November 1984) are that it is very flat (1 to 2^{o} at both sides), apparently accretional and consisting of fine marine sand (sand sizes: 224 micron at the south end, 242 micron at the north end). According to Schoonees (1986), 65 per cent of the longshore sand transport is north-going (Table 3). In addition to the hydraulic supply of sand, the bar is re-inforced by dunelets (0,5 to 1 m high) which are blown in from the south-west. Indicative of the north-eastward sand movement (hydraulic and aeolian) is the accumulation of sand in the north-eastern part of the estuarine basin.

The sediment survey carried out by Reddering and Esterhuysen (1984) shows a sharp demarcation between the areas under marine and fluvial regime of sedimentation. Roughly, the wide estuary basin behind the sandbar is dominated by flat deposits of marine sand, while the appendix-shaped channel upstream of the basin is the domain of fluvial sediment dynamics.

During the open phases of the estuary, which are caused by river outbreaks, marine sand transgresses into the channel during flood tide. This causes deposition of flat sand banks up to 1,5 km from the mouth, which are partially removed when the flow reverses. The hydraulic accumulation is supported by sand

FIG. 12: The Kabeljous Estuary with Kabeljous-on-Sea Township in the foreground. The substantial nature of the sandbar separating the lagoon from the sea can be seen (Alt. 300 m, ECRU: 86-01-22).

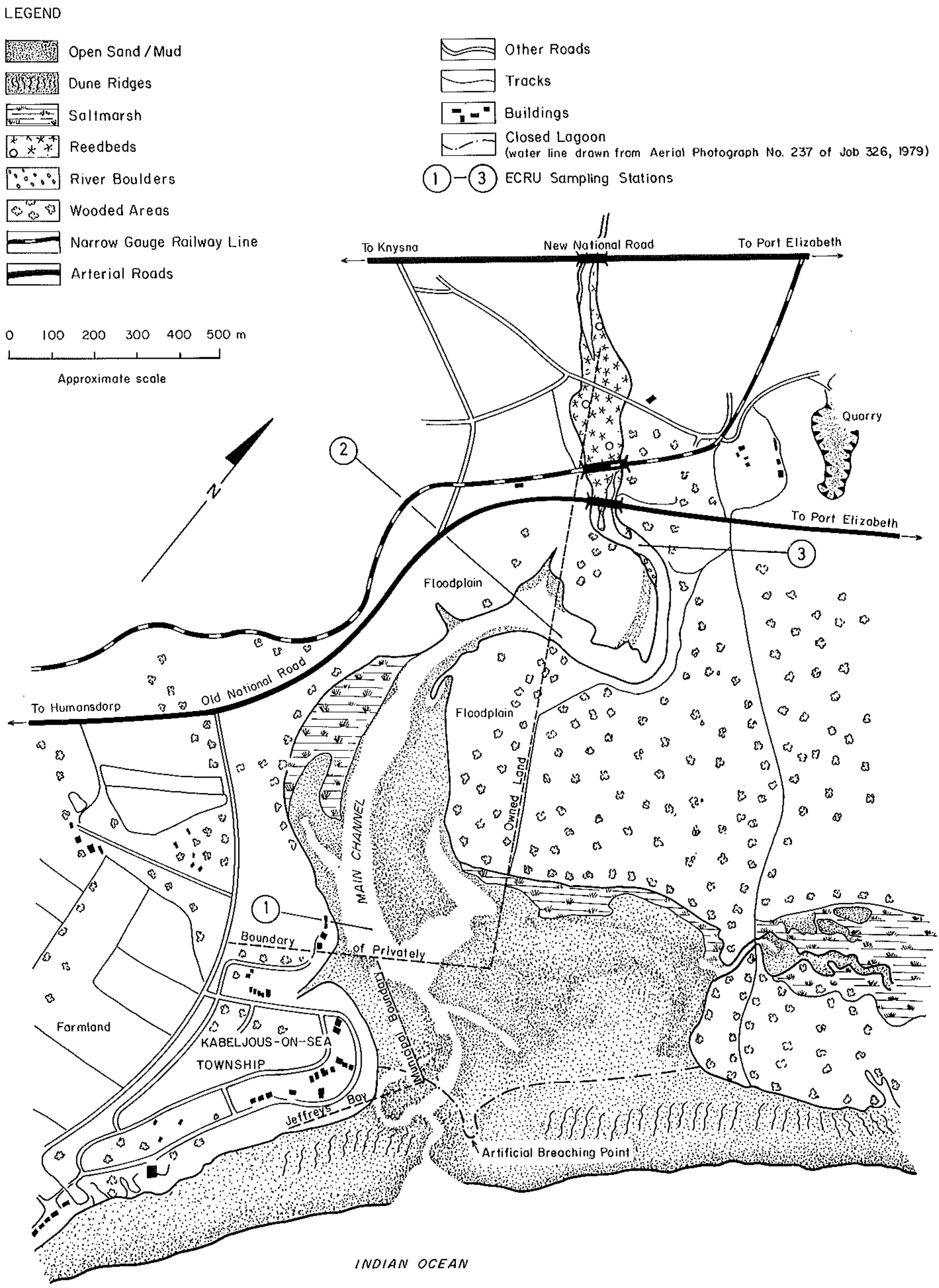
blown into the estuary from the Jeffreys Bay beaches and from the dune field north-east of the Kabeljous estuary by south-westerly and north-easterly winds, respectively. By using a method developed by Swart (1985) the potential aeolian influx of sand into the estuary has been calculated to be about 16 000 m^3 per year from the south-west and about 3 000 m^3 per year from the north-east. The erosion process during ebb-tide takes place along a 2 m-deep furrow which is indicated on the aerial photographs from 1942, 1960, 1961, 1971, 1975, 1979 and 1981.

In contrast to the appendix-shaped channel, the lower estuary basin is heavily sanded-up. Early aerial photographs indicate that this was already the case in 1942. If the photographs from 1942 are compared with recent ones (1979, 1981), only a slight increase of the sand filling this part of the estuary is discernible. It appears that in spite of the obviously continuous ingress of sand from the sea into the estuary basin by wash-over and wind transport across the sandbar, there is sufficient scour to clear excess sediment accumulating in the basin.

Aerial photographs of 1971 and 1975 show that the discharge channel, if open to the sea, meanders from the south-western to the north-eastern extremity of the estuary basin, and it is possible that this, together with some erratic strong floods, constitutes the mechanism by which the basin is regularly swept clear of accumulated sand.

In spite of the periodic scouring there is a slow net build-up of sand in the estuary. The progress of sanding-up of the estuary to date can best be assessed during open phases of the estuary and low-water tides. The aerial photograph of 14 July 1975, taken during low-water springs shows that the estuary consists virtually of only a narrow channel which cuts through a large flat sandy plain. In the fluvial upper section the channel is 60 m wide on average, and relatively

FIG. 13 : The Kabeljous Estuary (Drawn from Aerial Photograph No. 217/4 of Job 391, 1981)



deep, but in the marine lower basin the channel width decreases to 20 m, becoming shallower towards the mouth, where it is nearly choked with sand and where the outflowing water dissipates as a thin sheet-flow over a delta before reaching the sea.

The Kabeljous is similar to the Seekoei in that deep drainage of the estuary during open mouth and low-water spring conditions causes excessive loss of water surface, with large areas of the estuary bed falling dry during low tides.

Reddering and Esterhuysen (1984) ascribe the relatively sound state of the Kabeljous Estuary (in contrast to the Seekoei Estuary) to the fact that the Kabeljous is subjected to less human interference than the Seekoei. Although this applies to the estuary as such, it has to be borne in mind that increasing land-use in the catchment such as housing developments and agriculture, including damming-up of tributary streams, river obstructions by causeways and roads, and extraction of irrigation and domestic water from the river and the lowering of the ground water table will cause deterioration of the estuary through decreasing run-off and increasing siltation due to soil erosion. Stagnant water conditions in the estuary basin, which enhance encroachment by aquatic weeds (green algae), are causing some degradation of the estuary already. Siltation and sanding-up of the estuary can, therefore, be expected in the long term (a few decades).

3.2.2 Land Ownership/Uses

KROMME

On the southern bank of the mouth is the St Francis Bay Local Area. This comprises Marina Glades (the construction of which began in 1960) St Francis Bay and Santareme Bay (Sea Vista Extension 9). The whole area contains 1 300 plots, 500 of which had been built on by 1985 (N D Geldenhuys, Department of Environment Affairs, *in litt.)* and is represented by the St Francis Bay Ratepayers Association. The Humansdorp Divisional Council is responsible for maintenance of the marina canals.

Just upstream of the Kromme mouth on the northern bank are 26 holiday shacks which fall under the auspices of the Kromme River Mouth (Pty) Limited. The maximum number of holiday units at this resort has been limited to 30 (W L Basson, Secretary, Humansdorp Divisional Council, pers. comm.).

Upstream of the roadbridge across the Kromme, several smallholdings on the southern bank, some of which have holiday houses on them, fall under Goedgeloof Properties. There are also 69 holiday houses with 61 boathouses spread along the northern bank of the Kromme upstream of the roadbridge. These are situated on a subdivision of the farm Osbosch owned by Mr R van der Watt and comprise the Kromrivier Holiday Resort. The land on which the holiday houses are built is to be excised from the farm by subdivision and will fall under the ownership of the house-owners association.

The coastal strip from the mouth of the Kromme to the southern end of the Paradise Beach Township to the north, was bought by the Paradise Beach Township Group (Pty). This company was liquidated in 1985 but according to a report in the Sunday Times Business Times (15 November 1987) the Dirk Fourie Trust now plans to develop the area.

Other land around the estuary consists mainly of farmland and small-holdings some of which are used for low-intensity grazing.

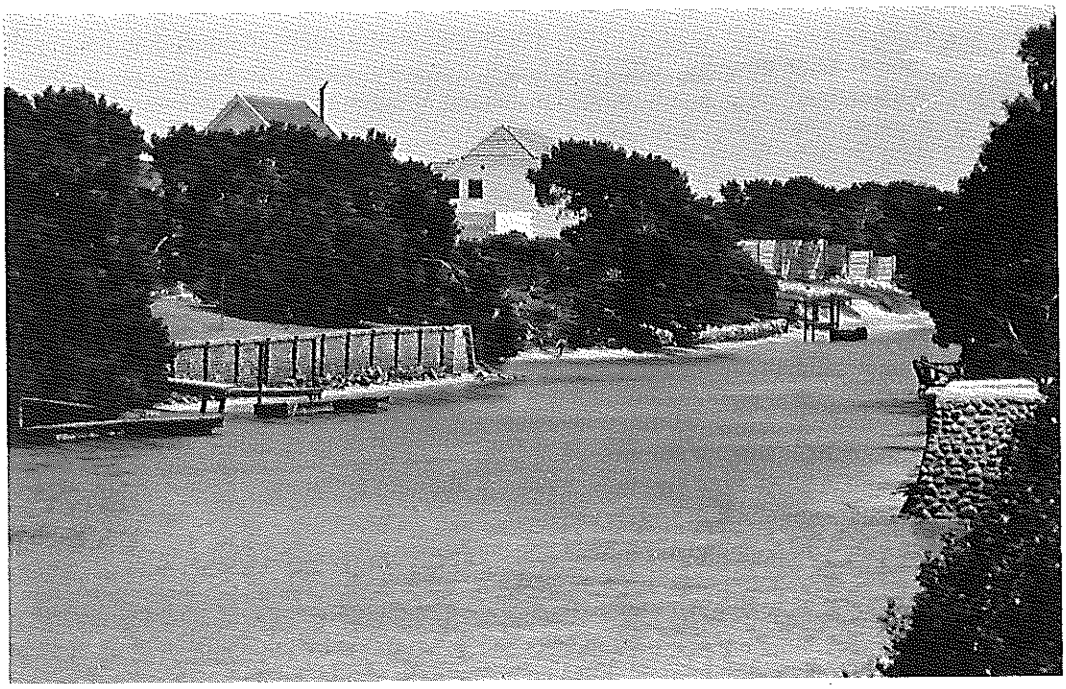


FIG. 14: A typical view of a Marina Glades canal. (ECRU: 84-11-20).

The Kromme and the beach adjacent to Sea Vista Township are heavily used for recreational purposes particularly during peak holiday periods. Ski-boat operators moor their boats in the Marina Glades canals and under most conditions enjoy free access to the sea via the mouth of the estuary. Power-boating, yachting, board-sailing and angling are popular activities in the estuary and are facilitated by the launching amenities at Marina Glades. In view of the demands being placed on the Kromme, and also with a view to restricting future development, the Humansdorp Divisional Council requested the Environmental Evaluation Unit (EEU) of the University of Cape town to carry out a study in order to determine the recreational carrying capacity of the estuary. This study was completed in 1986.

The EEU assessment (University of Cape Town. Environmental Evaluation Unit, 1986) found that the current level of recreational use of the estuary by power-boats and sailing craft does not exceed the carrying capacity. However, in the area adjacent to and just upstream of the marina, incompatible recreational activities (water-skiing, boat fishing and sailing) are all intensively pursued. In this area the recreational carrying capacity is already exceeded. Furthermore, the projected increase in numbers of recreational craft that will use the estuary when more residential sites are developed will lead to congestion on the water surface.

Of the recommendations emanating from the EEU report, the following are of major consideration:

1. New developments in the St Francis/Kromme area which will result in an increase in the number of boats using the estuary must not be permitted unless careful measures are introduced to regulate the numbers and activities of boats using the estuary during peak holiday periods.

2. Water-skiing must be restricted to the water area above the road bridge, upstream of the 69 holiday shacks situated on the northern bank of the river which comprise the Kromrivier Holiday Resort (see Figure 6).

3. No power-boating activities must be permitted on the estuary adjacent to and just upstream of Marina Glades and power-boats must only utilize this stretch of water to gain access to the estuary from the waterways, from one section of the river to another, and must not travel at a speed in excess of 10 km/h in this restricted area.

4. Additional public access to the estuary must be provided for board-sailOrs.

5. The proposed development of facilities for commercial fishing boats should not be permitted.

St Francis Bay, from Cape St Francis to Jeffreys Bay, offers some of the finest surfing in the world and has become a mecca for surfing enthusiasts from many countries. This coastline has received much acclaim in recent years through articles in local and international surfing publications.

SEEKOEI

The residential/holiday townships of Aston Bay and Paradise Beach are situated on the northern and southern banks respectively of the lower reaches of the Seekoei. An unusual feature of the Seekoei is that the estuary and its original mouth area fall within the privately-owned land of the townships of Aston Bay and Paradise Beach and the open water areas are demarcated as public open space (W L Basson, Humansdorp Divisional Council, pers. comm.). Under normal circumstances this area is designated as State Land but in this particular instance it appears as if this land was alienated prior to the promulgation of the Sea Shore Act of 1935 and is therefore exempted from certain provisions of the Act. This allowed the construction of the previously-mentioned swimming pool/car park complex over the previous mouth position and the artificial manipulation of the previous mouth channel such that it now opens to the south. It has also allowed the construction of the causeway which is used for vehicle access between Aston Bay and Paradise Beach.

Upstream of Aston Bay Township on the northern banks and also on the triangular tongue of land between the Swart and Seekoei rivers, is the Seekoei River Nature Reserve which is administered by the Cape Department of Nature and Environmental Conservation. This reserve which also encompasses the water surface was established in 1969 largely because of the prolific bird life on the Seekoei Estuary. Since the construction of the causeway and swimming pool in the lower reaches of the estuary, the numbers of aquatic birds appear to have declined (see Section 4.2.6). The reserve is visited by day-trippers particularly during holiday periods (Cape Provincial Administration, 1970/71 - 1981/82).

Further upstream, the Seekoei and Swart rivers are bordered by privately-owned farmland.

Recreational activities on the Seekoei include boating, board-sailing and angling in the lower reaches (i.e. below the causeway). No boating is allowed in the upper reaches above the causeway (P J Barnard, Cape Department of Nature and Environmental Conservation, pers. comm.).

Just to the north-east of Aston Bay a canal-estate development connected to the sea by a lock waterway system has been proposed. This is a highly ambitious scheme.

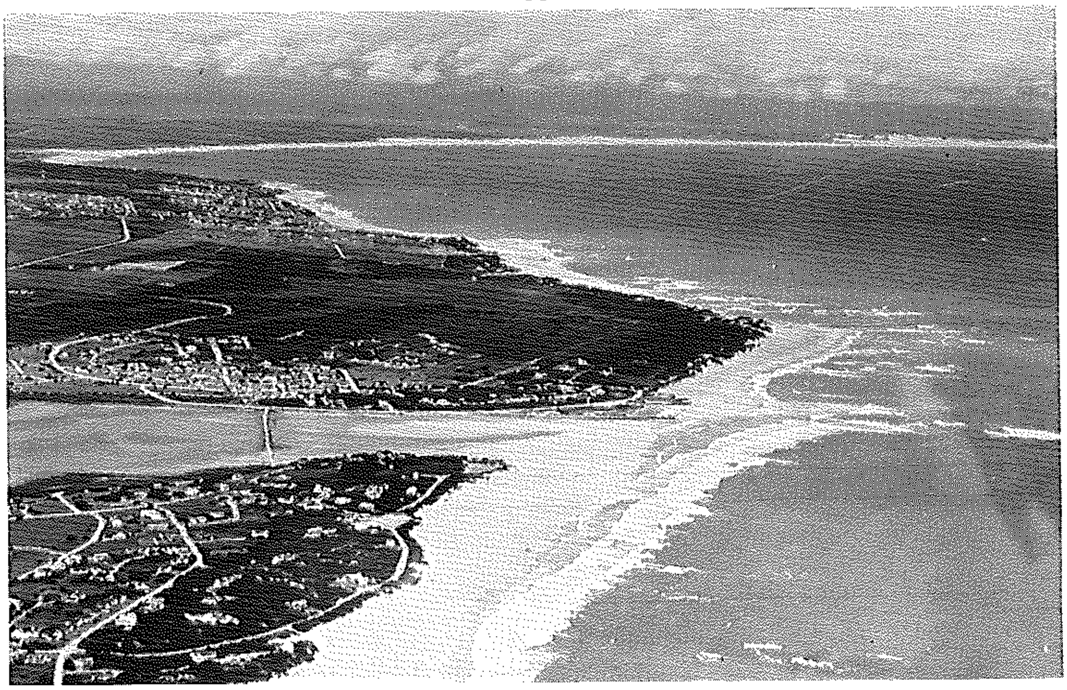


FIG. 15: A view of the Seekoei Estuary mouth showing Paradise Beach in the foreground, Aston Bay in the centre of the photo and Jeffreys Bay to the left of centre in the background. (Fisheries Development Corporation: 81-12-08).

KABELJOUS

On the south-western side of the Kabeljous is the holiday township of Kabeljous-on-Sea which was established in 1963 and falls within the jurisdiction of Jeffreys Bay Municipality (Figure 13). The middle reaches of the Kabeljous and the land on either side of the middle reaches are privately owned by Mr L C du Toit whose house overlooks the southern side of the estuary (W L Basson, Humansdorp Divisional Council, pers. comm.; Reddering and Esterhuysen, 1984). The water and biota in the Kabeljous, however, still fall under the control of the Cape Department of Nature and Environmental Conservation. As is the case with the Seekoei, private ownership of part of the Kabeljous appears to be due to alienation of the land before promulgation of the Sea Shore Act of 1935. The land on either side of the upper reaches of the Kabeljous and that lying to the north-west of the estuary is State Land administered by the Humansdorp Divisional Council. A Coloured recreational development is planned for part of this area (W L Basson, Humansdorp Divisional Council, pers. comm.).

3.2.3 Obstructions

KROMME

At the head of tidal reach in the Kromme is a series of natural rapids which mark the limit of upstream penetration of saline water (Hecht, 1973).

Upstream of the Humansdorp/St Francis Bay roadbridge at the Krom River Holiday Resort, there are numerous jetties which protrude into the estuary in front of the holiday houses.

Approximately 3 km upstream of the mouth the Humansdorp/St Francis Bay roadbridge crosses the Kromme Estuary. From an ecological viewpoint this bridge, which was completed in 1979, is well-designed as it does not obstruct the movement of water during normal non-flood conditions. Furthermore the embankment supporting the northern end of the bridge has three large culverts for the through-flow of flood waters. This should to some extent reduce the damming effect during floods which is normally caused by similar embankments without culverts. Reddering and Esterhuysen (1983) point out that the roadbridge does not interfere with the tidal hydraulics of the estuary.

SEEKOEI

The major obstructions to the flow of water in the Seekoei Estuary are described in Section 3.2.1. They are the swimming pool/car park complex with protective embankment on the northern side of the mouth and the causeway across the estuary about 700 m upstream of the mouth. Much discussion about these disruptions of the normal hydrology of the Seekoei has ensued. This includes reference to the situation as a "ramp toestand" (disaster situation) by the developer who was initially responsible for the disruptions, after part of the causeway had washed away during floods and the beach was strewn with rubble. These obstructions, and possible solutions to the problems they have created are discussed in Section 3.2.1.

KABELJOUS

At the head of the Kabeljous the old National Road and narrow gauge railway line running between Humansdorp and Port Elizabeth traverse the main water course by means of short-span bridges supported by embankments. Approximately 200 m upstream of the railway bridge, a gravel secondary road crosses the reed-choked water course via a causeway constructed of rubble. This was probably constructed to prevent the river upstream from becoming saline as it would then be worthless for livestock watering (Reddering and Esterhuysen, 1984).

During the ECRU survey in November 1984 large amounts of rubble were being dumped into the Kabeljous in front of a house on the southern bank of the lagoon. This was in an attempt to prevent waves from washing onto the garden of the property during very high water levels (L C du Toit, property owner, pers. comm.).

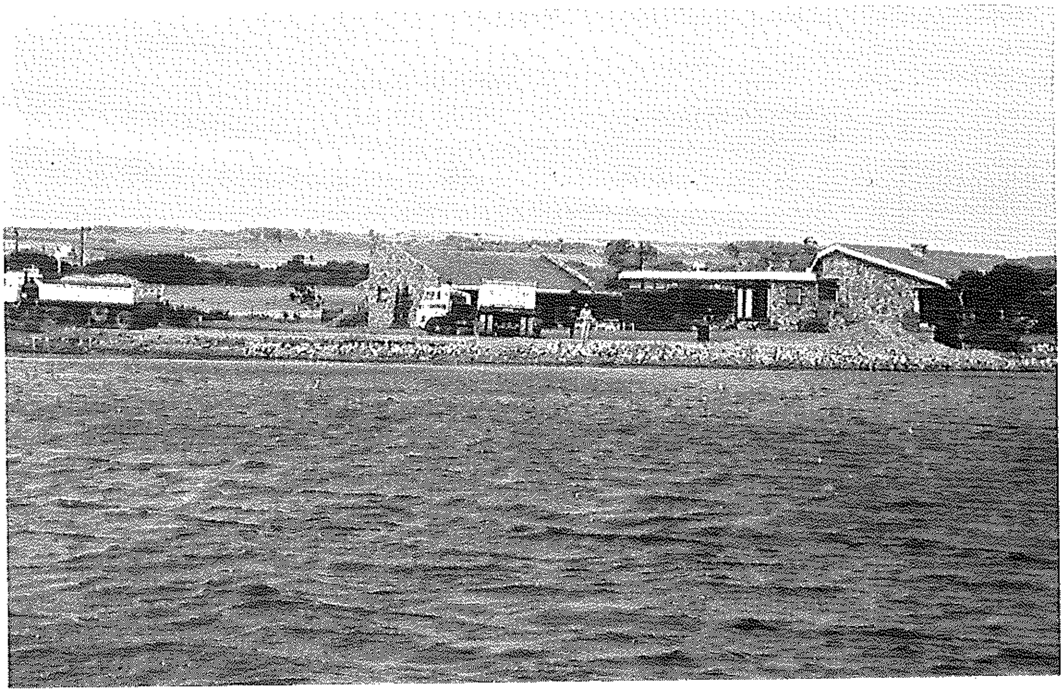


FIG. 16: Rubble being dumped in front of a house on the southern bank of the Kabeljous Estuary in order to prevent flooding during high-water levels. (ECRU: 84-11-23).

3.2.4 Physico-chemical Characteristics

KROMME

Several studies of zoological and ecological aspects of the Kromme have been carried out by the University of Port Elizabeth (Hecht, 1973; Baird *et al.*, 1981; Hanekom, 1982; Marais, 1983; and Marais, 1984). As a result, physico-chemical conditions in the Kromme have been well documented. Of the above references, the most comprehensive set of physico-chemical data are to be found in Hecht (1973). These data were collected from September 1972 to August 1973 during monthly sampling of 12 stations fairly evenly distributed between the mouth of the Kromme and the head of tidal reach. They comprise the bulk of the data presented here and are augmented by physico-chemical data collected during the ECRU survey in November 1984.

pH

Hecht (1973) gives mean surface and bottom pH values for his 12 sampling stations (see Figure 6) between September 1972 and August 1973 (see Table 3). These values were consistent during his study period and reflect the strong marine influence in the Kromme. Slightly lower surface values at the head (Station 12) of the estuary are due to salinity layering which was most noticeable in the month of October when low salinity water was entering the head of the estuary (Hecht, 1973).

Emmerson and Erasmus (1987) in a study of the nutrient status of the Kromme Estuary from June 1979 to September 1981, recorded a mean pH of 8,0 and range of 7,1 to 9,2.

The surface pH data collected during the ECRU Survey in November 1984 had values similar to those obtained by Hecht (1973).

TABLE 3: The mean surface and bottom pH recorded in the Kromme Estuary at 12 stations between September 1972 and August 1973 (from Hecht, 1973)

	Stations											
	1	2	3	4	5	6	7	8	9	10	11	12
Mean Surface pH	8,15	8,20	8,20	8,15	8,0	8,05	8,15	8,0	8,10	8,10	8,0	7,95
Mean Bottom pH	8,20	8,20	8,20	8,20	8,15	8,10	8,15	8,20	8,15	8,20	8,25	8,40

Water temperature

Hecht (1973) recorded surface temperatures in the range 12,0°C in August to 27,8°C in January. The lowest temperature of 10,2°C was recorded in the month of July in the lower reaches of the estuary. Mean annual temperatures were generally higher on the bottom than at the surface in the lower reaches of the estuary, whereas in the upper reaches the mean annual temperatures were slightly higher on the surface than on the bottom. This latter feature was probably associated with salinity layering in the upper reaches of the estuary.

Hanekom (1982) recorded a water temperature range of 11,7-28,0°C in the main channels during an ecological study of the *Zostera* beds of the Kromme from 1979 to 1981. This range is similar to that recorded by Hecht (1973). However, in the shallows where *Zostera* beds occurred, the range was larger being of the order of 10-33°C (Hanekom, 1982).

TABLE 4: Physico-chemical data for the Kromme (mouth open), Seekoei (mouth closed) and Kabeljous (mouth closed) estuaries collected during the ECRU Surveys in November 1984. (See Figures 6, 8 and 13 for sampling station positions).

Station number	System and date	Time	Depth (m)	D.O. (mg/l)		Salinity o/oo		Temperature (oC)						pH	Water transparency
										S (18 hrs)		B			
				S	B	S	B	S	B	Max.	Min.	Max.	Min.	S	(m)
Figure 6	**Kromme**														
Station 1	20.11.84	13h54	1,82	7,91	7,31	35,0	35,0	18,0	18,0	23,0	14,0	19,0	17,0	8,25	1,82
Station 2	20.11.84	13h40	1,50	n.d.	n.d.	35,0	n.d.	18,4	18,4	n.d.	n.d.	n.d.	n.d.	n.d.	1,30
Station 3	20.11.84	13h00	3,50	6,85	6,49	38,0	37,0	21,3	21,3	21,0	20,0	21,0	21,0	8,10	0,52
Station 4	20.11.84	11h45	2,60	6,85	6,72	35,0	38,0	21,8	21,6	23,0	19,0	20,0	20,0	7,85	1,20
Figure 8	**Seekoei**														
Station 1	22.11.84	09h45	1,50	7,68	7,40	27,0	27,0	17,5	17,6	n.d.	n.d.	n.d.	n.d.	8,00	> 1,50 (depth)
Station 2	21.11.84	17h24	0,75	7,49	7,95	26,0	26,0	18,2	18,1	n.d.	n.d.	18,0	18,5	8,00	0,45
Station 3	22.11.84	11h30	1,20	7,40	7,68	27,0	27,0	18,8	17,7	n.d.	n.d.	n.d.	n.d.	8,00	0,70
Station 4	22.11.84	17h03	1,60	7,86	7,86	26,0	26,0	18,5	18,6	20,0	18,0	18,5	18,0	6,75	0,80
Figure 12	**Kabeljous**														
Station 1	22.11.84	16h49	1,70	9,05	9,69	32,0	32,0	20,9	20,8	19,0	19,0	21,5	18,5	8,40	> 1,70 (depth)
Station 2	22.11.84	17,00	2,30	10,51	9,78	30,0	30,0	22,1	21,7	22,0	21,0	23,0	21,0	8,60	2,20
Station 3	22.11.84	17h25	1,60	8,59	8,32	30,0	30,0	22,5	19,7	23,0	21,0	21,0	20,0	8,35	1,60

S = Surface
B = Bottom
n.d. = No data

Emmerson and Erasmus (1987) recorded a temperature range from 11,0°C in winter to 25,2°C in summer with an overall mean of 17,8°C for the estuary.

Water transparency

Hecht (1973) gives mean high water spring tide and mean low water spring tide Secchi disc readings for 12 sampling stations on the Kromme. For high water, the lowest mean (0,80 m) was for the station at the mouth of the Geelhoutboom River whereas the highest means (1,8 m and 2,0 m) were obtained at the two sampling stations in the uppermost reaches of the estuary. For low water the lowest means (0,80 m and 0,90 m) were obtained for sampling stations in the lowest reaches of the estuary and the highest means (2,0 m and 2,4 m) for stations in the uppermost reaches. The data indicate that during high tides, relatively clear sea water enters the lower reaches of the estuary with the middle reaches remaining fairly turbid and the sheltered upper reaches being the least turbid. During low tides the turbid water from the middle reaches moves downstream towards the mouth as might be expected. The uppermost reaches of the estuary, being sheltered from the wind by the steep sides of the river gorge are characterized by clear water during both high and low tides. This probably also reflects the lack of sediment in the run-off into the estuary, as a result of the Churchill Dam.

Secchi disc records for the period from March 1979 to August 1981 (Hanekom, 1982) indicated a range from 0,2 m to 1,9 m which was lower than that obtained by Hecht (1973). These lower readings appeared to be related to increased turbidities due to flooding.

Turbidity data collected at the time of the ECRU Survey during high spring tides (Table 4) suggested a similar trend to that found by Hecht (1973).

Salinity

Table 5 shows the mean surface and bottom salinities for the 12 sampling stations (see Figure 6) sampled by Hecht (1973).

The data reflect the run-off or lack thereof, of fresh water into the upper reaches of the estuary and the increased marine influence during the dry part of the year. During the month of December the onset of the dry period is indicated by fairly uniform salinities (approximately 35 parts per thousand) throughout the estuary. From January to March salinities in the lower reaches of the estuary remained close to that of seawater, whereas in the upper reaches the high summer evaporation rates caused hypersaline (up to 39 parts per thousand) conditions giving rise to a reversed salinity gradient. From April to November run-off from the Churchill Dam and lower Kromme catchment gave rise to a more typically estuarine salinity gradient from the mouth to the head of the estuary. Also, salinity stratification became evident in the upper reaches. Figure 17 (from Hecht, 1972) shows the mean annual salinity profile for the length of the estuary. The maximum and minimum salinities are also shown. These probably reflect the typical summer (dry period) and late winter (wet period) profiles before construction of the Elandsjagt Dam.

Salinity data are probably typical of the conditions in the Kromme from the time of completion of the Churchill Dam to the implementation of the present water release policy for the Elandsjagt Dam. Impoundment of the summer run-off by the Churchill Dam combined with high summer evaporation rates appears to have been the cause of periodic hypersalinity in the upper reaches of the Kromme. The present water release policy for the Elandsjagt Dam is designed to compensate

TABLE 5: The mean surface and bottom salinity values in parts per thousand for 12 stations from the mouth to the head of the Kromme Estuary during the period from September 1972 to August 1973 (from Hecht, 1973).

Month	Salinity	Stations											
		1	2	3	4	5	6	7	8	9	10	11	12
September	Surface	30,9	29,5	29,0	24,0	23,0	21,5	21,2	20,5	20,5	18,6	13,1	2,05
	Bottom	30,8	29,4	29,0	24,7	25,0	28,7	25,4	23,3	25,7	22,3	28,4	24,6
October	Surface	33,5	33,3	33,1	32,9	31,3	30,4	29,9	29,4	28,8	28,0	27,7	1,3
	Bottom	33,4	33,4	33,1	32,9	32,2	33,0	33,5	30,0	31,8	29,5	30,8	28,9
November	Surface	34,5	33,7	33,5	33,2	32,0	31,6	30,5	30,6	29,3	29,0	28,9	17,0
	Bottom	34,5	33,8	33,5	33,4	32,3	31,6	30,9	31,2	31,4	30,0	30,6	30,6
December	Surface	34,9	34,9	36,8	35,0	35,0	34,9	35,2	35,0	34,5	33,8	33,7	33,7
	Bottom	34,9	34,9	34,5	34,9	35,2	34,9	35,6	35,3	34,6	35,0	34,8	34,2
January	Surface	35,0	35,0	35,2	35,8	36,1	37,0	37,0	37,5	37,6	37,7	37,5	37,7
	Bottom	35,1	35,1	35,3	35,8	36,5	37,1	37,7	37,5	37,9	37,8	37,7	37,7
February	Surface	35,0	35,3	36,2	36,3	36,6	36,9	37,3	37,5	37,7	38,5	39,1	39,1
	Bottom	35,0	35,3	36,2	36,5	36,8	37,1	37,3	37,6	38,0	38,5	39,2	39,2
March	Surface	35,0	35,0	35,5	35,5	36,3	36,8	37,1	37,2	37,8	37,7	38,9	39,0
	Bottom	35,2	35,0	35,4	35,5	36,4	36,8	37,1	37,2	37,9	38,4	38,9	39,0
April	Surface	35,0	35,1	35,2	35,3	35,9	36,2	36,3	36,3	36,3	35,9	33,2	4,9
	Bottom	35,1	35,2	35,3	35,3	35,8	36,2	36,3	36,3	36,2	35,8	35,2	35,5
May	Surface	33,2	33,2	33,2	33,0	31,6	30,7	29,8	29,3	28,6	27,9	27,6	1,3
	Bottom	33,5	33,5	33,2	33,2	32,1	31,5	32,0	30,7	30,8	29,7	31,0	28,7
June	Surface	34,0	34,0	33,7	33,4	32,0	31,4	30,9	30,7	29,7	29,6	24,8	16,9
	Bottom	34,2	33,9	33,8	33,6	33,4	33,5	31,9	31,5	31,6	30,7	31,1	30,8
July	Surface	34,4	34,2	33,8	33,4	31,6	31,0	30,7	30,6	29,3	28,8	20,0	7,4
	Bottom	34,4	34,2	33,8	33,6	32,6	33,3	31,7	31,6	31,9	30,4	31,4	30,5
August	Surface	33,7	33,5	33,3	32,5	32,3	31,9	30,9	30,7	29,3	27,8	29,7	26,9
	Bottom	34,5	34,5	32,5	32,4	32,4	32,4	32,0	31,8	32,0	31,4	31,0	31,0

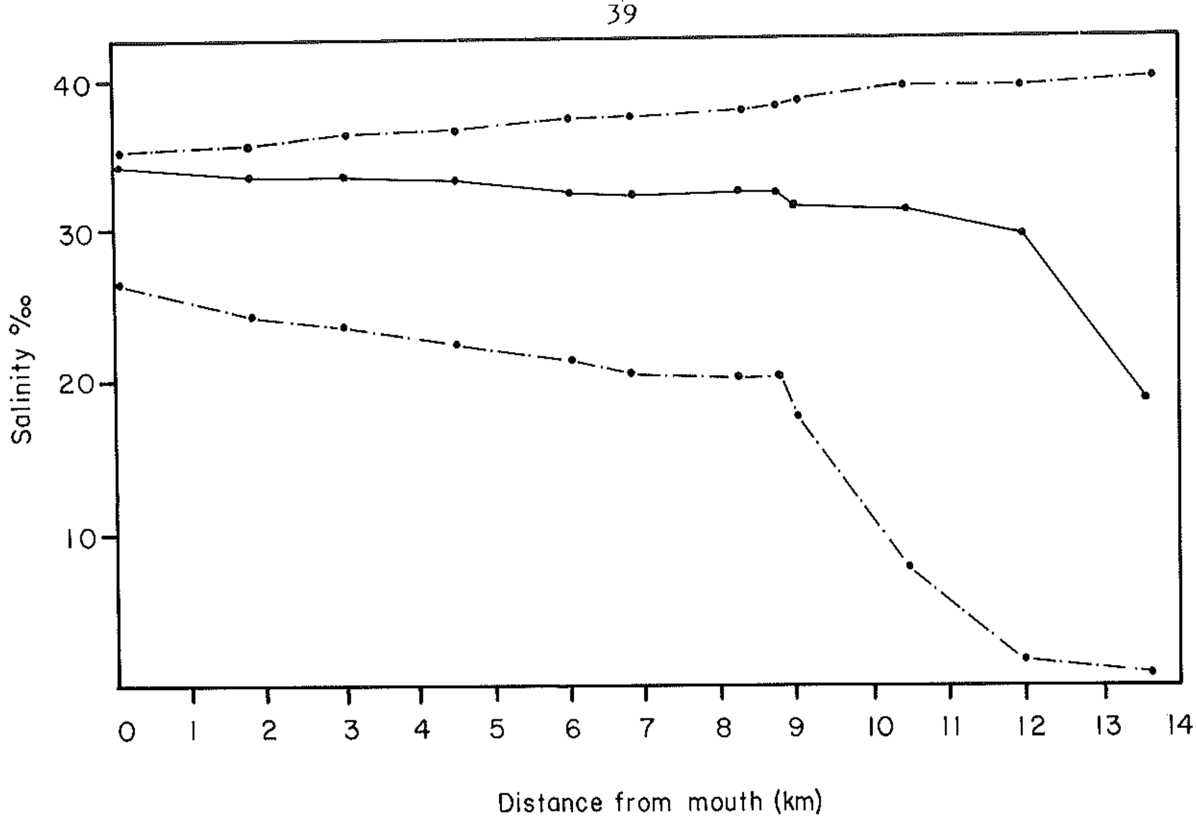


FIG. 17: The mean annual salinity (continuous line) and the maximum and minimum salinity values (dotted lines) for the Kromme Estuary, during the period September 1972 to August 1973 (from Hecht, 1973).

for the high summer evaporation rates in the estuary (C P R Roberts, Directorate of Water Affairs, pers. comm.). This will hopefully prevent hypersaline conditions from occurring in the future.

Salinity data from Baird *et al.* (1981), Marais (1983) and the ECRU Survey (Table 4) were within the range measured by Hecht (1973) whereas those of Hanekom (1982) and Emmerson and Erasmus (1987) ranged from 0 to 36 parts per thousand. The lowest readings (0 parts per thousand) were recorded in the upper reaches of the estuary after floods in June 1981.

Emmerson and Erasmus (1987) similarly reported a salinity range of 0 to 30 parts per thousand with a mean of 25,8 parts per thousand for the period June 1979 to September 1981. There was a salinity gradient down the estuary during both winter and summer indicating a continuous freshwater input into the system. Furthermore, no reverse gradients developed and at the head of the estuary vertical salinity stratification was always present (Emmerson and Erasmus, 1987).

Dissolved oxygen

Hecht (1973) recorded surface and bottom dissolved oxygen values at sampling stations along the length of the Kromme Estuary. Surface values ranged from 5,71 to 7,87 milligrams per litre (mg/l) with the variation between the top and bottom waters being minimal except in October 1972 when there was a vast difference in surface and bottom salinities at the head of the estuary (Hecht, 1973). He furthermore noted that during the rainy season the oxygen values increased from the mouth to the head of the estuary whereas the reverse was recorded in the dry season. This was related to the lower oxygen saturation values for higher salinity water.

Dissolved oxygen values recorded by Hanekom (1982) and during the ECRU Survey (Table 4) were all within the ranges recorded by Hecht (1973). Baird *et al.* (1981) in an investigation of the effects of Marina Glades on the ecology of the Kromme found the water in the canals to be well-mixed and oxygen saturated. Surface values ranged from 7,13 mg/l to 7,20 mg/l and bottom values from 6,15 mg/l to 7,18 mg/l (Baird *et al.*, 1981).

Emmerson and Erasmus (1987) found the waters of the Kromme to be well-oxygenated with an overall mean of 7,4 mg/l and a range of 3,6 to 10,1 mg/l. Winter values were predictably higher than those for summer, with little difference along the estuary or between surface and bottom readings, indicating good mixing. As found by Hecht (1973), Emmerson and Erasmus (1987) recorded low oxygen values in bottom waters at the head of the estuary, mainly during summer when temperatures there were above 23°C suggesting a degree of organic decay.

Nutrients

Hecht (1973) gives substratum nitrogen content data for 20 stations sampled during a study of the benthic communities of the Kromme Estuary. Nutrient concentrations for the surface waters of the Kromme are given by Hanekom (1982) whilst Watling (1982) gives data for surface and bottom water samples collected in the winter and spring of 1981 and Emmerson and Erasmus (1987) discuss the nutrient status of the Kromme for the period from June 1979 to September (1981).

The nitrogen content of the substrata at sampling stations spread along the length of the estuary showed peaks at stations where substrate subsieve fractions were highest, that is, there was a higher proportion of fine sediments. These were at sampling stations in the vicinity of saltmarshes. The range of values for the whole estuary was 0,08-1,82 milligrams of nitrogen per gram of dry substrate (Hecht, 1973).

Surface water nitrate (NO_3-N) concentrations given by Hanekom (1982) ranged from 0,005 to 0,2 mg/l. Nitrate concentrations were generally highest in the wet winter months (mean of 0,102 mg/l) particularly after floods, and lowest in the dry summer months (mean of 0,029 mg/l), indicating a significant fluvial source (Hanekom, 1982). Conversely phosphate (PO_4-P) concentrations had a total range of 0,03 to 0,262 mg/l and were highest during summer dry periods (mean of 0,143 mg/l) and lowest during the wet winter (mean of 0,136 mg/l) periods (Hanekom, 1982) suggesting marine origins. Similarly the total phosphorus concentrations for surface samples ranged from 0,025 to 0,415 mg/l and were highest in the summer (mean of 0,195 mg/l) and lowest in the winter (mean of 0,165 mg/l) months (Hanekom, 1982).

Table 6 contains a summary of the nutrient analyses for the Kromme Estuary and lower reaches of the Geelhoutboom River given by Watling (1982) and Emmerson and Erasmus (1987). Nutrient levels, especially nitrate and silicate were noticeably higher at the single station sampled in the Geelhoutboom River. This appeared to be due to clearance of indigenous bush and thicket on the slopes in the vicinity of the sampling station which resulted in considerable surface wash-off (Watling, 1982).

The nutrient concentration data of Hanekom (1982) and Watling (1982), at comparable sampling stations, are of similar orders of magnitude. Comparison with the equivalent data for three other Eastern Cape estuaries, the Swartkops, Sundays and Great Fish (Hanekom, 1982; Watling, 1982), indicates that the nutrient load of the Kromme is relatively low. This is to be expected with the reduced run-off and sediment levels entering the estuary through impoundment in the catchment. The low nitrate and phosphate concentrations also suggest that there is no significant enrichment due to leaching of fertilizers from the adjacent farmlands.

TABLE 6: Nutrient concentration ranges and means for surface and bottom samples collected during winter and spring (Watling, 1982) and bimonthly from June 1979 to September 1981 (Emmerson and Erasmus, 1987) surveys of the Kromme Estuary (six sampling stations) and lower reaches of the Geelhoutboom River (one sampling station).

Nutrients	Concentrations in mg/l								
	Watling (1982)						Emmerson & Erasmus (1987)		
	Winter 1981			Spring 1981			June 1979 to Sept. 1981		
	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.
Total Ammonia	<0,001	-	0,004	0,010	0,034	0,062	ND	0,012	ND
NO_2 - N	0,005	0,020	0,029	0,060	0,094	0,240*	ND	0,005	0,030
NO_3 - N	0,087	0,158	0,286*	0,037	0,076	0,223*	-	0,064	0,345
PO_4 - P	<0,005	-	0,070	0,030	0,083	0,290	-	0,121	0,450
Total P	0,029	0,077	0,120*	0,032	0,088	0,299	0,012	0,208	0,860
Si O_3 - Si	2,250	3,464	4,800*	0,460	2,036	3,850*	ND	3,435	ND

Note: * denotes Geelhoutboom samples.
ND denotes no data.

Seasonal variations in the nutrient data of Emmerson and Erasmus (1987) were as follows: Nitrate values along the estuary were higher in winter than in summer. Phosphate values were higher in summer especially in the middle reaches of the estuary. Winter silicate values were almost double those of summer and the highest silicate values were encountered in the middle reaches at the mouth of the Geelhoutboom River. Emmerson and Erasmus (1987) concluded that the Kromme is low in nitrogen, conservative in silicate and low in phosphorus, while the Geelhoutboom supplies nitrogen, phosphorus and silicate to the system. These authors classified the Kromme as a non-conservative mesotrophic marine-dominated estuary which probably exhibits some nutrient recycling.

SEEKOEI AND KABELJOUS

Physico-chemical data for the Seekoei and Kabeljous estuaries are largely limited to those collected during the ECRU Survey in November 1984 when their mouths were closed (see Table 4).

pH

In the Seekoei the pH values obtained during the ECRU Survey were typical of sea-water with the exception of Station 4 where a lower pH of 6,75 suggested more of a fluvial influence.

In the Kabeljous, pH values ranged from 8,35 to 8,60 at three sampling stations (see Table 4). These high pH values could have been due to photosynthetic activity by the dense masses of macrophytes and algae present at the time. According to Schütte and Elsworth (1954), removal of carbon dioxide under such conditions causes a rise in pH.

Water temperature

During the ECRU Survey, water temperature ranges measured in the Seekoei were 17,5°C to 20,0°C on the surface and 17,6°C to 18,6°C on the bottom. In the Kabeljous surface temperatures ranged from 19,0°C to 23,°C and bottom temperatures from 18,5°C to 23,0°C (see Table 4).

Water transparency

In the Seekoei, water transparency measurements taken during the ECRU Survey indicated that downstream of the causeway (Station 1) the water is less turbid than in the upper and middle reaches of the estuary (see Table 4). This is probably a reflection of the greater amount of fine material in the substratum upstream of the causeway.

In the Kabeljous, water transparencies were high (>1,60 m) at the three stations sampled during the ECRU Survey (see Table 4).

Salinity

Grindley (1976) reported salinities downstream and upstream of the causeway in the Seekoei as having been measured as 27 and 7 parts per thousand respectively, thereby indicating that the upper part of the estuary was virtually cut off from marine influence. During the ECRU Survey in November 1984, salinities measured in the Seekoei were relatively consistent throughout and ranged from 26,0 to 27,0 parts per thousand (see Table 4). The mouth was, however, closed at the time and some mixing of the water upstream and downstream of the causeway must have occurred. There was also no noticeable salinity stratification at any of the four stations sampled.

The Kabeljous was also closed at the time of the ECRU Survey and salinities measured at the three stations sampled there indicated little variation with a range of 30,0 to 32,0 parts per thousand.

There are no published salinity data for either the Seekoei or the Kabeljous estuaries.

Dissolved oxygen

In the Seekoei Estuary dissolved oxygen values measured during the ECRU Survey were all slightly below the saturation values for the surface and bottom salinity and temperature combinations measured at the four sampling stations (see Table 4). Bottom and surface dissolved oxygen concentrations were of a similar order indicating good water turn-over as a result of wind-induced mixing.

In the Kabeljous, the dissolved oxygen concentrations measured during the ECRU Survey were all higher than the saturation values for the surface and bottom salinity/temperature combinations at the three sampling stations. Dissolved oxygen concentrations ranged from 8,32 milligrams per litre to 10,51 milligrams per litre. These high concentrations could have been due to photosynthetic activity by the large amounts of macrophytes (*Ruppia* sp.) and algae in the water at the time.

Nutrients

No nutrient data are available for either the Seekoei or Kabeljous estuaries.

3.2.5 Pollution

Sewage

KROMME

Sewage disposal in the St Francis Bay Township is via septic tank systems (W L Basson, Humansdorp Divisional Council, pers. comm.). This form of disposal is also employed at other smaller developments on the banks of the Kromme.

There is no indication of sewage pollution of the Kromme as borne out by the dissolved oxygen concentration data which are close to saturation (Hecht, 1973; Hanekom, 1982 and ECRU data - Table 4) and low nutrient concentrations (Hanekom, 1982; Watling, 1982).

Baird *et al*. (1981) found the water in the Marina Glades canals to be well-oxygenated throughout, suggesting that there is little, if any, seepage of septic tank effluent into the waterways. More recently, however, concern has been expressed by local residents about pungent odours emanating from the canals (J D D Kettlewell, St Francis/Kromme Trust, pers. comm.). During a visit to the marina in April 1985 by ECRU personnel, seepage of what appeared to be septic tank effluent, through a canal embankment, was observed. The possibility of pollution of the Marina Glades canals by septic tank effluent needs to be investigated and the necessary microbiological and chemical monitoring should be carried out.

SEEKOEI AND KABELJOUS

Sewage disposal at Paradise Beach and Aston Bay on either side of the Seekoei Estuary and at Kabeljous-on-Sea just south of the Kabeljous Estuary is by means of septic tanks (W L Basson, Humansdorp Divisional Council, pers. comm.). No reports of sewage pollution in either the Seekoei or Kabeljous estuaries could be found.

According to Mr W L Basson a sewage treatment works is being planned for Jeffreys Bay. This will also handle sewage from Kabeljous-on-Sea and Aston Bay.

Oil

Contingency plans for combatting oil pollution have been drawn up for the whole South African coastline by the Department of Environment Affairs. The St Francis Bay coastline is considered to be a high risk area and has therefore received priority attention in this respect (L F Jackson, Sea Fisheries Research Institute, pers. comm.). Details can be obtained by referring to the document: Coastal Oil Spill Contingency Plan No. 9, Humansdorp Zone compiled by the Department of Environment Affairs.

In December 1985 the tanker *Botany Triad* was holed in a collision in thick fog off St Francis Bay. The resultant oil slick posed a threat to the Kromme Estuary but was fortunately blown offshore by south-westerly winds (*The Argus* 9 December 1985). Some of the oil which was of the light lubricating type was washed ashore at the mouth of the Seekoei Estuary necessitating artificial closing of its mouth by means of bulldozers (L F Jackson, pers. comm.).

Trace metals

KROMME

The distribution of trace metals in water, surface sediment and core samples from the Kromme indicates that the river drains an essentially unpolluted catchment (Watling, 1982). However, there is evidence that metal-rich (chromium, lead, nickel, cadmium) sediment from the Geelhoutboom River is being deposited in the midstream island situated at the confluence of the Geelhoutboom and Kromme rivers (Watling, 1982; Watling and Watling, 1982a). The source of these metals is uncertain in so far that it has not been delineated but is evidently related to catchment mineralization (Watling and Watling, 1982a).

SEEKOEI AND KABELJOUS

The results of a trace metal survey of St Francis Bay indicated that there was some input of metals into the area between the Kabeljous and Gamtoos estuaries (Watling and Watling, 1982b). These authors suggested that the high chromium levels in particular, found in the sediment core samples in this area had a source in the vicinity of the Kabeljous Estuary mouth and that this source was unlikely to be geochemical and may have been derived from run-off from agricultural land. Furthermore, although the chromium concentrations between the Kabeljous and Gamtoos estuary mouths were about an order of magnitude above background, they do not represent a threat to the coastal environment (Watling and Watling, 1982b).

No evidence of elevated metal concentrations was found in the vicinity of the Seekoei Estuary mouth (Watling and Watling, 1982b).

Pesticides and herbicides

According to Mr F Weitz (Agricultural Technical Services) aerial spraying of wheat fields in the Kromme, Seekoei and Kabeljous catchments with pesticides and herbicides is carried out regularly. Persistent pesticides can be expected to leach out and accumulate in the estuaries.

Other forms of Pollution

On the southern bank of the Seekoei River approximately 2,5 km upstream of the confluence of the Seekoei and Swart rivers is the Paradise Beach refuse dump which is situated alongside a quarry. This is extremely unsightly as no effort is made to bury the refuse and much of it finds its way into the estuary.

3.2.6 Public Health Aspects

KROMME

Faecal *E. coli* counts for stations sampled in the Kromme in June and September 1981 were all low and ranged from less than 2 per 100 ml to a maximum of 230 per 100 ml (Watling, 1982).

E. coli and faecal coliform counts for samples collected in the Marina Glades canals in July and September 1984 by the Humansdorp Divisional Council did not reveal any septic tank contamination. The maximum counts in the 10 samples were 6 per 100 ml for both *E. coli* and faecal coliforms.

No official South African standards for the bacteriological quality of recreational waters exist. However, water quality criteria providing guidelines on the limits which must not be exceeded for certain water uses, drawn up by the Marine Pollution Monitoring Committee of SANCOR (Lusher, 1984), are listed below:

Microbiological Criteria

Beneficial use: Direct contact recreation (e.g. swimming, diving, boardsailing).

	Maximum acceptable count
Faecal coliforms per 100 ml	100 (50%)
	400 (90%)
	2 000 (99%)

Beneficial use: Collection of filter feeders for food use.

	Maximum acceptable count
Faecal coliforms per 100 ml	15 (50%)
	45 (90%)

(The percentages following the maximum acceptable count are the percentage of samples that must comply with the given count for the specified purposes).

Although insufficient bacteriological data for the Kromme are available, with the estuary's permanently open mouth and good circulation, it is doubtful whether there are any public health hazards other than possible point sources of pollution due to septic tank seepage during peak holiday periods.

SEEKOEI AND KABELJOUS

No bacteriological data for either the Seekoei or Kabeljous estuaries could be obtained. However, as these estuaries are not intensively developed there are unlikely to be any major public health hazards associated with them.

As a guideline, the water quality criteria for direct contact recreation as drawn up by the Marine Pollution Monitoring Committee of SANCOR (Lusher, 1984) should be adhered to in the Seekoei and Kabeljous.

4. BIOTIC CHARACTERISTICS

4.1 Flora

(Nomenclature according to Bond and Goldblatt, 1984).

KROMME

4.1.1 Phytoplankton/Diatoms

No data available.

4.1.2 Algae

Seaweeds do not form a conspicuous component of the estuary. Large epipsammic mats of *Chaetomorpha* sp. have been reported in the area of the confluence of the Geelhoutboom and Kromme rivers by Hanekom and Baird (1984). Filamentous, epiphytic red algae grow on the laminae of *Zostera capensis* and the occasional presence of the seaweeds *Codium* sp., *Gracilaria* sp., *Iyengaria stellata* has been noted.

FIG. 18a: Vegetation in and around the lower reaches of the Kromme Estuary

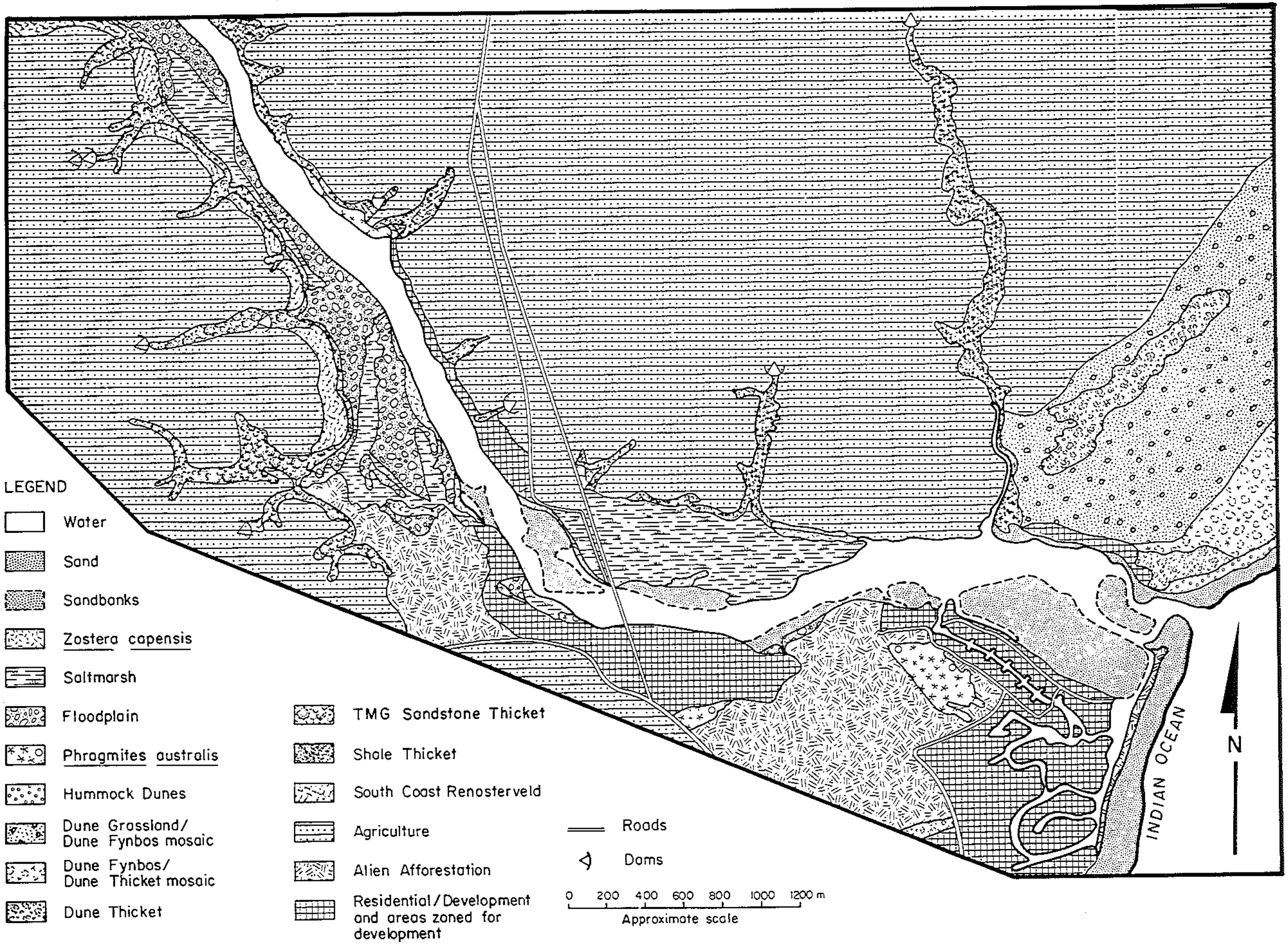
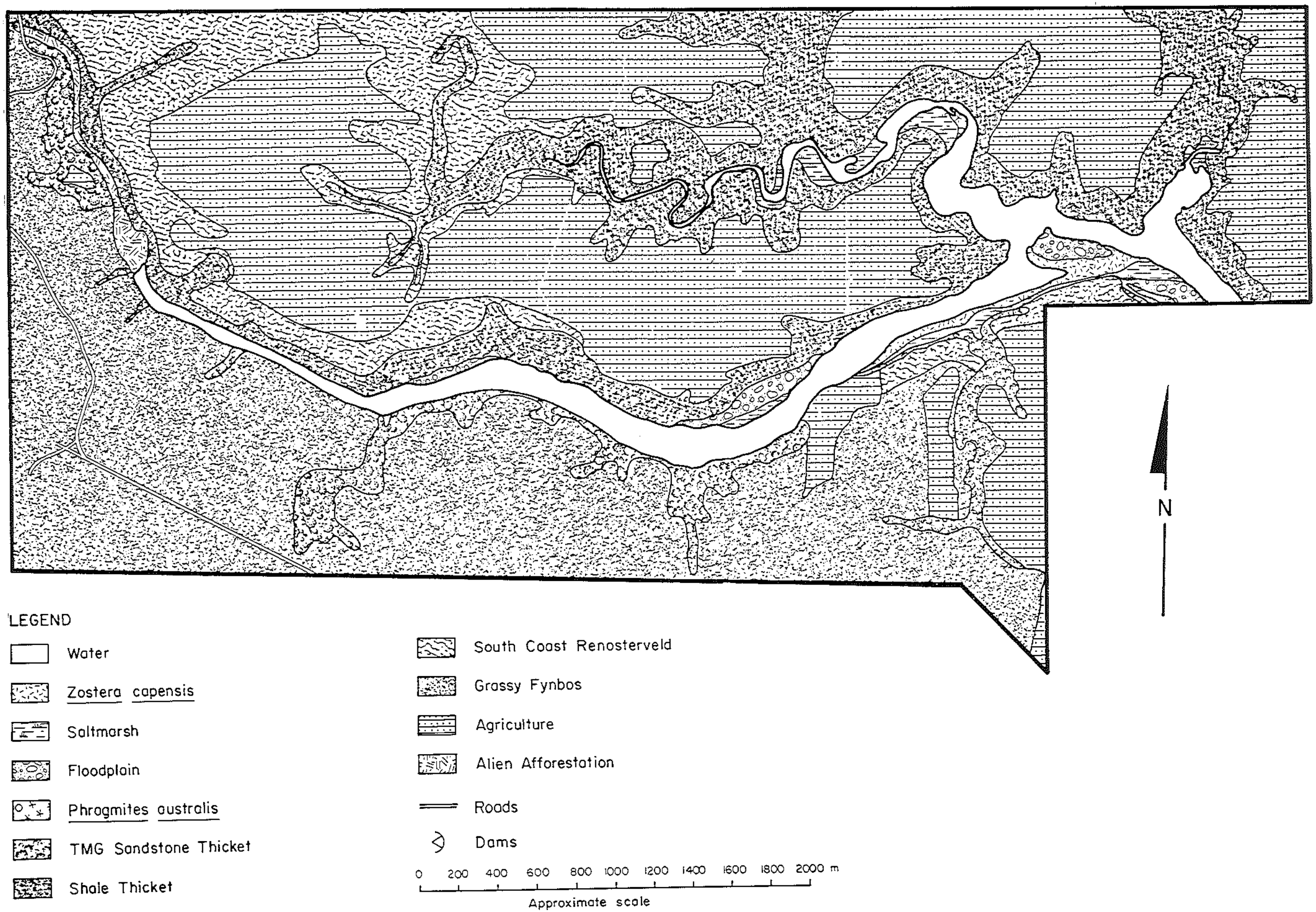


FIG. 18b: Vegetation in and around the upper reaches of the Kromme Estuary



In the calm waters of the Marina canals, several species of seaweeds have been reported growing on mooring poles etc. by Seagrief (1976). These include: *Ulva rigidum, Rhizoclonium* sp., *Enteromorpha* sp., *Codium* sp., *Colpomenia sinuosa, Ectocarpus* sp., *Polysiphonia* sp.. *Caulerpa filiformis* was noted growing subtidally in the oldest canals.

4.1.3 Aquatic and Semi-aquatic Vegetation

(The spatial distribution of mapping units identified under the categories of aquatic, semi-aquatic and terrestrial vegetation is shown in Figures 18(a) and 18(b). Appendix I(a) lists the species and physical features of each mapping unit).

(a) *Zostera capensis* (eelgrass)

Zostera covers approximately 14 ha in the estuary (Hanekom and Baird, 1984). The beds range from sparse, seasonal stands on the sand banks between the bridge and the mouth, to dense, broad-leaved stands in the protected waters of salt marsh creeks and in the upper reaches of the estuary. A detailed study of the vertical and horizontal distribution and biomass of *Zostera* is given by Hanekom (1982) and the *Zostera* and non-*Zostera* associated fish communities by Hanekom and Baird (1984).

Zostera beds and their fringes are highly susceptible to destruction by bait collectors. Stricter control and complete protection of reserve areas is essential.

(b) *Phragmites australis* (reedbeds)

Phragmites reedbeds are found in the brack water conditions where fresh streams enter the estuary. The largest stand of *Phragmites* remaining since the development of the Marina is now being drained for further extension to the canal systems. Its destruction represents a major loss in conservation terms in view of the unique avian habitat provided by *Phragmites*.

The role of reeds and rushes in stabilizing stream and estuary banks particularly during floods is well recognized and for this reason, reedbeds should not be disturbed in any way. Although the Elandsjagt Dam will reduce the effects of future floods, the smaller tributaries and streams feeding the estuary can experience frequent strong flows, situated as they are in the flood-prone SE Cape.

(c) Saltmarshes

There are numerous tidally-inundated salt marsh areas along the estuary, many occurring at the confluence of streams with the estuary. The species composition and structure does not vary markedly along the extent of the estuary except in the case of the exotic macrophyte *Spartina maritima* (cord grass) which is confined to the lower estuarine reaches. *Spartina* forms a dominant monospecific community fringing the estuary banks. It is most dominant in the large salt marsh traversed by the bridge. *Spartina* is able to colonize bare sand and encroach into the zone normally occupied by *Zostera*. It has increased in extent over the past 7 years and is highly resistant to flood-scouring in contrast to *Zostera*. This spread may be explained as the colonizing behaviour of a recent invasive (Pierce, 1982).

FIG. 19: Ecologically important saltmarsh area just upstream of the roadbridge on the northern bank of the Kromme. Such areas are highly sensitive and should not be disturbed in any way. (ECRU: 86-01-19).

At slightly higher elevations, *Spartina* forms either a mosaic with other salt marsh species, and/or each species occurs as dense, extensive monospecific mats. These species include *Sarcocornia perennis, S. capensis* (seekraal), *Chenolea diffusa* (soutbossie) and *Limonium scabrum* (sea lavender). Occasional tufts of *Juncus kraussii* grow on higher ground.

The major salt marshes have all been subject to various forms of disturbance viz. bridge building, private roads, cattle grazing. Salt marshes in the Kromme are limited in extent, but play important roles in the estuarine food web and in buffering flood effects. They should therefore be protected against any damage. Vehicular access and cattle grazing should be controlled strictly.

(d) Floodplain

This vegetation unit includes flat areas, slightly higher than salt marsh which are not regularly inundated, but fall below the flood line. The vegetation consists of a closed grassland dominated primarily by *Sporobolus virginicus* (brakgrass), *Stenotaphrum secundatum* (buffalo grass) and *Cynodon dactylon* (kweekgras). *Juncus kraussii* occurs in scattered tufts and also in dense reedbeds, often along creek banks. Most of these high marshes have been infested by *Acacia cyclops* (rooikrans), and in the area of Swan Island where the Geelhoutboom meets the Kromme, both *A. cyclops* and *A. saligna* (Port Jackson willow) are present in dense stands. The grassland of the high marsh is used as natural pasture by cattle farmers. The component grasses provide good grazing and are hardy; however the high marshes should be fenced off from the salt marsh proper to prevent cattle from walking onto and churning up the mud creeks and eroding the salt marsh edges. In the mid-reaches of the estuary much of the high marsh ground forms islands or peninsulas surrounded by salt marsh. Access to the peninsulas should be restricted so that salt marshes are not traversed and islands of high marsh should not be grazed. Causeways of rubble have been made across salt marsh creeks to provide vehicular access to houses, fishing and boating sites. Further practice of such activities should be discouraged.

4.1.4 Terrestrial Vegetation

(Community nomenclature according to Cowling, 1984).

(a) Hummock Dune low open herbland

Along the beach on the north-eastern side of the estuary mouth are some undisturbed ephemeral dune zones with species such as *Scaevola plumieri* (seeplakkie), *Arctotheca populifolia* (sea pumpkin) and *Ipomoea brasiliensis* (goat's foot). On the western bank this zone is absent owing to the artificial nature of the dune ridge. Near the mouth this ridge is maintained by the stacking of dead branches of *Acacia cyclops* (rooikrans). Further west along this beach, isolated areas of undisturbed dune communities of *Scaevola* and *Ipomoea* occur interspersed by thickets of *Acacia cyclops*. In places neither the natural nor the alien dune communities exist due to severe beach erosion.

(b) Dune Grassland/Fynbos/Thicket Mosaics

The vegetation units are different successional stages and include a grassland community, two dune fynbos communities and finally a dune thicket community. The first three mentioned communities are classified within South Coast Dune Fynbos and the latter a dune form of Kaffrarian Thicket (Cowling, 1984; Moll *et al.*, 1984). Because of the successional nature of the different communities, successive communities can co-occur as a mosaic.

Dune Grassland

The *Themeda triandra* - *Stenotaphrum secundatum* community (rooigras and buffalo grass) forms a closed grassland with scattered fynbos elements on deep seasonally waterlogged sands in dune valleys, and may also be maintained by frequent burns or bush cutting on well-drained sands. Species include: *Cynodon dactylon* (kweekgras), *Sporobolus africanus* (vleigras), and *Cotula sericea*. If the grassland on the latter type of substratum is left undisturbed, it develops into a small-leaved low shrubland or fynbos community.

Dune Fynbos

Of the two fynbos communities, the *Ischyrolepis eleocharis* - *Agathosma stenopetala* (riet and buchu) community occurs on shallower well-drained sands overlying calcrete. It forms a low shrubland with very low perennial herbs, occasional grasses and a preponderance of restioids (riete). Species include: *Muraltia squarrosa; Limonium scabrum; Imperata cylindrica* (silwergaargras); *Phylica litoralis* and *Felicia echinata*. Where this community occurs on the well-drained deep sands of dune ridges it is succeeded by the fynbos community described below.

The *Ischyrolepis eleocharis* - *Maytenus procumbens* (riet and duinekokoboom) community is transitional to Dune Thicket and consists of a mosaic of fynbos shrubs, restioids and thicket species. Species include: *Metalasia muricata* (blombos), *Agathosma apiculata* (knoffelboegoe), *Ficinia ramosissima, Olea exasperata* (coast olive) and *Myrica quercifolia* (maagpynbos).

Dune Thicket

The *Cassine aethiopica* - *Cussonia thyrsiflora* (koeboebessie and kuskiepersol) community forms a closed thicket (±3 m tall) which is relatively fire resistant. Species include: *Sideroxylon inerme* (milkwood), *Pterocelastrus tricuspidatus* (kershout) and *Olea exasperata* (coast olive). Thicket is slow in developing and well-established stands are centuries old. They form a unique habitat in providing refuge for bushbuck and monkeys. Also most species produce berries and support frugivorous birds. For these reasons the few remaining Dune Thickets should be conserved.

These dune communities are unique to the calcareous coastal dunes of the SE Cape with their centre of distribution lying between Huisklip and St Francis Bay. Several local endemic species are found in these communities which are seriously threatened by coastal development (see Appendix II).

(c) South Coast Renosterveld

This shrubland is restricted to the fine-grained moderately fertile soils derived from Bokkeveld shale. Although both banks of the Kromme Estuary are composed of Bokkeveld shale, on the south-western side, the shale is overlain by sand eroded from the Table Mountain Group sandstone ridge, forming a high plain lying above the estuary and below the ridge. As a result, on the western bank of the estuary, Renosterveld is restricted to a narrow band on the steep slopes extending from the plain down to the estuary where the sand mantle has eroded to reveal the underlying shale.

The *Themeda triandra - Cliffortia linearifolia* community in its natural state is a dense grassland. However, as a result of bad veld management practices, the grass component (especially *Themeda* or rooigras) has been largely replaced by shrubs, especially *Elytropappus rhinocerotis* (renosterbos), and unpalatable herbs. Species composition includes: *Cliffortia linearifolia, Ischyrolepis sieberi* (riet), *Arctopus echinatus* (platdoring), *Protasparagus capensis* (katdoring) and *Pentaschistis angustifolius.*

The *Metalasia muricata - Erica decipiens* community occurs on sloping ground and is transitional to thicket. Species in this Renosterveld community include: *Metalasia muricata* (blombos), *Passerina vulgaris, Rhus incisa* (taaibos) and *Muraltia ericaefolia.*

South Coast Renosterveld has relatively high numbers of endemic and threatened species (see Appendix II) and is severely threatened by agriculture. Most Renosterveld on level ground in the Kromme region has been converted to cultivated pastures. The majority of the remainder is rather poorly managed as natural rangeland. The use of Renosterveld as rangeland is not incompatible with conservation providing sound veld management is practised. Endemic and threatened species survive in well-managed veld.

(d) Shale Thicket

This vegetation type occurs on the shale soils of the steep slopes of the northern banks of the estuary.

The *Pterocelastrus tricuspidatus - Euclea undulata* (kershout and guarri) community succeeds and is adjacent to the *Metalasia / Erica* Renosterveld community. Both these communities are seriously threatened by ploughing on sloping ground. Both types should be protected against destruction owing to their important function in stabilizing the highly erodable shale slopes. The thicket also provides shelter for bushbuck and berries for frugivorous birds. Much thicket has been cleared along the more gentle slopes of the middle and lower reaches of the estuary for residential purposes. Further clearance should be strictly limited. Shale thicket species include: *Sideroxylon inerme* (milkwood), *Schotia afra* (boerboon), *Aloe africana, Olea europaea* (olienhout) and *Maytenus acuminata* (silky bark).

(e) Table Mountain Group (TMG) Sandstone Thicket

The *Pterocelastrus tricuspidatus - Gonioma kammasi* community is found on the sandy slopes of the south-western banks of the upper reaches of the estuary. This thicket is also an important stabilizing force and disturbance should be strictly controlled. Species include: *Sideroxylon inerme* (milkwood), *Rhoicissus digitata* (baboon grape), *Aloe arborescens,* and *Cassine peragua* (bastard saffron-wood).

(f) Grassy Fynbos

Grassy Fynbos is restricted to the deep, well-drained acid sands derived from Table Mountain Group sandstone. It occurs on the deep sand mantle on the high plain on the south-western side of the estuary. Grassy Fynbos comprises the typical elements of fynbos - ericoids (heaths), restioids (riete) but only resprouting proteoids have survived the frequent fire regime imposed by local farmers to encourage the grasses (e.g. *Themeda, Heteropogon).* It is this conspicuous grass component which makes this eastern Cape form of fynbos unique.

The *Thamnochortus glaber - Erica diaphana* community occurs in the area above Kromelmboog (see Figure 6). Species include: *Leucadendron salignum* (geelbos), *Leucospermum cuneiforme* (pincushion), *Diheteropogon filifolius* and *Tetraria compressa.*

The *Erica pectinifolia - Trachypogon spicatus* (steekgras) community occurs on the south-eastern banks above the Elandsjagt Dam. Some relic patches of *Protea neriifolia* (blue sugarbush) which have escaped the effects of the locally practised 4-5 year fire regime, occur there.

In spite of the high frequency fire regime imposed by local farmers, the Grassy Fynbos communities adjacent to the upper reaches of the Kromme Estuary and Elandsjagt Dam have not been overly disturbed, and are highly conservation-worthy, containing many endemic and threatened species (see Appendix II).

SEEKOEI

4.1.1 Phytoplankton/Diatoms

No data available.

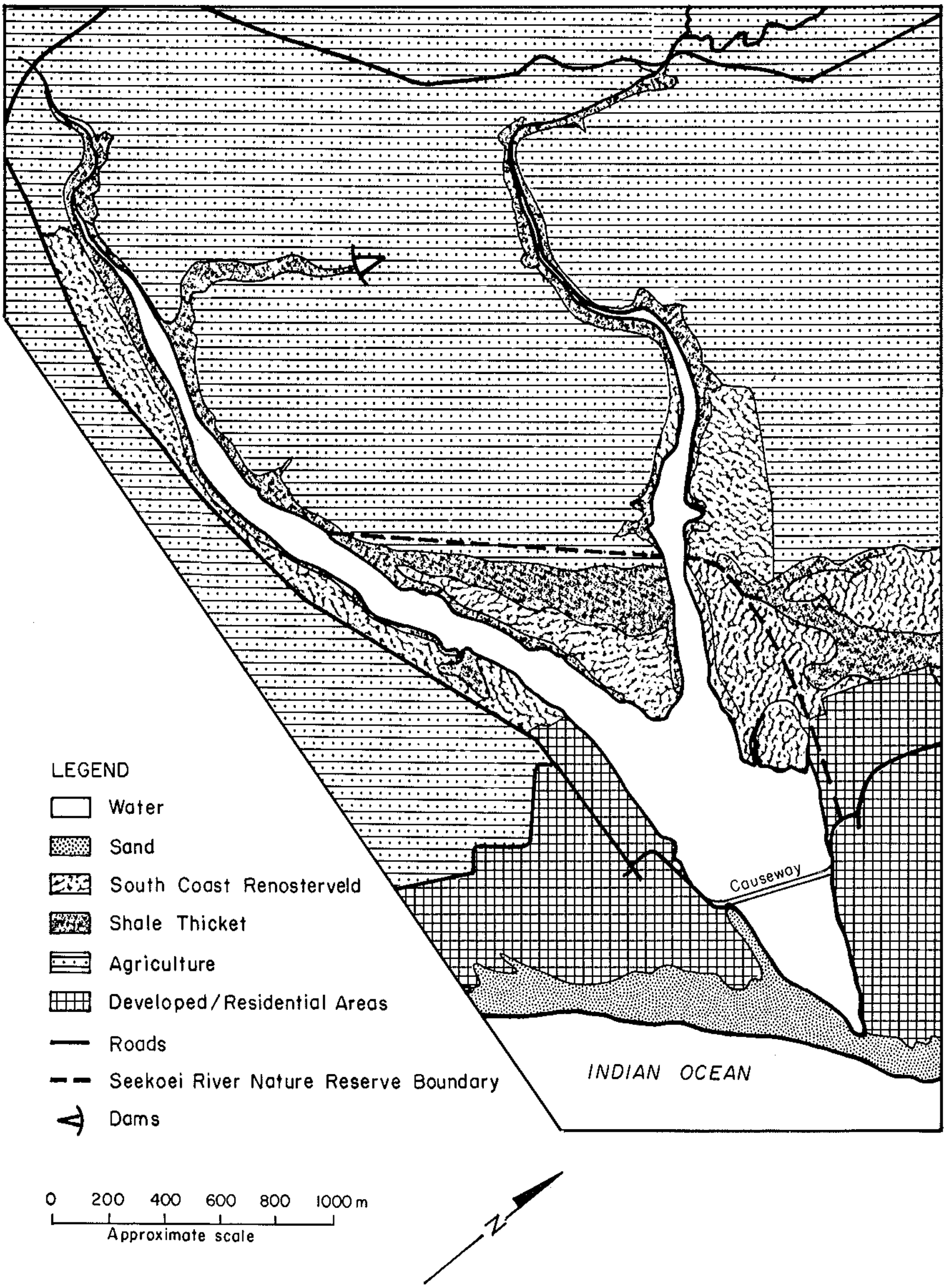
4.1.2 Algae

The botanical survey was undertaken in winter when the estuary mouth was closed and the water levels were extremely high. The winter die-back of seasonal macrophytes and the decay of submerged plant material results in eutrophication and the resultant bloom of the green alga *Enteromorpha* sp. This phenomenon has been noted in the Swartvlei (Taylor, 1983) and Kabeljous estuaries.

4.1.3 Aquatic and Semi-aquatic Vegetation

There are dense beds of *Zostera capensis* (seegras) in the estuary, concentrated in the shallow creeks. *Ruppia spiralis* is an important seasonal component as evidenced by the heaps of litter washed up on the shoreline. There was no evidence of *Potamogeton* sp. which is reported to have disappeared after the increased salinization as a result of the construction of the causeway (Cape Provincial Administration, 1978/79).

FIG.20: Vegetation in and around the Seekoei Estuary



There are small, isolated patches of *Phragmites australis* (fluitjiesriet) scattered along the banks, particularly at the confluence of small streams and seeps.

The estuary is fringed by a narrow bank of grassland, with most of the area submersed by the raised water level. The diversity of this grassland is very poor. It is dominated by *Paspalidium obtusifolium*, an aquatic/semi-aquatic grass, thought to have been introduced to southern Africa by migratory water birds (Meredith, 1955). The other component species are able to tolerate periods of inundation. These include *Stenotaphrum secundatum* (buffalo grass), *Cynodon dactylon* (kweekgras), *Sporobolus virginicus* (brakgras), *Sarcocornia natalensis* (seekoraal) and *Juncus kraussii*.

4.1.4 Terrestrial Vegetation

(The spatial distribution of mapping units identified is shown in Figure 20. Appendix I(b) lists the species and physical features of each mapping unit).

(a) Shale Thicket

This is the same community as found for the Kromme, namely, *Pterocelastrus-Euclea* community. Dominant species are *Sideroxylon inerme* (milkwood), *Euclea undulata* (guarri), *Pterocelastrus tricuspidatus* (kershout), *Rhus longispina* and *Cassine peragua* (bastard saffron wood). *Euphorbia triangularis* (noorsboom) may be locally dominant. On the southern side of the estuary, *Acacia cyclops* (rooikrans) has invaded degraded thicket and is spreading into the adjacent Renosterveld.

(b) South Coast Renosterveld

South Coast Renosterveld *(sensu* Cowling, 1984) occurs on shallow (0,2-0,3 m) shale-derived soils. Most has been cleared for agriculture. In areas where the shale is covered by a mantle of calcrete or calcareous sand, South Coast Dune Fynbos *(sensu* Cowling, 1984) elements are found. There are some unique transitional communities which are conserved within the Seekoei Nature Reserve. The major community is the *Elytropappus rhinocerotis-Metalasia muricata* community. Dominant species include *Themeda triandra* (rooigras), *Elytropappus rhinocerotis* (renosterbos), *Metalasia muricata* (blombos), *Eriocephalus africanus* (kapokbos), *Relhania genistaefolia* (gombossie), *Hermannia salviifolia, Euryops munitus* and *Agathosma ovata* (false buchu). In places the Renosterveld is transitional to Dune Fynbos and *Agathosma apiculata* (knoffelboegoe) and *Ischyrolepis eleocharis* (riet) are common.

KABELJOUS

4.1.1 Phytoplankton/Diatoms

No data available.

4.1.2 Algae

The survey was undertaken in winter when the estuary mouth was closed and the water level high. The consequent reduced light conditions and the extended submergence period resulted in the death and decay of leaves of aquatic and semi-aquatic plants. In addition, there was evidence of the winter die-back of *Ruppia spiralis*. Increased nutrient levels from this organic matter (that is, eutrophication) and conditions of lower light and temperature resulted in a massive bloom of the green alga, *Enteromorpha* sp.

4.1.3 Aquatic and Semi-aquatic Vegetation

(The spatial distribution of mapping units identified under the categories of semi-aquatic and terrestrial vegetation is shown in Figure 21. Appendix I(c) lists the species and physical features of each mapping unit).

Ruppia spiralis forms dense seasonal beds in the estuary as evidenced by the heaps of litter deposited along the shoreline. There are also dense beds of *Zostera capensis* (seegras) present particularly in the upper reaches. The semi-aquatic macrophyte *Phragmites australis* (fluitjiesriet) forms a reedbed between the old National Road bridge and the railway line and also below the bridge.

The estuary is seasonally blind and therefore lacks intertidal saltmarshes. Instead it is bordered by floodplain consisting of a very simple grassland dominated by species tolerant of periods of inundation. At the time of the survey much of the fringing grassland was submersed. Approximately 90 percent of the cover consisted of *Sporobolus virginicus* (brakgras). Other species include *Stenotaphrum secundatum* (buffalo grass) and *Cynodon dactylon* (kweekgras), as well as *Sarcocornia natalensis* (seekoraal), *S. pillansii* (brakbos), *Triglochin striata,* and scattered individuals of *Limonium scabrum* (sea lavender), *Disphyma crassifolia* and *Scirpus nodosus.* On the eastern shore of the estuary is a large pan which is covered largely by the above grasses and *Sarcocornia* spp. On the northern bank of the upper reaches of the estuary, *Juncus kraussii* forms a dense bed of rushes.

4.1.4 Terrestrial Vegetation

(a) Sedgeland

The sedgeland is continuous with the floodplain grassland and lacks a distinct boundary. The same grasses predominate but there is a greater preponderance of *Scirpus nodosus* (steekbiesie). At higher levels there are scattered shrubs of *Chrysocoma tenuifolia* . This category of sedgeland may be an artificial one, and may simply describe degenerate vegetation where grassland species have replaced disturbed or cleared Succulent Thicket (see below).

(b) Hummock Dune low open Herbland

There is an extremely narrow zone of hummock dunes on the western bank in front of the Residential Zone. It is unlikely to survive unless protected by the provision of formal paths and against further invasion by alien plants. Species include *Arctotheca nivea* (sea pumpkin), *Metalasia muricata* (blombos), *Passerina rigida* (gonnabas), *Chrysanthemoides monilifera* (bietou), *Felicia echinata* (bloublommetjie) and the exotic *Acacia cyclops* (rooikrans).

(c) South Coast Renosterveld

This comprises the *Elytropappus rhinocerotis-Eustachys paspaloides* community and is confined to shallow soils derived from Enon conglomerate (Uitenhage Group). Most of the Renosterveld is severely overgrazed by livestock. It is extremely rich in species and is in urgent need of conservation(see Cowling, Pierce and Moll, 1986). Dominant species include *Elytropappus rhinocerotis* (renosterbos), *Themeda triandra* (rooigras), *Relhania genistaefolia* (gombossie), *Aspalathus chortophilla, Metalasia muricata* (blombos), *Sporobolus africanus* (vleigras) and *Euryops euryopoides.*

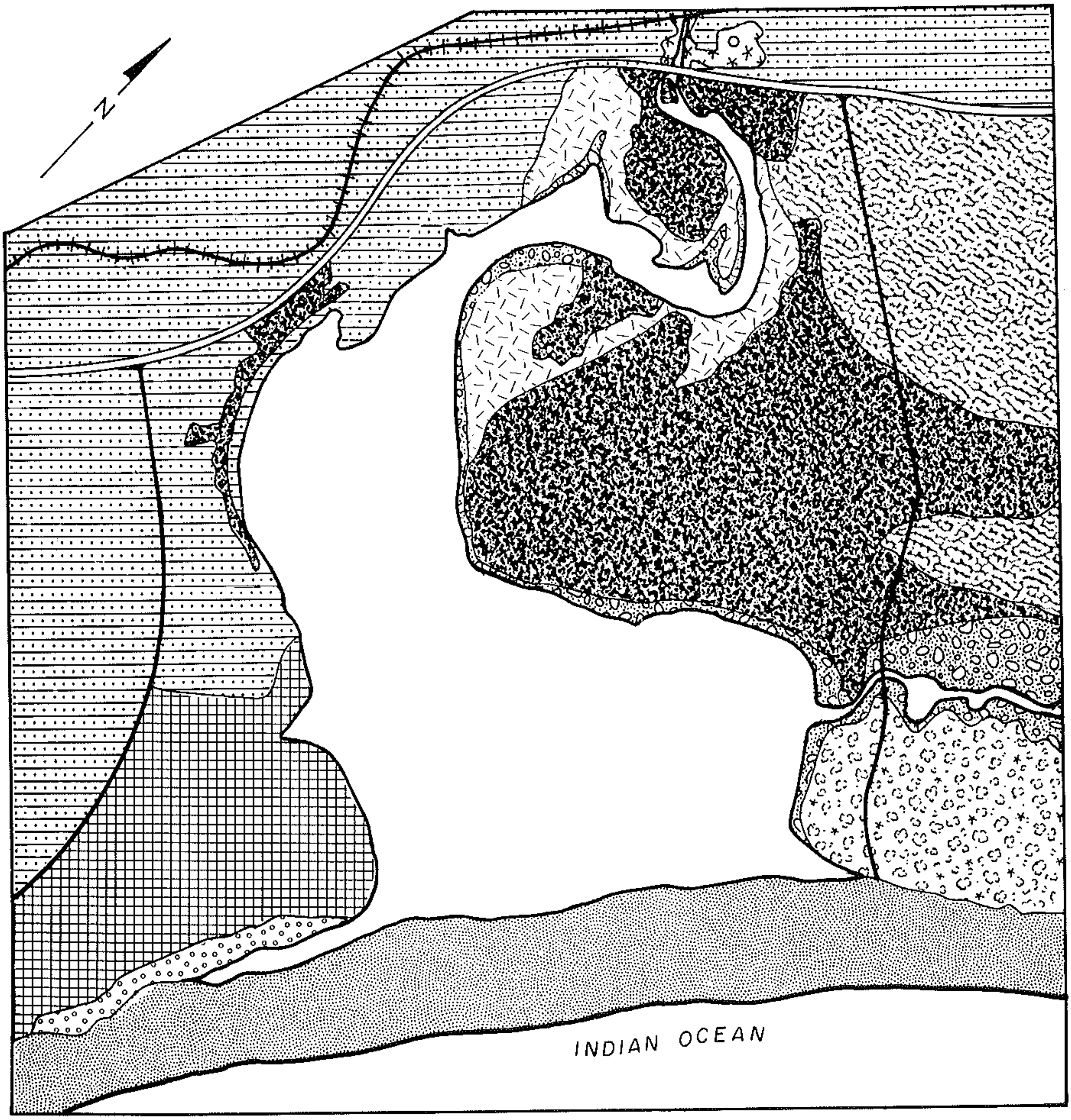
FIG. 21 : Vegetation in and around the Kabeljous Estuary

LEGEND

- Water
- Sand
- *Phragmites australis*
- Hummock Dune Low open Herbland
- Succulent Thicket
- Floodplain
- Sedgeland
- South Coast Renosterveld
- Dune Fynbos/Dune Thicket Mosaic
- Agriculture
- Residential / Development
- Major Roads
- Secondary Roads
- Railway Line

0 100 200 300 400 500 m

Approximate scale



(d) Succulent Thicket

Succulent Thicket occurs on the deep, well-drained alluvium of the estuarine basin. The thicket is 2-5 m in height, very dense, rich in spiny shrubs and succulents, some of which are local endemics (see Cowling, 1983). This is the *Sideroxylon inerme-Euphorbia grandidens* community. Dominant species include *Azima tetracantha* (needle bush), *Euclea undulata* (common guarri), *E. racemosa; Capparis sepiaria* (kapkappertjie), *Sideroxylon inerme* (milkwood), *Rhus longispina* (doringtaaibos), *Euphorbia triangularis* (riviernaboom), *E. mauritanica* (geelmelkbos), *Cassine aethiopica* (koeboebessie), *Schotia afra* (boerboon) and *Hypoestes aristata* (seeroogblommetjie).

This thicket is particularly rich as it includes plant communities on conglomerate, alluvium and calcareous sands. Every effort should be made to conserve this unusual assemblage.

(e) Dune Thicket

Dune thicket *(sensu* Cowling, 1984), a form of Kaffrarian Thicket, is confined to the calcareous sands of the dune coast on the north eastern side of the estuary mouth. It occurs in a mosaic with Dune Fynbos (see botanical section on the Kromme). Dominant species include *Pterocelastrus tricuspidatus* (kershout), *Sideroxylon inerme* (milkwood), *Colpoon compressum* (Cape sumach), *Rhus crenata* (duinekraaibessie), *R. glauca* (blue kuni bush) and *Euclea racemosa* (sea guarri).

(f) Dune Fynbos

Dune Fynbos *(sensu* Cowling, 1984) is often successional to Dune Thicket. It forms a low (0,5-1,5 m), small-leaved shrubland including many restioids (riete). Dominant species include *Nylandtia spinosa* (skilpadbessie), *Ischyrolepis eleocharis* (riet), *Chondropetalum microcarpum, Passerina rigida* (gonnabas) and *Agathosma apiculata* (knoffelboegoe).

4.2 Fauna

Much information on the aquatic fauna of the Kromme Estuary can be obtained from publications emanating from the research efforts of the Zoology Department of the University of Port Elizabeth. The major sources were: Baird *et al.* (1981) - zooplankton, meiofauna, comparison of fauna occurring in the estuary and marina; Mellville-Smith (1981) - ichthyoplankton; Hecht (1973) - macrobenthos; Hanekom (1982) - fauna associated with *Zostera* beds; Marais (1984) - fishes; Emmerson *et al.* (1982) - community analysis. In addition the faunal data collected during the ECRU survey are included.

For the Seekoei and Kabeljous, the limited faunal data were obtained during the ECRU survey as no sampling had been carried out previously.

4.2.1 Zooplankton

KROMME

Baird *et al.* (1981) recorded 22 species of zooplankton during summer and winter surveys of the Kromme Estuary. These authors give species composition and numbers per cubic metre for 2 sites in the marina area and 10 sites in the estuary for both surveys (see Appendix III).

In the mouth region of the estuary, species associated with marine waters were recorded. These include *Corycaeus* spp., *Euterpina acutifrons, Microsetella norvegica, Paracalanus crassirostris, Pseudodiaptomus nudus* and *Sagitta* spp., which enter the estuary on the flood-tide and move out again on the ebb-tide.

In the upper reaches of the canal system, typical estuarine species such as *Pseudodiaptomus hessii, Acartia longipatella, Tortanus capensis* and the mysid *Mesopodopsis slabberi* were recorded (Baird, *et al.*, 1981).

The zooplankton in the lower reaches of the marina canals where current velocities were retalively high, were considered to be typical of the mouth region of the estuary (Baird *et al.*, 1981). Mellville-Smith (1981) in a study of the ichthyoplankton of the Kromme recorded 12 larval fish families of which 12 species were identified.

SEEKOEI AND KABELJOUS

No data available.

4.2.2 Meiofauna

KROMME

The meiofauna throughout the Kromme is dominated by nematodes which account for 88 percent of the total number of organisms (Baird *et al.*, 1981). These authors found that the remainder of the meiofauna consisted of mystacocarids (4 percent), harpacticoid copepods (3 percent) and other taxa (5 percent). There was no significant difference between the average number of nematodes and the number of all taxa combined found in the main estuary and in the marina canals (Baird *et al.*, 1981).

SEEKOEI AND KABELJOUS

No data available.

4.2.3 Aquatic Macro-invertebrates

KROMME

Appendix IV lists the aquatic macro-invertebrate species recorded in the Kromme Estuary. The list comprising 56 species was compiled from Hecht (1973), Baird *et al.* (1981), Hanekom (1982) and Emmerson *et al.* (1982).

Hecht (1973) found that there were 10 dominant benthic macro-invertebrate species in the Kromme Estuary. The distribution and abundance of these species are shown in Figure 22. The 10 species could be classified into three groups. These were *Callianassa kraussi, Upogebia africana* and burrowing bivalves. Of these, the sand prawn *C. kraussi* is the dominant animal over the length of the estuary at all depths, with the burrows extending from 0,5 km from the mouth to the head of the estuary (Hecht, 1973). *C. kraussi* is abundant in the upper reaches of the estuary although the average size of the prawns there is smaller than at the mouth (Hecht, 1973). It is restricted in the sands at the mouth, by a high density of the burrowing bivalve *Loripes clausus* (136 per m^2). The mud prawn *U. africana* is restricted to the muddy substrates of the Kromme as are the burrowing bivalves *Macoma litoralis, Dosinia hepatica* and *Solen corneus* (Emmerson *et al.*, 1982). Considering the macro-benthos as a whole, the mouth area is characterized by *C. kraussi* and *L. clausus,* the middle reaches (2 to 9 km upstream of the mouth) by *U. africana* and burrowing bivalves, and the upper reaches (9 to 14 km upstream of the mouth) by *C. kraussi*. Furthermore, the southern bank of the estuary contains a greater number of animals than the northern bank (Emmerson *et al.*, 1982) and throughout the estuary the greatest biomass occurs at the mid-tide level (Hecht, 1973).

Many species are more abundant in *Zostera* beds than on the bare flats. Twelve species of invertebrates (419 g per m^2 wet mass) were recorded in a *Zostera* bed compared with 8 species (44 g per m^2) on an open bank (Day, 1981).

Emmerson *et al.* (1982) list standing crop figures (numbers per m^2) for the entire estuary for 43 species of invertebrates. The highest densities recorded were for the sand prawn *Palaemon pacificus* (1 016 per m^2), the bivalve *Arcuatula (Lamya) capensis* (469 per m^2), the crab *Cleistostoma edwardsii* (296 per m^2), the snail *Nassarius kraussianus* (241 per m^2), the bivalve *Macoma litoralis* (181 per m^2), the crab *Cleistostoma algoense* (156 per m^2), the bivalve *Loripes clausus* (136 per m^2), the mud prawn *Upogebia africana* (128 per m^2), the sand prawn *Callianassa kraussi* (100 per m^2) and the marsh crab *Sesarma catenata* (80 per m^2).

Baird *et al.* (1981) compared the macrofauna in the Marina Glades canals with that of the lower estuary in June and November 1978 and recorded a total of 16 species in the intertidal zones of the two areas. Three of the 16 species (*Glycera tridactyla, Tellina gilchristi* and *Macoma litoralis*) were found in the main estuary only, whilst two species, *Natica tecta* and *Thaumastoplax spiralis*, were found only in the marina.

Furthermore Baird *et al.* (1981) found that the densities and structure of sand prawn (*C. kraussi*) and bloodworm (*A. loveni*) populations in the estuary and marina differed. Sand prawn biomass and numbers per m^2 were much lower in the main estuary than in the marina canals. These authors also found that the sand prawns in the marina were larger (mean carapace length - 10,4 mm) than those in the main estuary (mean carapace length - 7,0 mm). These findings were ascribed to the heavier exploitation of *C. kraussi*, which is a popular bait organism, on the sandbanks in the main estuary than in the marina where deeper water would make the prawns less accessible to bait collectors. Larger individuals are preferred, which would account for their absence in the samples, or the growth of the population could have become stunted due to bait exploitation (Baird, *et al.*, 1981).

The bloodworm *A. loveni* was also present in higher numbers in the marina, particularly during the summer. This observation was probably related to the heavy bait exploitation during the holiday season (Emmerson *et al.*, 1982). Sampling in January after the December peak holiday period showed a marked reduction in population density in the estuary and a drastic change in population structure with a total absence of larger animals (Baird *et al.*, 1981). The January population structure of bloodworm in the marina did not change from that of November (Baird *et al.*, 1981).

C M Gaigher (Cape Department of Nature and Environmental Conservation, *in litt.*) sampled the Kromme in March 1980 as part of a survey of bait organisms in Cape estuaries. He observed signs of drought stress and marine sediment invasion smothering mud prawn populations at the time. Table 7 below gives the distribution and densities of the major bait organisms sampled in the lower reaches of the Kromme Estuary.

FIG. 22 : The different species constituting the macro-benthic infauna of the Kromme Estuary. The dotted lines indicate the different reaches. (from Hecht 1973)

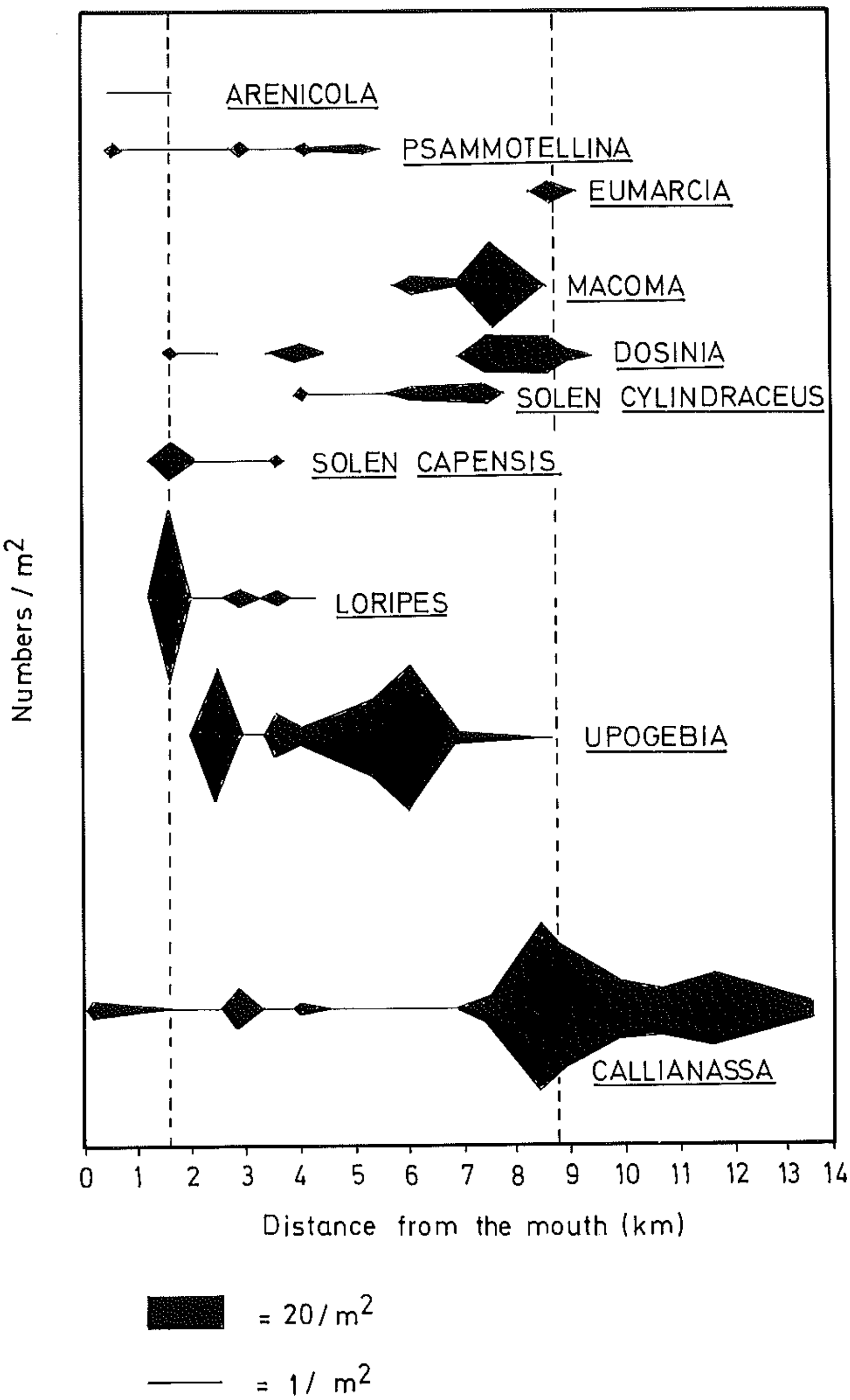


TABLE 7: Distribution and densities of the major bait organisms in the lower reaches of the Kromme Estuary in March 1980. Densities are given as the number of organisms per number of cores using a prawn pump and the number of burrow openings (holes) per m^2. The data are from C M Gaigher *(in litt.)*.

Species	Mouth area	Downstream of roadbridge	Upstream of roadbridge
Callianassa kraussi	3/10 cores and 7 holes/m^2 on right bank near mouth	Widespread but sparse in hard sandy substrata. In marina canals	1-12/10 cores and 23-106 holes/m^2. Sparse in mid-channel sandbars
Upogebia africana	None	Dense in saltmarshes off left bank and along water's edge, and in suitable substrata off left and right banks. 12-28/100 cores; 206-490 holes/m^2	Small localized populations, some threatened by marine sediments. 2-23/100 cores and 290-643 holes/m^2
Solen capensis	In sandy substrata and sandbars near mouth 3-10 holes /m^2 on left bank and up to 2,5 holes /m^2 on right bank	Extensive population, which is the largest in a Cape estuary, seaward of the bridge	A small population extends to above the bridge
Arenicola loveni	Much reduced population in sandbars near the mouth. Densities 0,5-1,0/m^2	Widespread but sparse off the the right bank shoals. Densities up to 1/m^2	Individuals only extend to above the bridge

More deailed information on the distribution, abundance, biomass and production of the aquatic macro-invertebrates in the Kromme can be found in Hecht (1973), Baird *et al.* (1981), Hanekom (1982) and Emmerson *et al.* (1982).

SEEKOEI AND KABELJOUS

No information on the aquatic macro-invertebrates of either the Seekoei or Kabeljous estuaries has been published.

During the ECRU survey in November 1984 the sand shrimp *Palaemon pacificus* and crown crab *Hymenosoma orbiculare* were collected in the Seekoei at sampling stations upstream of the causeway using a beam trawl. These two decapod crustacean species as well as the crab *Cleistostoma edwardsii* and the amphipod *Melita zeylanica* were also collected in the dense beds of *Ruppia spiralis* in the Kabeljous. Egg-bearing *P. pacificus* females were present in the Kabeljous samples.

C M Gaigher *(in litt.)* sampled the major bait organisms in the Seekoei and Kabeljous estuaries in March 1980. In the Seekoei *C. kraussi* was dominant seaward of the causeway with *U. africana* confined to muddy substrates near the causeway. Upstream of the causeway the unusual phenomenon of mixed mud and sand prawn populations occurred. There were also signs of instability and adjustment with marine sediments moving up into the estuary in the vicinity of the causeway and *C. kraussi* extending its distribution. Catches for *C. kraussi* ranged from 14 to 43 prawns per 10 cores with a prawn pump and hole counts ranged from 70 to 434 holes per m^2. For *U. africana* catches ranged from 2 to 4 prawns per 10 cores and hole counts from 10 to 16 holes per m2. Shells of the bivalve *Solen corneus* were seen. *C. kraussi* catches ranged from 10 to 45 prawns per 10 cores with a prawn pump and hole counts from 71 to 397 holes per m2.

4.2.4 Fish

KROMME

A total of 45 fish species have been recorded in the Kromme Estuary and its tributaries (see Appendix V). This total is derived from the records of Baird *et al.* (1981), Hanekom (1982), Emmerson *et al.* (1982), Marais (1983), the Cape Department of Nature and Environmental Conservation and the ECRU survey. Of this total, 38 species are marine or estuarine and seven are freshwater species.

Marais (1983) caught 22 species of fish by gill-netting at 3 sites in the Kromme from February 1977 to November 1980. Compared to the Swartkops and Sundays estuaries, the Kromme yielded the greatest catch per unit effort in terms of number of fish but was second highest in terms of biomass (Marais, 1983). The most abundant fish species in terms of numbers and mass were the leervis *Lichia amia* which was more abundant in summer than winter and sea-catfish *Galeichthys feliceps* which breeds in the estuary (Marais, 1983).

During the ECRU survey in November 1984 gill-net sampling in the lower, middle and upper reaches of the Kromme Estuary yielded a total catch of 68 fish comprising 10 species (see Table 8). The most abundant species was the sea cat-fish *G. feliceps* with a catch of 41 fish with a total mass of 20,4 kg. The second most abundant species was the leervis *L. amia* with a total catch of 7 immature fish weighing a total of 4,0 kg.

Baird *et al.* (1981) carried out comparative gill and seine netting in both the estuary and the Marina Glades canals during June and November 1978. The species composition in the estuary and the marina was found to be similar but both gill and seine net catches in the estuary yielded a greater total number of individuals and total biomass than for catches made in the marina (Baird *et al.*, 1981). The greater biomass and number of fish in the gill-net catches in the estuary were mainly due to the large numbers of sea-catfish *G. feliceps* caught during November. Seine net catches at six stations in the marina canals did not indicate any definite distribution pattern of fish within the marina. Species such as the southern mullet *Liza richardsonii,* the groovy mullet *L. dumerili,* estuarine round-herring *Gilchristella aestuaria,* white steenbras *Lithognathus lithognathus,* blacktail *Diplodus sargus* and species of Gobiidae and Soleidae were recorded at the three stations while other species were sampled at one or two stations. The entire canal system therefore appears to be accessible to estuarine fish (Baird *et al.*, 1981).

Hanekom (1982) and Hanekom and Baird (1984) sampled *Zostera* and non-*Zostera* regions of the upper middle reaches of the Kromme Estuary. Twenty-four fish species were recorded. Only two species, the Cape moony *Monodactylus falciformis* and Cape stumpnose *Rhabdosargus holubi,* were recorded in significantly higher numbers in the *Zostera* than non-*Zostera* regions and community analyses revealed no significant differences between the catches from the two regions (Hanekom and Baird, 1984). These results are contrary to the findings of most previous studies in southern African estuaries in that the latter generally revealed greater fish diversity and number in *Zostera* than in non-*Zostera* regions (Hanekom and Baird, 1984). The possible reasons for the above-mentioned differences are discussed by these authors.

The fish species found primarily in *Zostera* beds in the Kromme were the tank goby *Glossogobius giurus,* the prison goby *Caffrogobius multifasciatus,* the Knysna sand goby *Psammogobius knysnaensis,* the longnose pipefish *Syngnathus acus,* the Cape stumpnose *Rhabdosargus holubi,* the flathead mullet *Mugil cephalus* and the Cape moony *Monodactylus falciformis* (Hanekom, 1982). The above

TABLE 8: Gill-net catches for the Kromme (3 stations), Seekoei (2 stations) and Kabeljous (2 stations) estuaries during the ECRU survey in November 1984. A standard gill-net was set for a 12-hour period (dusk to dawn) at each station. The sampling was carried out by Mr M King of the Cape Department of Nature and Environmental Conservation who also supplied the catch data.

Species	Kromme (3 stations)			Seekoei (2 stations)			Kabeljous (2 stations)		
	Number caught	Mean fork length (cm)	Length range (cm)	Number caught	Mean fork length (cm)	Length range (cm)	Number caught	Mean fork length (cm)	Length range (cm)
Mugil cephalus	-	-	-	7	33,2	25,0-42,0	1	-	34,0
Liza richardsonii	7	25,2	19,9-28,7	1	-	24,0	27	30,3	22,5-37,0
Liza dumerili	-	-	-	10	19,7	17,8-20,6	3	24,6	24,0-25,0
Liza tricuspidens	-	-	-	1	-	36,9	-	-	-
Myxus capensis	-	-	-	-	-	-	1	-	36,0
Lichia amia	7	37,2	28,2-47,7	2	45,6	43,5-47,6	2	37,3	37,2-37,3
Lithognathus lithognathus	-	-	-	11	29,4	17,8-46,4	-	-	-
Lithognathus mormyrus	1	-	20,8	-	-	-	-	-	-
Rhabdosargus holubi	2	15,5	11,1-20,0	17	13,6	10,5-17,0	1	-	13,5
Argyrosomus hololepidotus	3	52,5	48,9-55,0	1	-	50,0	8	44,1	39,5-52,1
Elops machnata	1	-	60,0	-	-	-	-	-	-
Pomadasys commersonnii	1	-	60,0	1	-	54,4	1	-	16,5
Pomadasys olivaceum	-	-	-	-	-	-	21	13,8	12,7-15,2
Pomatomus saltatrix	4	32,7	21,3-47,3	1	-	34,0	2	34,6	26,9-42,2
Galeichthys feliceps	41	33,8	28,0-42,4	10	18,3	14,8-22,4	-	-	-
Solea bleekeri	-	-	-	9	11,3	10,5-12,0	-	-	-
Monodactylus falciformis	1	-	12,3	2	14,9	13,3-16,5	1	-	15,8
Oreochromis mossambicus	-	-	-	1	-	31,8	-	-	-
Total number	68			74			68		

species, with the exception of the last three were classified as permanent residents, spending virtually their entire life cycle in *Zostera* beds. *R. holubi*, *M. cephalus* and *M. falciformis* were regarded as the major seasonal residents and these were mainly juveniles sheltering in the estuary before moving out to sea as adults (Hanekom, 1982).

In a study of the feeding ecology of major carnivorous fish from four eastern Cape estuaries, Marais (1984) found that the sea-catfish *G. feliceps* enter the Kromme largely for breeding rather than feeding purposes. This was seen during the ECRU survey in November 1984 with *G. feliceps* making up 60 percent of the gill-net catches by numbers (see Table 8), most of which were brooding eggs or juveniles.

The Kromme Estuary, being permanently open to the sea and strongly tidal is readily accessible to marine fish species (Marais, 1983). Furthermore the original Marina Glades canals, being well flushed with tidally driven water are inhabited by marine and estuarine fish species (Baird *et al.*, 1981).

SEEKOEI AND KABELJOUS

No information on the fish fauna of either the Seekoei or Kabeljous has been published. During the ECRU survey in November 1984, the Seekoei and Kabeljous estuaries were sampled using gill-nets and a beam trawl. The fish species recorded, along with records of freshwater species obtained from the Cape Department of Nature and Environmental Conservation, are listed in Appendix VI. For the Seekoei Estuary and its tributaries, 19 marine or estuarine and 3 freshwater species are listed. For the Kabeljous Estuary and its tributaries, 14 marine or estuarine and 3 freshwater species are listed.

Gill-netting at 2 stations upstream of the causeway in the Seekoei Estuary yielded a total catch of 74 fish comprising 14 species (see Table 9). The most abundant species by numbers was the Cape stumpnose *Rhabdosargus holubi* with a total catch of 17 juveniles and a total mass of 1,0 kg. The second most abundant species was the white steenbras *Lithognathus lithognathus* with a catch of 11 immature fish weighing a total of 5,1 kg.

Two gill-net sampling stations in the Kabeljous yielded a total of 68 fish comprising 11 species (see Table 9). The most abundant species by numbers was the southern mullet *Liza richardsonii* with a total catch of 27 adult fish weighing 11,1 kg. The second most abundant species was the piggy *Pomadasys olivaceum* with a total catch of 21 juveniles.

Since the Seekoei and Kabeljous estuaries are closed off from the sea by substantial sandbars for much of the time, recruitment of marine fish species can only take place after flood- or artificially-induced breaching opens the estuaries to the sea. The flow data in Pitman *et al.* (1981) suggest that natural breaching of the mouths would usually occur in late winter.

4.2.5 Amphibians and Reptiles

A checklist of reptile and amphibian species for the areas covered by the 1:50 000 Topographical sheets 3424 BB Humansdorp and 3324 DD Hankey is shown in Appendix VII. The Kromme Estuary, Seekoei Estuary and much of its catchment and lower reaches of the Kabeljous Estuary are situated in the area covered by the grid square 3424 BB. The upper reaches of the Kabeljous Estuary and much of its catchment fall within the area covered by the grid square 3324 DD.

For grid square 3424 BB, recorded species include 9 frogs, 8 lizards and 4 snake species. In grid square 3324 DD, 3 frog species, 1 tortoise species, 1 lizard species and 3 snake species have been recorded (Appendix VII). According to A L de Villiers (Cape Department of Nature and Environmental Conservation, pers. comm.) the lizard checklists in Appendix VII are far from complete as lizard taxonomy in southern Africa is under review at present.

None of the reptile or amphibian species is listed in the South African Red Data Book (Mc Lachlan, 1978) as being rare or threatened.

4.2.6 Birds

Bird count data for the Kromme, Seekoei and Kabeljous estuaries are given in Appendix VIII. These data are for summer 1978/79 counts in all 3 estuaries as well as spring 1977 and summer 1982/83 counts for the Kabeljous. At the Kromme a total of 1 183 birds comprising 35 species was counted. The wader component of this total amounted to 1 005 birds comprising 20 species. Of these there were 951 migrants comprising 14 species and 54 residents consisting of six species.

The summer bird counts for the Kromme, Seekoei and Kabeljous estuaries are comparable in terms of total numbers of species and birds (Appendix VIII). In view of the relatively larger size of the Kromme a higher bird count might have been expected. A possible reason for the proportionately lower count for the Kromme is the disturbance factor due to recreational activities on the estuary. Further differences between the counts for the Kromme and the other two estuaries are that there were more waders but a total lack of waterfowl (African Shelduck, Cape Shoveller, Yellow-billed Duck, Red-billed Teal and Red-knobbed Coot) in the Kromme. This could be due to the bigger shallow circumference area in the Kromme.

The Seekoei River Nature Reserve was established in 1969 primarily as a waterfowl sanctuary, and bird counts have been made. These counts, which cover the period 1965 to 1985 (C W Heyl, Cape Department of Nature and Environmental Conservation *in litt.*), are the only quantitative biological data available for the estuary. Because the waterfowl are 'top consumers' in the system, the status of the population and its species composition can provide an integrated picture of the status of the estuary as a whole.

While there are seasonal fluctuations in the numbers of birds at the Seekoei (Appendix IX), Heyl *(in litt.)* is of the opinion that the absence of the Southern Pochard and Cape Teal for the period August 1979 to April 1985, the low numbers of Cape Shoveller and Maccoa Duck over this extended period and the lower average number of waterfowl compared to the pre-1970 data, could indicate a progressive deterioration in environmental conditions for waterbirds in the estuary. This view is strengthened by the current predominance of waterfowl capable of utilizing terrestrial habitats. It appears therefore that, with the exception of the January to June 1983 period, conditions for the aquatic-feeding species (e.g. Cape shoveller, Cape Teal, Southern Pochard and Maccoa Duck) deteriorated. Such changes could have resulted from the recent developments, such as the construction of the causeway which isolates the upper estuary from tidal influence.

Overall, the Seekoei Estuary has become less attractive as a feeding ground for waterfowl and may now serve primarily as a predator free refuge. The lack of regular tidal exposure of the foreshore has made it less attractive to waders and flamingos.

The high bird counts for the Seekoei at the beginning of 1983 were also reflected in the January 1983 count (Appendix VIII) for the Kabeljous which was closed at the time. A total of 3 430 birds consisting of 33 species was counted. The high count was largely attributable to the large numbers of Curlew Sandpipers (2 300) and Common/Arctic Terns (400). It is notable that the month of January is characterized by low rainfall and run-off (see Figure 2) and progressive drying out of the closed Kabeljous (and Seekoei) lagoon may have been the reason for the high abundance of birds, in particular waders.

Generally it appears that the Kromme, despite its large size, does not support large numbers of waterbirds. The reasons for this are probably related to the lack of extensive intertidal mud flats and saltmarsh areas and also the disturbance factor associated with development, in particular boating.

The smaller Seekoei and Kabeljous, however, support greater densities of water birds than the Kromme, particularly during the summer months when they are closed. The upper reaches of the Seekoei, in particular, are inhabited by large numbers of waterfowl. In recent years, since the construction of the causeway, there has been a predominance of waterfowl capable of utilizing terrestrial feeding habitats (e.g. Egyptian Goose) possibly indicating a deterioration in the habitat for aquatic feeding species (Cape Shoveller, Cape Teal, Southern Pochard and Maccoa Duck) (C W Heyl, *in litt.)*. The protection afforded by the Seekoei River Nature Reserve is undoubtedly a major factor in attracting waterbirds to the estuary.

The Kabeljous is relatively undisturbed which makes it an attractive waterbird habitat, particularly during the dry months when it is closed. The wetland area and associated channels immediately to the north-east of the lower reaches of the lagoon constitute an important area for waders in particular (Underhill *et al.*, 1980).

4.2.7 Mammals

A checklist of the mammal species (P H Lloyd, Cape Department of Nature and Environmental Conservation, *in litt.)* which have been recorded in and which are likely to occur in the areas covered by the 1:50 000 Sheets 3424 BB Humansdorp and 3324 DD Hankey is given in Appendix X. The Kromme, Seekoei and lower reaches of the Kabeljous are covered by 3424 BB whereas the upper reaches of the Kabeljous and its catchment are covered by 3324 DD.

Twelve species have been recorded in the two areas. Of this total only the Spectacled dormouse is recorded as being "rare" in the South African Red Data Book for Terrestrial Mammals (Smithers, 1986).

Fifty-eight species are listed in Appendix X (P H Lloyd, *in litt.)* as being likely to occur in the above-mentioned areas. Of this total, nine species are listed as being "vulnerable, rare, indeterminate" or "not designated" in the South African Red Data Book Terrestrial Mammals (Smithers, 1986).

The mammal species which occur in the Seekoei River Nature Reserve are Bushbuck, Blue duiker, Grey duiker, Grysbok and Vervet monkey (P J Barnard, Cape Department of Nature and Environmental Conservation *in litt.)*.

5. SYNTHESIS AND RECOMMENDATIONS

Present state of the systems

The Kromme is a permanently open estuary which has been subject to disruption through coastal developments as well as the construction of two major dams in its catchment. The general sanding up of the estuary and the recent development of sand spits near the mouth and bridge could have profound effects on the functioning of the Kromme as an open estuary.

The saltmarshes, the eelgrass beds with their associated fish communities and the sand- and mudbank organisms are all vitally dependent on tidal exchanges.

Saltmarsh fringes and sandbanks have in recent years indicated a gradual succession from subtidal to intertidal plant species. This suggests that the sanding up of the estuary may be a permanent rather than a cyclical process, particularly as the new Elandsjagt Dam will dampen the effects of minor floods.

The Seekoei and Kabeljous rivers end in seasonally closed coastal lagoons which would naturally break open to the sea after floods and high-water levels. At present they are artificially opened when rising water-levels threaten property. On the South African coast, both estuaries are unusual in being largely privately-owned. Their catchments are small and obstructed by many small farm dams which strongly reduce run-off, particularly in dry years (Maaren and Moolman, 1986). A large dam is proposed for the Kabeljous River for irrigation of farmland and to supplement the water supply to Jeffreys Bay.

All three estuaries have reasonably undisturbed areas of saltmarsh and submersed plant and animal communities. These communities should be maintained and protected against further disturbance to ensure that these estuaries remain ecologically functional. Similarly much of the area surrounding the estuaries is still in a natural state. To maintain the viability of the estuaries *(inter alia* through maintenance of the stability of embankments) these areas should not be disturbed.

In view of the conservation value of the vegetation in the area and the threat of development, the existing nature reserves are inadequate. The nature reserves include: Cape St Francis Nature Reserve (CPA), Irma Booysen (Private), Elandsjagt (DEA) and Seekoei River (CPA).

Present state of knowledge

Aspects of the ecology of the Kromme Estuary (see Sections 3.2.4 and 4.2) have been studied by the Zoology and Geology departments of the University of Port Elizabeth and, to a lesser extent, the NRIO. The research efforts of these organizations have given a good understanding of the bio-physical functioning, of the Kromme. However, a major void in the available information on the Kromme is the lack of quantitative data on the rates of sediment movement associated with the estuary mouth dynamics.

The investigation of the influence of the Marina Glades on the ecology of the estuary (Baird *et al.*, 1981) concentrated primarily on the beneficial effects of the increased area on the estuarine fauna, although the potential for stagnation in some of the blind canals was mentioned. Subsequent to this study the marina has been considerably extended. Insufficient data are available for the prediction and modelling of the hydrology of the marina and its interchanges with the estuary proper. There is insufficient information on the effect of possible reduced flow in the marina as a result of the sanding up of the estuary and on the effect of septic tank loads on the marina system once all canal-side plots have been developed.

The erosion at Sea Vista Beach has been monitored quantitatively and the causative factors have been investigated (see Section 3.2.1). Erosion has been partially attributed to the stabilization of the sand dunes to the south-west of the Kromme which used to feed sand into Kromme Bay (St Francis Bay Beach Erosion, 1980; The Kromme Estuary, 1984; Lubke, 1985). Studies by the NRIO (St Francis Beach Erosion, 1980; The Kromme Estuary, 1984) have indicated that, before stabilization, sand used to blow from the dunes near Cape St Francis into the surf zone and be transported and deposited on the beaches by the northerly current during calmer conditions. At present only a very small portion of the dune remains unstabilized - a strip of shifting sand connecting Kromme Bay with Seal Bay (between Seal Point and Cape St Francis). Following the recommendations of the NRIO, this sand bypass system (which allows sand to move from Seal Bay into Kromme Bay thereby bypassing Cape St Francis) has been ensured through its annexation to the Cape St Francis Nature Reserve. This sediment source should be preserved at all cost. However, availability of this source of sand to the St Francis Bay beach region, could be threatened by the location of the proposed small boat harbour in Kromme Bay and this is a matter which needs careful consideration.

Knowledge of the Seekoei Estuary is largely limited to sediment studies relating to the disruptions caused by the construction of the swimming pool/car-park complex at the mouth and the consequent building of the causeway higher up in the lagoon (see Section 3.2.1). Minimal work on the biological features of this coastal lagoon has been carried out although regular bird counts have been conducted from the early 1970s to present (see Section 4.2.6).

Other than the sediment studies of Reddering and Esterhuysen (1984) and the ECRU survey for this report, little or no work has been carried out on the Kabeljous Estuary.

A detailed survey of the vegetation in the region from Tsitsikamma to the Gamtoos River mouth and inland, has been completed. Certain vegetation types were identified as being unique in occurring along this part of the coast only and for this reason are highly conservation worthy. Furthermore these recommendations were endorsed by the Cape Department of Nature and Environmental Conservation and the National Committee for Nature Conservation (NAKOR).

Problems: present and foreseeable

ST FRANCIS BAY/KROMME AREA

Present and forseeable problems include:

(1) Sanding up of the lower estuary.

(2) Erosion of the beach at St Francis Bay Village.

(3) Possible implications of the proposed small-boat harbour in Kromme Bay.

(4) Coastal ribbon development.

(5) Alien plant invasions.

(1) Sanding up of the lower Kromme Estuary (see Section 3.2.1)

In historical times the Kromme Estuary has been perennially open to the sea. However, since the early part of this century the river has undergone major man-induced alterations to its natural course. The Churchill Dam was built in its upper reaches in 1943. In the 1950s the course of the wide delta-like mouth was restricted for the development of a marina system on its south bank. The marina also altered the confluence of a seasonal tributary, the Sand River. Instead of entering the Kromme via a dense reed-bed swamp, the Sand River now enters the estuary higher up over a sandy area which is now covered in alien acacias. The marina was linked by two canals to the estuary, the first canal close to the estuary mouth and the other canal joining the estuary about 1 km upstream of the mouth. Since their establishment, the canals have been kept open by sporadic dredging. However, in recent years more frequent maintenance dredging has been required. In 1980 the bridge spanning the estuary was built about 3 km from its mouth. The supporting embankments have disturbed a large portion of one of the largest saltmarshes of the estuary. In 1983 the Elandsjagt Dam was built about 1 km above the tidal reach, effectively reducing run-off from the catchment of the estuary. According to Fromme and Badenhorst (1987) the dams, especially the Elandsjagt Dam, will substantially dampen floods smaller than those with a magnitude of 1-in-30 years.

The individual contributions of these manmade changes are difficult to isolate. The estuary functions similarly to most open estuaries. Sand of marine origin is brought in by the incoming tides and deposited in the estuary. Under natural conditions periodic floods would have scoured this sand out and maintained the estuary in an open state. However, there are indications that the lower estuary is sanding up, particularly since the completion of the Elandsjagt Dam. In addition the extension of sandbanks in the region of the Sand River suggests that some sand is being imported into the estuary from this source.

(2) Erosion of the beach at St Francis Bay (see Section 3.2.1)

Sea Vista beach appears to have eroded considerably over the past 20 years, thereby threatening the stability of some beach-front houses and severely reducing the size of the beach at high spring tides. The rate of erosion increased during the early 1980s and was monitored during that period (Lubke, 1985). More recently the beach appears to have stabilized relative to that period of rapid loss, although erosion cannot be assessed without further bench-mark surveys. It is not possible at this stage to assess the short or long-term nature of the erosion. Nevertheless, construction of a harbour wall in Kromme Bay could affect littoral sediment movement and further aggravate the beach erosion problem.

(3) Possible implications of the proposed small-boat harbour in Kromme Bay

A small-boat harbour has been proposed off the coast near Second Bush, north of Cape St Francis Point, largely to serve the needs of the squid jigging fishery centred on the Cape south coast. Studies on the squid populations indicate a viable, though highly seasonal fishery (C J Augustyn, Sea Fisheries Research Institute, pers. comm.). Whether the industry justifies the construction of a harbour has not been clearly demonstrated.

Some support for the harbour project relates to the possible solution it offers to problems caused by the use of the Kromme Estuary for the mooring of commercial squid fishing boats. This view can be debated on the grounds of the uncertain future of the estuary due to sanding up of the mouth region, and the possible effect of the harbour walls on beach erosion. The impact of a fishing harbour on the area will be manifold. It appears that the reefs off St Francis Bay have already been overfished and the danger of over exploitation of intertidal areas for bait, by increasing numbers of fishermen cannot be overlooked. The importance of development of employment prospects for the local population cannot be over-emphasized, but present information suggests that squid fishing boat crews will be 'imported' into the area. The sociological implications of introducing substantial numbers of fishermen into an area which presently does not provide appropriate facilities and where unemployment is a problem, are serious.

Under these circumstances a final decision concerning the development of the Kromme Bay small-boat harbour should be delayed until such time as the compatibility of a sophisticated holiday/residential area with the requirements of a commercial fishing venture, have been properly weighed up against each other.

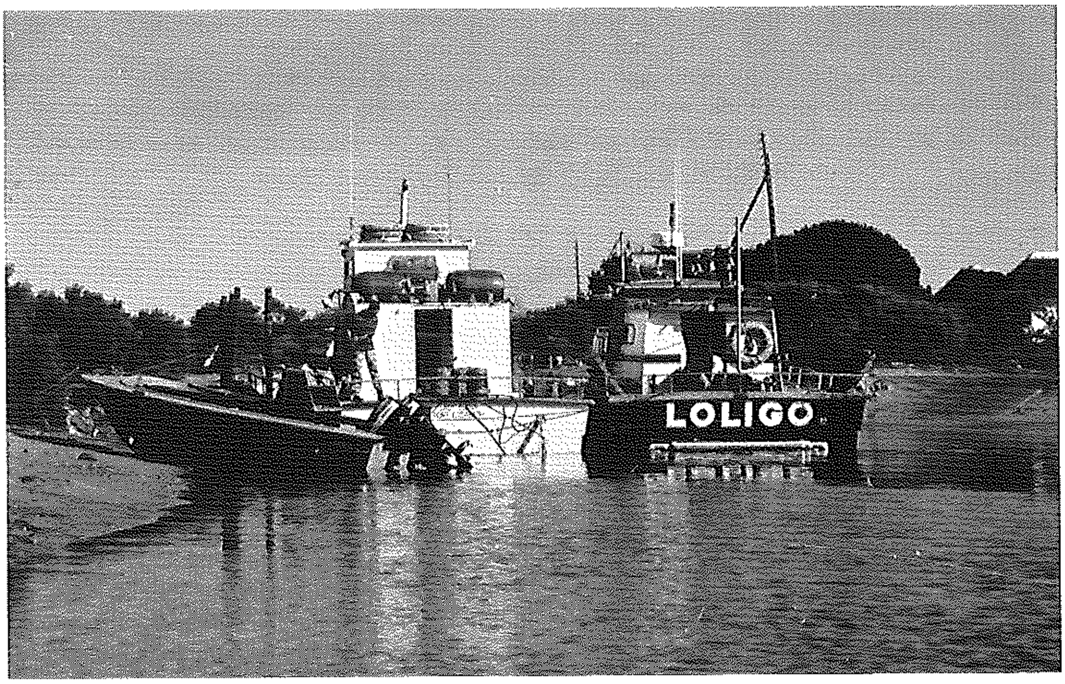


FIG. 23: Commercial squid fishing boats moored in a Marina Glades canal. Squid fishing activities are incompatible with the recreational and residential use for which the marina was designed and the recreational activities in the Kromme Estuary. (ECRU: 86-07-31).

(4) Coastal ribbon development

At present the entire coastal strip from the Gamtoos River mouth to St Francis Bay is earmarked for development. Coastal ribbon development in a holiday resort area which is dependent upon natural amenities is highly undesirable. Naturally vegetated areas which have been identified as being unique, face extinction under threat of coastal development. An example of this situation is at Second Bush which is adjacent to the proposed harbour site and which has been identified as a priority area for conservation by the Cape Department of Nature and Environmental Conservation and NAKOR. Another example is the proposal for a road through the Rebelsrus Private Nature Reserve to give access to a future development further along the coast. Permission for this road would set a bad precedent, especially when alternative routes are possible. The establishment and maintenance of private nature reserves, particularly along the coast, should be encouraged by the State and Province, especially in view of the rising cost of land.

(5) Alien plant invasion

The role of the Port Jackson willow and rooikrans in the stabilization of sand has been highly successful. However, these two species have invaded natural vegetation and are severely threatening its future existence. Plant, bird and animal richness will be lost if this invasion is unchecked. Furthermore, the establishment of the alien acacias in the dunes to the south-west of St Francis Bay Township, has enhanced the hazard of fire.

SEEKOEI AND KABELJOUS

The sandbars at the mouths of both the Seekoei and Kabeljous estuaries are artificially breached when water levels threaten surrounding properties and structures. Such action is ecologically deleterious as it not only prevents the water from spreading naturally amongst wetland fringe areas, but also from building up to a level which would enable effective scouring to take place. Unless absolutely essential, artificial breaching of the sandbars at the mouths of these two systems should not be permitted. If breaching cannot be avoided, the Department of Environment Affairs (DEA) should be consulted to determine the highest level to which the water in the estuary should be allowed to rise before the mouth is opened artificially.

Furthermore the time of breaching is important. This should coincide with peak rainfall and run-off in the area (see Figure 2), namely, late winter/early spring and be carried out just before (±2 hours) spring low tide.

The major problems associated with the Seekoei have been discussed in Section 3.2.1. In brief, the natural dynamics of the mouth have been severely disrupted by the construction of the swimming pool/car-park complex and the subsequent construction of the causeway as a solution is problematic. The existing culverts (see Figure 24) are too small and are wrongly sited thereby preventing adequate circulation. The causeway is too low necessitating premature artificial breaching of the mouth. However, the main problem to be faced by the controlling authorities is the influx of sediment through the open mouth or by washover over the sandbar. A further problem is that scouring by future floods may prove to be inadequate for tidal exchange.

The Kabeljous is at present in a relatively undisturbed ecological state, but impoundment of the run-off from the catchment could have deleterious effects on the natural dynamics. According to Fromme and Badenhorst (1987) the volume of marine and wind-driven sand which enters the Kabeljous is only slightly greater than is removed by flood-scouring. The biology of the estuary is relatively undisturbed by human impact.

The sedimentary equilibrium is apparently maintained by a mechanism whereby depositions of marine sand by sheet flow accretion during flood tides is balanced by channel erosion during ebb-tides. However, increasing land-use in the catchment resulting in decreased run-off and thus, scouring power of the river, and with the continuous influx of sand from the sea by washover and wind transport across the sandbar, shoaling of the estuary basin is in slow progress (Fromme and Badenhorst, 1987). Hence any further reduction in run-off in the Kabeljous will exacerbate this process and furthermore could result in the onset of hypersaline conditions through evaporative water loss, particularly after the hot summer season. Under these circumstances it is unfortunate that a dam is to be built on the Kabeljous River and some facility for the controlled release of water to fulfil the requirements of the estuary should be incorporated into the planning of the dam.

The existing development on or near the edge of the estuary is on the south-western banks in the lower reaches of the estuary. Some of this development is low-lying and is in danger of being flooded during very high water-levels. Any further development around the estuary should be above the 1 in 50-year flood-line to obviate the need for artificial breaching. Furthermore, to avoid pollution, conservancy tanks should be stipulated in areas where water table contamination is a risk.

Because of its unique vegetation, the area on the northern and north-eastern banks should be maintained in its natural state. It is well suited to limited development for recreation (e.g. picnic sites). Controls on vehicle tracks and thicket disturbance are badly needed at present. The wetland and lagoon channels which are tidally flooded when open to the sea should not be disturbed (e.g. vehicle tracks). These are important habitats for migrant water species (Underhill *et al.*, 1980).

FIG. 24: Central section of the Seekoei Causeway showing existing culverts which are insufficient to accommodate adequate water circulation. The water level downstream (RHS) of the causeway was significantly lower than upstream (LHS) in this photograph due to the mouth having just been breached. (ECRU: 86-01-19).

Recommendations

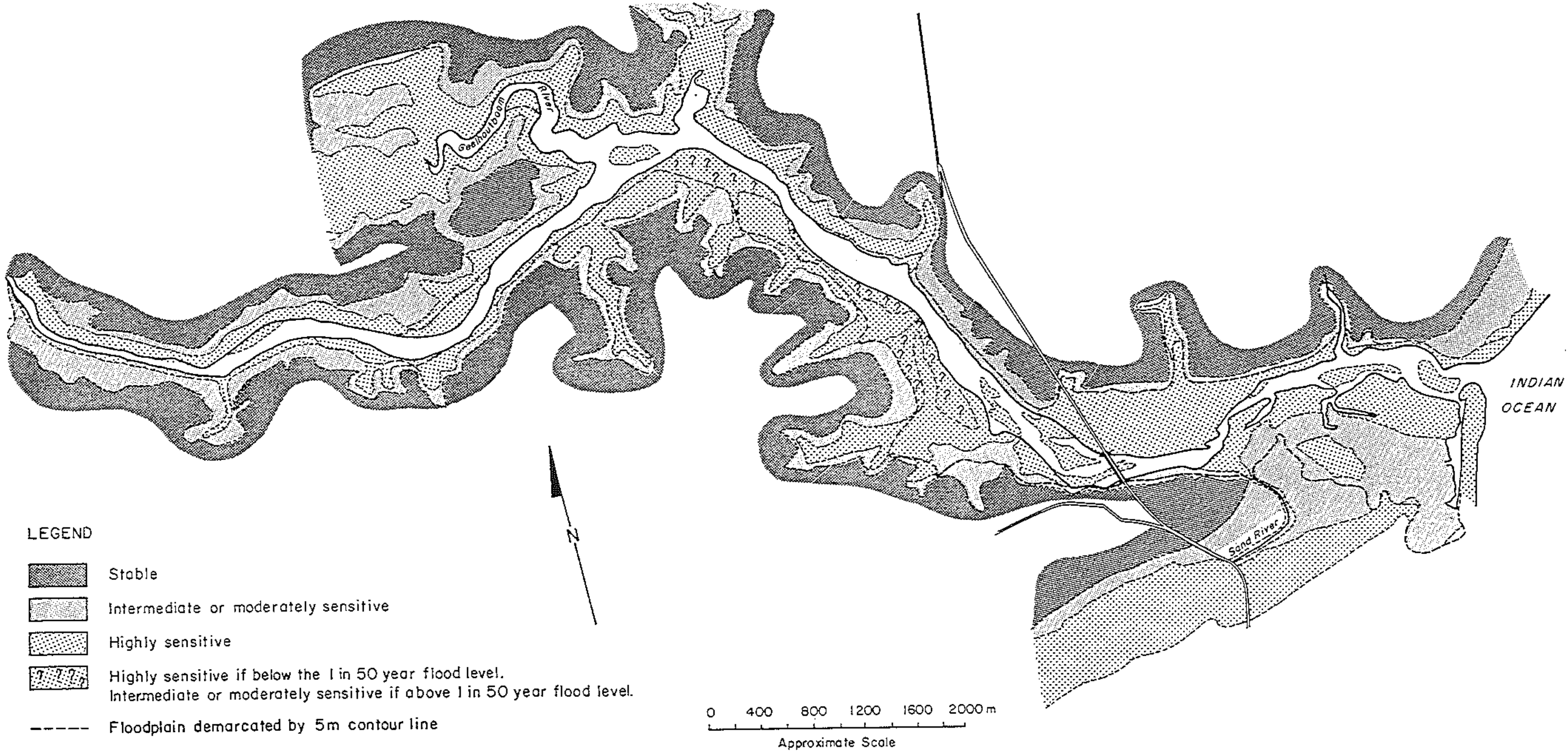
In view of the changing needs of the communities in the area, the rate of expansion of development and the ecological sensitivity of the coastline and estuaries, an overall structure plan is urgently needed for the sub-region. Because of the lack of a structure plan, development proposals in the area cannot be assessed on the basis of land-use zonation. This has resulted in such proposals being considered on a site-specific basis. The CPA Department of Local Government, Town and Regional Planning Section is at present compiling a sub-regional structure plan for the coastal area from the Gamtoos River in the north-east to the Eerste River and Oubosstrand in the west. Hopefully this plan will take into account the necessity to preserve the natural resources of the area.

In general, development should be restricted to areas which have already been disturbed by earlier developments or by invasion of alien plants such as rooikrans. Areas which are still in a natural state should, as far as possible be protected against development. Ecologically sensitive areas around the Kromme Estuary (Bickerton, 1986) have been classified according to a report "Principles and Objectives for Coastal Zone Management in the Republic of South Africa" (Report No. 1) (Heydorn, 1986) and mapped in Figure 25, which designates:

Stable areas where development could take place with relatively little risk if sound ecological and planning guidelines are adhered to.

Intermediate or **Moderately sensitive** areas where further investigations must be carried out to determine whether development is feasible or desirable. In this case, developments must be carried out according to specific guidelines. (These guidelines are at present being compiled by the Committee for Coastal and Marine Systems of the Council for the Environment (Schneier, in prep.)).

FIG. 25 : Classification of sensitive areas associated with the Kromme Estuary (from Bickerton, 1986)



Highly sensitive areas where no development should be considered. Broadly speaking these areas would correspond to the "areas of high risk as a result of natural processes" referred to in Report No. 1 mentioned above.

The above-mentioned sensitivity classification is provided for guidance. However, all proposals for future developments should be subject to environmental impact assessments by independent bodies to ensure that alternatives to environmentally harmful developments are considered.

The estuaries

KROMME

In terms of its conservation status the Kromme Estuary is rated as Category C (controlled status where development is prohibited or strictly controlled by recreational activities, including fishing and bait collecting are allowed) (Grindley and Cooper, 1979). A working group of the SA National Committee for Oceanographic Research (SANCOR) (Heydorn, ed., 1986) allocated the Kromme to Category 3 (develop but according to environmentally acceptable guidelines) rating.

More specific management recommendations for the Kromme Estuary are as follows:

(1) It is essential that steps be taken to control the sanding up of the lower Kromme Estuary. Quantitative data are needed on the rates of sediment movement associated with the estuary mouth dynamics. A study should be carried out in order to establish feasible remedial measures. Dredging, although costly, may be the final solution. A stabilization and re-vegetation programme for the Sand River is strongly recommended.

(2) Associated with (1) above, there is also a need to investigate the effects of the two dams, in particular the Elandsjagt Dam, on the estuary. Although this applies particularly to the sediment dynamics of the lower estuary, some consideration of the effects of impoundment on salinities in the estuary, particularly in the upper reaches, is necessary. Facilities for increasing the rates of controlled water releases to meet the requirements of the estuary should be considered.

(3) No further extensions to the Marina Glades canals should be permitted until the detailed hydrology of the present and proposed canal systems has been completed. Furthermore, the water quality of the Marina Glades should be monitored during peak holiday season and tested for stagnation (dissolved oxygen concentrations) and for possible septic tank contamination (*E. coli* counts).

(4) All saltmarshes around the estuary should be conserved and protected against any further damage, in particular by vehicles and trampling by man and livestock.

(5) The steep slopes of the Kromme and Geelhoutboom rivers upstream of their confluence must be protected against any form of destruction as the substratum is highly prone to erosion. Much of this area is covered in dense thickets of very old trees which are highly conservation worthy. At a meeting of the Humansdorp Divisional Council, the CPA Department of Local Government, the Cape Department of Nature and Environmental Conservation, the Department of Environment Affairs and the NRIO it was decided in principle that, in order to conserve as much as possible of the upper reaches, the lower reaches only of the Kromme should be considered for development. This decision is fully supported.

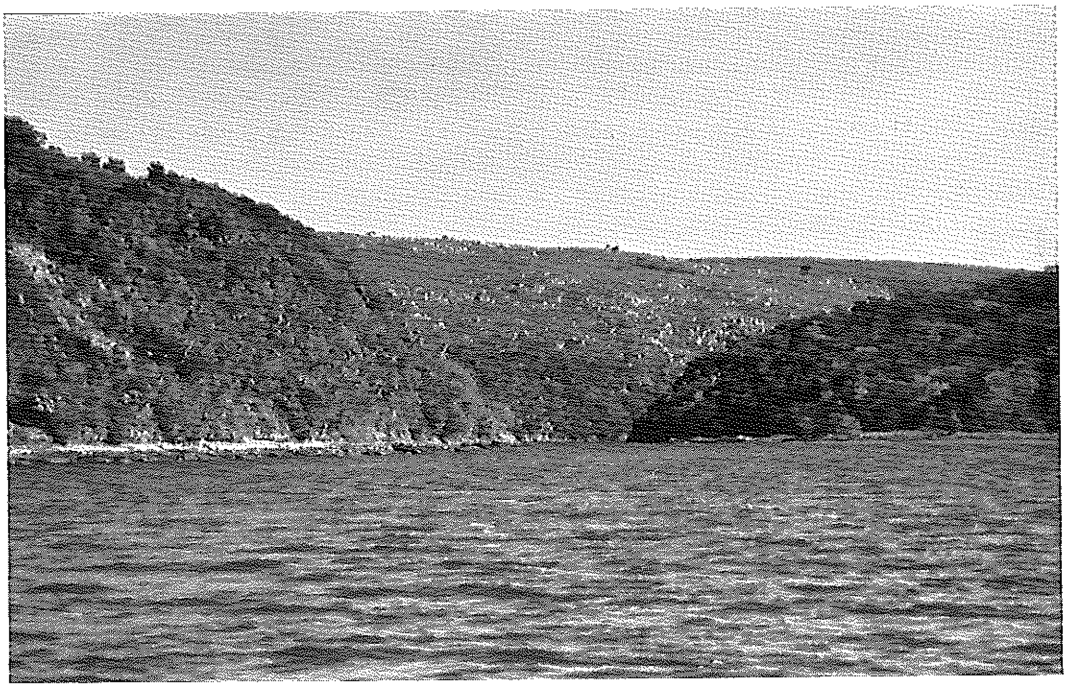


FIG. 26: A typical view of the upper reaches of the Kromme Estuary. Prominant features are the steeply-sloping sides and natural vegetation which contribute significantly to the aesthetic appeal. (ECRU: 86-07-31).

(6) The recommendations of the Environmental Evaluation Unit (UCT) listed in Section 3.2.2 should be followed. These were that:

(a) the numbers and activities of boats on the estuary must be regulated during peak holiday periods;

(b) water-skiing should be restricted to the area upstream of the Kromrivier Holiday Resort;

(c) power-boats should not travel in excess of 10 km/h in the region of, and just upstream of, the marina system, and should use this section for access only, restricting their activities to other areas of the estuary;

(d) additional access should be provided for board-sailors;

(e) the proposed development of facilities for commercial fishing boats should not be permitted;

(f) communal jetties and slipways should be favoured over numerous private facilities.

SEEKOEI AND KABELJOUS

The condition of the Seekoei was described as 'poor' by the SANCOR Working Group (Heydorn, ed., 1986) but that it could be rehabilitated. It was given a Category 3 rating (develop but according to environmentally acceptable guidelines).

The Kabeljous was rated B which is reserve status with no exploitation allowed, but unrestricted public entry, and controlled boating (Grindley and Cooper, 1979). The SANCOR Working Group (Heydorn, ed., 1986) rated the estuary as Category 2 (conserve but permit controlled development). The north-eastern banks are rated as Category 1 (conserve in present state).

Specific management recommendations for the Seekoei and Kabeljous estuaries are as follows:

(1) The causeway across the Seekoei Estuary should be upgraded (as recommended in Section 3.2.1), thereby improving tidal exchange over the whole area of the estuary.

(2) There is an urgent need for an impact assessment on the proposed dam on the Kabeljous River to ensure that the dam specifications meet the water release requirements for the estuary.

(3) Any future development on the north-eastern banks of the Kabeljous should not unduly disturb the natural vegetation and wetland area with associated channels immediately to the north-east of the lower reaches of the lagoon.

(4) The natural vegetation of the saltmarshes and on the banks of the Kabeljous and Seekoei estuaries should be protected against further destruction. In particular the dumping ground on the south-western bank of the Seekoei should be closed. The siting of a dumping area adjacent to a natural water body is likely to result in pollution and possibly a health hazard.

(5) Investigation is needed to determine the most ecologically favourable conditions (time, frequency and water level) for artificial drainage of the Seekoei and Kabeljous lagoons to take place.

The coastline

In view of the increasing holiday and residential impacts on the natural resources of the coastline it is recommended that certain sections of the coastline including the rocky intertidal areas be proclaimed coastal reserves before becoming too degraded. Proposals are made below:

In terms of intertidal reserves, this protection will benefit users of unprotected areas by providing nursery grounds for intertidal animals to spawn and recolonize the exploited areas. This principle would also apply to angling fish species. The areas recommended for protection are those nearest to the developed resorts where impacts are greatest and where protection of natural resources may serve recreational and educational purposes. In addition it is strongly recommended that the rocky shore of the Cape St Francis Nature Reserve be proclaimed an intertidal reserve.

The proposal by the Cape Department of Nature and Environmental Conservation for the Cape St Francis Coastal Park is endorsed. The park would comprise core areas proclaimed as nature reserves with the remaining areas in the category of Schedule 5 National Park. The proposed boundaries are:

(1) In the north, the northern bank of the Kromme River from the mouth to the point where the N2 National Road crosses the river.

(2) In the west, the township of Oyster Bay and the gravel road to Oyster Bay from Humansdorp.

(3) In the south, the coastline from the Kromme Estuary mouth to Oyster Bay.

Existing State-owned land should be given primary conservation status. For the remainder, landowners should be motivated to register their land under Schedule 5 in order to maintain the veld in its natural state and receive some State aid for doing so.

It is furthermore recommended that the coastal land between Oyster Bay and the Tsitsikamma National Park similarly be given the status of a coastal park, consisting of core nature reserves (State-owned land) with the remaining areas in the category of Schedule 5 National Park.

It is recommended that in the area of the St Francis Bay village aquifer to the north-west of the old power station, development should be restricted in order to retain this valuable source of potable water for possible future needs.

Full support is given to the proposal by Heydorn and Tinley (1980) and Tinley (1985) that the coastline between the Kabeljous and Gamtoos estuary mouths be made a priority area for conservation. The area comprises barrier vleis between the primary dunes and hinterland forming a rich wetland. Heydorn and Tinley (1980) recommended a Category B reserve rating (reserve status with no exploitation allowed and controlled public entry so that the carrying capacity of the area is not overloaded). Being near major towns, the reserve would fulfil important recreational and educational functions.

On the recommendations of archaeologists, sites of historical value, such as shell middens, should be preserved. These sites are at present protected by an Act of Parliament. Co-operation with developers should be favoured rather than rigid application of regulations and a compromise between development and preservation of historical and cultural sites should be encouraged.

Impact assessment

Thorough impact assessments are required before construction of the proposed small boat harbour. Considerations should be as follows:

(1) The impact of the harbour on beach erosion particularly at St Francis Bay Beach.

(2) The impact on the world famous surfing wave known as Bruce's Beauties which is down-swell of the harbour site. This wave is world-renowned and is part of the major draw-card to international surfers on the professional competition circuit, being the site of one of the world's most perfect waves. It would be a national loss should the quality of this surfing wave be degraded in any way.

(3) The sociological impact of fishing crews on St Francis Bay Village which caters mainly for holiday-makers (as well as being a residential area for many retired people) and offers no facilities for fishermen on shore.

Concluding statement

It is imperative that the sub-regional structure plan presently being compiled for the area between the Gamtoos River in the north-east and Oubosstrand in the south-west take the natural features and resources into account and that the planners decide on the overall direction of the area and plan accordingly. Of consideration is the fact that for the Storms-Fish River region, only 0,2 percent of South Coast Renosterveld, 2,1 percent of Grassy Fynbos and 8,9 percent Dune Fynbos/Thicket is currently conserved (Jarman, 1986).

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Aerial Photographs

Estuary	Date	Job no.	Photo nos	Scale 1:	Type	Source
Kromme	1942	2/42	162,163,165	30 000	B&W	Trig. Survey
	1961	459	833,3	36 000	B&W	Trig. Survey
	1979	326	241-43	10 000	Col.	Univ. of Natal
	1980	349	65	20 000	B&W	Univ. of Natal
	1980	374	130	20 000	B&W	Univ. of Natal
	1981	391	224-27/4	20 000	Col.	Univ. of Natal
	1986	891	3553-8 3595-7 3611	50 000	B&W	Trig. Survey
	1987	-	770-780	10 000	Col.	ECRU/NRIO
Seekoei	1942	2/42	96-99	30 000	B&W	Trig. Survey
	1961	459	8336	36 000	B&W	Trig. Survey
	1968	295/8	9577-79	8 000	B&W	Trig. Survey
	1979	326	238-40	10 000	Col.	Univ. of Natal
	1980	349	66	20 000	B&W	Univ. of Natal
	1980	374	129	20 000	B&W	Univ. of Natal
	1981	391	220-23/4	20 000	Col.	Univ. of Natal
	1986	891	3552 3590-91	50 000	B&W	Trig. Survey
	1987	-	783-786	10 000	Col.	ECRU/NRIO
Kabeljous	1942	2/42	9099	30 000	B&W	Trig. Survey
	1961	459	8339	36 000	B&W	Trig. Survey
	1979	326	236, 37	10 000	Col.	Univ. of Natal
	1980	349	67	20 000	B&W	Univ. of Natal
	1980	374	128	20 000	B&W	Univ. of Natal
	1981	391	217-19/4	20 000	Col.	Univ. of Natal
	1987	-	790-793	10 000	Col.	ECRU/NRIO

8. 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°, 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(a): Physical features and species of the vegetation mapping units for the area mapped in and around the Kromme Estuary.

Mapping unit	Area (ha)	% of area studied	Average height (m)
Water	262,68	6,27	
Open sand	27,94	0,67	
Sandbanks	59,28	1,42	
Zostera capensis	15,81	0,38	
Saltmarsh	104,93	2,51	0,1
Floodplain	68,55	1,64	0,1-0,5
Phragmites australis	18,91	0,45	2,0
Hummock dunes	3,91	0,09	0,1-0,4
Dune grassland/Dune fynbos mosaic	130,58	3,12	0,1-0,5/0,5-2,0
Dune Fynbos/Dune thicket mosaic	19,81	0,47	0,5-2,0/1,0-3,0
Dune thicket	21,32	0,51	1,0-3,0
TMG sandstone thicket	119,31	2,85	2,0-5,0
Shale thicket	366,14	8,74	2,0-5,0
South coast renosterveld	199,75	4,77	0,2-1,0
Grassy fynbos	502,92	12,01	0,5-1,0
Agriculture	1 974,24	47,13	
Alien afforestation	146,54	3,50	3,0
Residential/Development	146,56	3,50	
TOTAL	4 189,18	100,03	

Symbols in brackets following each species name, represent Braun-Blanquet Cover-Abundance classes as follows:

r - 1/few individuals, cover less than 0,1 percent of area
\+ - occasional plants, cover less than 1 percent of area
1 - abundant, cover 1 - 5 percent of area
2 - any number, cover 6 - 12 percent of area
3 - any number, cover 26 - 50 percent of area
4 - any number, cover 51 - 75 percent of area
5 - any number, cover 76 - 100 percent of area.

APPENDIX I(a): (Cont.)

Saltmarsh

Chenolea diffusa (1); *Cotula coronopifolia* (1); *Juncus kraussii* (1); *Limonium linifolium* (1); *L. scabrum* (+); *Plantago crassifolia* (+); *Ruschia tenella* (+); *Sarcocornia perennis* (1); *S. capensis* (1); *Spartina maritima* (2); *Triglochin bulbosa* (1); *T. striata* (1).

Floodplain

Acacia cyclops (2); *A. saligna* (1); *Cotula coronopifolia* (1); *Cynodon dactylon* (2); *Disphyma crassifolia* (+); *Juncus kraussii* (2); *Sporobolus virginicus* (3); *Stenotaphrum secundatum* (2).

Hummock dune low open herbland

Acacia cyclops (3); *Arctotheca populifola* (2); *Carpobrotus acinasiformis* (1); *Chrysanthemoides monilifera* (2); *Cynanchum obtusifolium* (+); *Hebenstreitia cordata* (+); *Ipomoea brasiliensis* (2); *Metalasia muricata* (1); *Scaevola plumieri* (+); *Zaluzianskya maritima* (+).

Dune Grassland

***Themeda-Stenotaphrum* community**

Centella coriacea (1); *Cotula sericea* (+); *Cullumia decurrens* (1); *Cynodon dactylon* (1); *Ficinia indica* (1); *Geranium incanum* (1); *Hermannia althaeoides* (1); *Setaria flabellata* (2); *Sporobolus africanus* (1); *Stenotaphrum secundatum* (4); *Themeda triandra* (4).

Dune Fynbos

***Ischyrolepis-Agathosma* community**

Agathosma stenopetala (2); *Chondropetalum microcarpum* (2); *Felicia echinata* (1); *Imperata cylindrica* (1); *Ischyrolepis eleocharis* (3); *Lasiochloa longifolia* (1); *Limonium scabrum* (+); *Linum africanum* (+); *Muraltia squarrosa* (1); *Rhus laevigata* (1).

***Ischyrolepis-Maytenus* community**

Agathosma apiculata (3); *Cassine tetragona* (+); *Cassytha ciliolata* (+); *Ficinia ramosissima* (2); *Ischyrolepis eleocharis* (3); *Maytenus procumbens* (2); *Metalasia muricata* (2); *Myrica quercifolia* (+); *Olea exasperata* (1); *Rhoicissus tridentata* (+); *Salvia africana-lutea* (1); *Sutera microphylla* (1).

Dune Thicket

***Cassine-Cussonia* community**

Carissa bispinosa (1); *Cassine aethiopica* (3); *Cussonia thyrsiflora* (2); *Euclea racemosa* (2); *Olea exasperata* (1); *Pterocelastrus tricuspidatus* (3); *Putterlickia pyracantha* (2); *Rhus glauca* (1); *Scutia myrtina* (2); *Solanum quadrangulare* (1); *Sideroxylon inerme* (3); *Tarchonanthus camphoratus* (1).

TMG sandstone Thicket

***Pterocelastrus-Gonioma* community**

Aloe arborescens (1); *Buddleja saligna* (2); *Cassine peragua* (1); *Diospyros dicrophylla* (2); *Gonioma kamassi* (3); *Hippobromus pauciflorus* (2); *Chionanthus foveolata* (2); *Maytenus acuminatus* (3); *Pterocelastrus tricuspidatus* (3); *Rhoicissus digitata* (2); *Scutia myrtina* (2); *Sideroxylon inerme* (3).

Shale Thicket

***Pterocelastrus-Euclea* community**

Aloe africana (1); *Carissa bispinosa* (1); *Euclea undulata* (3); *Hippobromus pauciflorus* (3); *Maytenus acuminatus* (1); *Maytenus heterophylla* (2); *Olea europaea* (1); *Protasparagus aethiopicus* (2); *Pterocelastrus tricuspidatus* (3); *Rhus longispina* (3); *Scotia afra* (2); *Scutia myrtina* (3); *Sideroxylon inerme* (3).

APPENDIX I(a): (Cont.)

South Coast Renosterveld

***Themeda-Cliffortia* community**

Arctopus echinatus (+); *Cliffortia linearifolia* (3); *Cotula turbinata* (+); *Elytropappus rhinocerotis* (2); *Ischyrolepis sieberi* (1); *Lobelia erinus* (+); *Pentaschistis angustifolius* (1); *Protasparagus capensis* (+); *Selago canescens* (1); *Spiloxene minuta* (+); *Tetraria cuspidata* (1); *Themeda triandra* (5).

***Metalasia-Erica* community**

Elytropappus rhinocerotis (1); *Erica decipiens* (4); *Hermannia flammea* (+); *Metalasia muricata* (4); *Montinia caryophyllaceae* (+); *Muraltia ericaefolia* (1); *Passerina vulgaris* (1); *Phylica axillaris* (1); *Restio triticeus* (2); *Rhus incisa* (+).

Grassy Fynbos

***Thamnochortus-Erica* community**

Carpacoce vaginellata (1); *Diheteropogon filifolius* (1); *Erica diaphana* (2); *Erica pectinifolia* (2); *Eriospermum cordiforme* (+); *Helichrysum teretifolium* (1); *Hypodiscus willdenowia* (1); *H. aristatus* (2); *Leucadendron salignum* (2); *Leucospermum cuneiforme* (1); *Tetraria circinalis* (2); *Tetraria compressa* (1); *Thamnochortus glaber* (3).

***Trachypogon-Erica* community**

Erica pectinifolia (2); *Leucadendron salignum* (2); *Leucospermum cuneiforme* (1); *Protea neriifolia* (1); *Restio triticeus* (2); *Themeda triandra* (2); *Trachypogon spicatus* (2).

APPENDIX I(b): Physical features and species of the vegetation mapping units for the area mapped in and around the Seekoei Estuary.

Mapping unit	Area (ha)	% of area studied	Average height (m)
Water	87,60	8,82	
Sand	27,72	2,79	
South coast renosterveld	86,68	8,72	0,2-1,0
Shale thicket	67,41	6,78	2,0-4,0
Agriculture	616,62	62,06	
Residential/Development	107,61	10,83	
TOTAL	993,64	100,0	

Shale Thicket

Aloe africana (1); *Azima tetracantha* (2); *Carissa bispinosa* (1); *Cussonia thyrsiflora* (2); *Euclea undulata* (3); *Hippobromus pauciflorus* (2); *Hypoestes aristata* (2); *Maytenus heterophylla* (1); *Putterlickia pyracantha* (2); *Rapanea gilliana* (1); *Rhus glauca* (2); *Schotia afra* (2); *Scutia myrtina* (2); *Tarchonanthus camphoratus* (2).

APPENDIX I(b): (Cont.)

***Pterocelastrus-Euclea* community**
Acacia cyclops (1); *Cassine peragua* (3); *Euphorbia triangularis* (2); *Pterocelastrus tricuspidatus* (2); *Rhus longispina* (2).

South Coast Renosterveld
Anthospermum aethiopicum (1); *Brachiaria serrata* (2); *Chrysocoma tenuifolia* (1); *Cymbopogon marginatus* (2); *Eragrostis capensis* (1); *Eriocephalus africanus* (2); *Helichrysum teretifolium* (1); *Indigofera denudata* (1); *Metalasia muricata* (3); *Passerina rubra* (2); *Pelargonium dichondraefolium* (+); *Selago corymbosa* (1); *Sporobolus africanus* (2).

***Elytropappus-Metalasia* community**
Agathosma ovata (+); *Elytropappus rhinocerotis* (3); *Euryops munitus* (1); *Hermannia salvifolia* (1); *Relhania genistaefolia* (1); *Themeda triandra* (4).

NOTE: See Appendix I(a) for Braun-Blanquet Cover-Abundance classification.

APPENDIX I(c): Physical features and species of the vegetation mapping units for the area mapped in and around the Kabeljous Estuary.

Mapping unit	Area (ha)	% of area studied	Average height (m)
Water	226,47	22,22	
Sand	126,57	10,55	
Phragmites australis	3,78	0,32	2,0
Hummock dune low open herbland	8,11	0,68	0,1-1,0
Succulent thicket	195,21	16,28	2,0-5,0
Floodplain	35,83	2,99	0,1-0,3
Sedgeland	41,60	3,47	0,1-0,3
South coast renosterveld	97,00	8,09	0,2-1,0
Dune fynbos/Dune thicket mosaic	49,46	4,12	0,5-1,0/1,0-3,0
Agriculture	286,89		
Residential/Development	88,72	7,40	
TOTAL	1 199,24	100,01	

Hummock dune low open herbland
Acacia cyclops (1); *Arctotheca nivea* (2); *Chrysanthemoides monilifera* (1); *Felicia echinata* (+); *Metalasia muricata* (1); *Passerina rigida* (1).

South Coast Renosterveld
Aspalathus nivea (1); *Chrysocoma tenuifolia* (2); *Cynodon dactylon* (3); *Euryops algoensis* (1); *Falkia repens* (1); *Ficinia tristachya* (1); *Glottiphyllum longum* (+); *Helictotrichon hirtulum* (+); *Hypoxis stellipilis* (+); *Protasparagus capensis* (1); *Rhus incisa* (1); *Walafrida geniculata* (1).

APPENDIX I(c): (Cont.)

***Elytropappus-Eustachys* community**
Aspalathus chortophilla (2); *Elytropappus rhinocerotis* (3); *Euryops euryopoides* (1); *Metalasia muricata* (1); *Relhania genistaefolia* (2); *Sporobolus africanus* (1); *Themeda triandra* (3).

Succulent Thicket
Aloe africana (2); *Canthium spinosum* (2); *Cassine tetragona* (1); *Delosperma ecklonis* (2); *Euphorbia fimbriata* (+); *Grewia occidentalis* (2); *Maytenus heterophylla* (1); *Plumbago auriculata* (1); *Protasparagus racemosus* (1); *Putterlickia pyracantha* (1); *Rhus glauca* (2); *Scolopia zeyheri* (1).

***Sideroxylon-Euphorbia* community**
Capparis sepiaria (2); *Cassine aethiopica* (2); *Euclea racemosa* (3); *E. undulata* (3); *Euphorbia mauritanica* (1); *E. triangularis* (3); *Hypoestes aristata* (3); *Rhus longispina* (2); *Scotia afra* (2); *Sideroxylon inerme* (2).

Dune Thicket
Aloe africana (1); *Cassine tetragona* (+); *Olea exasperata* (2); *Polygala myrtifolia* (2); *Protasparagus capensis* (+); *P. racemosus* (+); *Rapanea gilliana* (1); *Rhoicissus digitata* (1); *R. tridentata* (1).

***Cassine-Cussonia* community**
Colpoon compressum (1); *Euclea racemosa* (3); *Pterocelastrus tricuspidatus* (1); *Rhus crenata* (2); *R. glauca* (2); *Sideroxylon inerme* (2).

Dune Fynbos
Agathosma apiculata (2); *Cassytha ciliolata* (+); *Chondropetalum microcarpum* (2); *Crassula expansa* (+); *Helichrysum teretifolium* (1); *Ischyrolepis eleocharis* (3); *Metalasia muricata* (2); *Nylandtia spinosa* (2); *Passerina rigida* (1); *Salvia africana-lutea* (1).

NOTE: See Appendix I(a) for Braun-Blanquet Cover-Abundance classification.

APPENDIX II: List of plant species confined to the south-eastern Cape (*sensu* Cowling, 1983) which occur in the area around the Kromme Estuary. For those marked with an asterisk the Cape St Francis area comprises one of the last remaining refuges.

Grassy fynbos	Dune fynbos	South coast renosterveld	Kaffrarian thicket
Agathosma gonaquensis	*Agathosma stenopetela**	*Agathosma acutissima*	*Aloe africana*
Aloe microcantha	*Brunsvigia litoralis**	*Brunsvigia gregaria**	*Cassine reticulata*
Anapalina intermedia	*Centella hermaniifolia**	*Erica unilateralis*	*Delosperma ecklonis*
Argyrolobium incanum	*Cyrtanthus speciosus**	*Euryops munitus*	*Euryops euryopoides*
Aspalathus setacea	*Erica chloroloma**	*Euphorbia gorgonis*	*Ledebouria socialis*
Blepharis procumbens	*Eriospermum brevipes*	*Felicia zeyheri*	*Senecio pyramidatus*
Erica pectinifolia	*Felicia echinata**	*Gasteria armstrongii**	
E. sparmannii	*Haplocarpha lyrata*	*Hypoxis stellipilis*	
Euryops munitus	*Helichrysum argenteum*	*Lampranthus productus*	
Gnidia coriacea	*Muraltia squarrosa*	*Metalasia aurea*	
G. styphelliodes	*Othonna rufibarbis**	*Pelargonium dichondrifolium**	
Haplocarpha lyrata	*Phylica litoralis**	*Sutera atrocaerulea**	
Indigofera hispida	*Polygala ericifolia**		
I. sulcata	*Rapanea gilliana**		
Otholobium polyphyllum	*Satyrium princeps**		
Passerina pendula	*Thesium leptocaule*		
Phylica abietina	*Zygophyllum uitenhagense**		
Protea foliosa			
Senecio crenulatus			

APPENDIX III: Zooplankton species recorded at two sites in the Marina Glades canals and at 10 sites in the Kromme Estuary sampled in June and November 1978 (Data from Baird *et al.*, 1981)

ANNELIDA
Polychaete larvae

CRUSTACEA
Copepoda
Acartia longipatella

Acartia natalensis

Copepod spp.

Corycaeus sp.
Euterpina acutifron
Microsetella norvegica
Nauplii larvae
Oithona spp.

Oncaea spp.
Paracalanus crassirostris
Pseudodiaptomus hessei

Pseudodiaptomus nudus

Tortanus capensis

MYSIDACEA
Gastrosaccus brevifissura
Adult males and non-brooding females
Brooding females

Immature and juveniles

Mesopodopsis slabberi
Adult males and non-brooding females

Brooding females

Immature and juveniles

Rhopalopthalmus terranatalis

Cumacea
Iphinoe truncata

Amphipoda
Melita zeylanica

Brachyura

Megalopa larvae

Zoea larvae

CHAETOGNATHA
Sagitta spp.

APPENDIX IV: Macro-invertebrates recorded in the Kromme Estuary and Marina Glades canals. Records from Hecht (1973), Baird *et al.* (1981), Hanekom (1982) and Emmerson *et al.* (1982).

Scientific Name	Common Name
NEMERTEA	
Polybrachiorhynchus dayi	Tapeworm
ECHIURIDA	
Ochaetostoma capense	Tongue worm
ANNELIDA : Polychaeta	
Errantia	
Glycera tridactyla	Polychaete
Ceratonereis erythraensis	Polychaete
Marphysa sanguinea	Polychaete

APPENDIX IV: (Cont.)

Scientific Name	Common Name
Sedentaria	
Arenicola loveni	Bloodworm
Mercierella enigmatica	Polychaete
Potamilla reniformis (marina canals only)	Polychaete
Sabellastarte longa (marina canals only)	Giant fan-worm
ARTHROPODA : Crustacea	
Cirripedia	
Balanus elizabethae (marina canals only)	Barnacle
Malacostraca : Peracarida	
Isopoda	
Cyathura carinata	Isopod
Exosphaeroma hylecoetes	Isopod
Cirolana fluviatilis	Isopod
Apseudes digitalis	Isopod
Amphipoda	
Grandidierella lignorum	Amphipod
Corophium triaenonyx	Amphipod
Melita zeylanica	Amphipod
Malacostraca : Eucarida	
Penaeus indicus	White prawn
Penaeus monodon	Tiger prawn
Penaeus latisulcatus	Brown prawn
Alpheus crassimanus	Cracker shrimp
Palaemon pacificus	Sand shrimp
Betaeus jucundus	Shrimp
Callianassa kraussi	Sand prawn
Upogebia africana	Mud prawn
Diogenes brevirostris	Hermit crab
Cleistostoma edwardsii	Crab
Cleistostoma algoense	Crab
Cyclograpsus punctatus	Shore crab
Sesarma catenata	Marsh crab
Thaumastoplax spiralis	Three-legged crab
Rhyncoplax bovis	Crab
Hymenosoma orbiculare	Crown crab
Lupa pelagica	Blue swimming crab
Scylla serrata	Giant mud crab
MOLLUSCA : Pelecypoda	
Loripes clausus	Mussel
Macoma litoralis	Mussel
Psammotellina capensis	Mussel
Tellina gilchristi	Mussel
Dosinia hepatica	Mussel
Donax sordidus	Mussel
Eumarcia paupercula	Mussel
Arcuatula (Lamya) capensis	Estuarine mussel
Solen capensis	Pencil bait
Solen cylindraceus	Pencil bait
Musculus virgiliae	Mussel

APPENDIX IV: (Cont.)

Scientific Name		Common Name
Gastropoda		
Siphonaria oculus	(marina canals only)	Limpet
Haminea alfredensis		Snail
Nassarius kraussianus		Snail
Natica tecta		Necklace shell
Hydatina physis	(marina canals only)	Snail
Notarchus leachii		Sea slug
Cephalopoda		
Sepia afficianalis		Cuttlefish
Octopus granulatus	(marina canals only)	Octopus
ECHINODERMATA : Echinoidea		
Parechinus angulosus	(marina canals only)	Sea urchin
TUNICATA : Ascidiacea		
Pyura stolonifera	(marina canals only)	Red bait

APPENDIX V: Fish species recorded in the Kromme Estuary and its tributaries. Records from Baird *et al.* (1981), Mellville-Smith (1981), Hanekom (1982), Emmerson *et al.* (1982), Marais (1983), S C Thorne, Cape Department of Nature and Environmental Conservation, *in litt.*, and the ECRU survey carried out in November 1984. Nomenclature according to Smith and Heemstra (1986) and Bruton *et al.* (1982).

Marine/Estuarine

Scientific Name	Common Name
Mugil cephalus	Flathead mullet
Liza tricuspidens	Striped mullet
Liza richardsonii	Southern mullet
Valamugil buchanani	Bluetail mullet
Liza dumerilii	Groovy mullet
Myxus capensis	Freshwater mullet
Lichia amia	Leervis
Argyrosomus hololepidotus	Kob
Pomadasys commersonnii	Spotted grunter
Elops machnata	Tenpounder
Pomatomus saltatrix	Elf
Galeichthys feliceps	Sea-catfish
Rhabdosargus holubi	Cape stumpnose
Rhinobatus annulatus	Lesser guitarfish
Acanthopagrus berda	Riverbream
Monodactylus falciformis	Cape moony
Myliobatus aquila	Eagle ray
Lithognathus lithognathus	White steenbras
Lithognathus mormyrus	Sand steenbras
Sarpa salpa	Strepie
Dasyatis brevicaudatus	Short-tail stingray
Diplodus sargus	Blacktail
Diplodus cervinus	Zebra
Pomadasys olivaceum	Piggy
Gilchristella aestuaria	Estuarine round-herring
Syngnathus acus	Longnose pipefish

APPENDIX V: (Cont.)

Scientific Name	Common Name
Hepsetia breviceps	Cape silverside
Clinus superciliosus	Super klipfish
Caffrogobius multifasciatus	Prison goby
Glossogobius giurus	Tank goby
Psammogobius knysnaensis	Knysna sandgoby
Spondyliosoma emarginatum	Steentjie
Heteromycteris capensis	Cape sole
Solea bleekeri	Blackhand sole
Etrumeus teres	Red-eye round-herring
Hemirhamphus sp.	Halfbeak
Omobranchus woodi	Kappie blennie
Stolephorus holodon	Thorny anchovy

Freshwater

Scientific Name	Common Name
Barbus pallidus	Goldie barb
Barbus afer	Eastern Cape redfin
Sandelia capensis	Cape kurper
Tilapia sparrmanii	Banded tilapia
Glossogobius tenuiformis	River goby
Lepomis macrochirus	Bluegill sunfish
Micropterus salmoides	Largemouth bass

APPENDIX VI: Fish species recorded in the Seekoei and Kabeljous estuaries. Records from S C Thorne, Cape Department of Nature and environmental Conservation *(in litt.)* and the ECRU survey carried out in November 1984. Nomenclature according to Smith and Heemstra (1986) and Bruton *et al.* (1982).

Scientific Name	Common Name	Seekoei	Kabeljous
Marine/Estuarine			
Mugil cephalus	Flathead mullet	*	*
Liza richardsonii	Southern mullet	*	*
Liza dumerilii	Groovy mullet	*	*
Liza tricuspidens	Striped mullet	*	-
Myxus capensis	Freshwater mullet	-	*
Lichia amia	Leervis	*	*
Lithognathus lithognathus	White steenbras	*	-
Rhabdosargus holubi	Cape stumpnose	*	*
Argyrosomus hololepidotus	Kob	*	*
Pomadasys commersonnii	Spotted grunter	*	*
Pomadasus olivaceum	Piggy	-	*
Pomatomus saltatrix	Elf	*	*
Galeichthys feliceps	Sea catfish	*	-
Monodactylus falciformis	Cape moony	*	*
Gilchristella aestuaria	Estuarine round-herring	*	-
Atherina breviceps	Cape silverside	*	-
Heteromycteris capensis	Cape sole	*	-
Solea bleekeri	Blackhand sole	*	-
Glossogobius giurus	Tank goby	-	*

APPENDIX VI: (Cont.)

Scientific Name	Common Name	Seekoei	Kabeljous
Glossogobius callidus (tenuiformis)	River goby	*	
Psammogobius knysnaensis	Knysna sand goby	*	*
Caffrogobius multifasciatus	Prison goby	-	*
Clinus superciloisus	Super klipfish	*	-
Freshwater			
Barbus afer	Eastern Cape redfin	*	*
Barbus pallidus	Goldie barb	-	*
Sandelia capensis	Cape kurper	*	*
Oreochromis mossambicus	Mocambique tilapia	*	-
Total number of species recorded		22	17

APPENDIX VII: Checklist of Amphibians and Reptiles recorded from (X) and likely to occur (L) in the areas covered by the 1:50 000 Topocadastral Sheets 3424 BB Humansdorp and 3324 DD Hankey (M E Steyn and A L de Villiers, Cape Department of Nature and Environmental Conservation, *in litt.*). The Kromme Estuary, the Seekoei Estuary and its tributaries and the lower reaches of the Kabeljous Estuary fall within the area covered by 3424 BB. The Kabeljous River and upper reaches of the estuary fall within the area covered by 3324 DD. See foot of appendix for key to record sources.

Common Name	Scientific Name	3424 BB	3324 DD
FROGS			
Common platanna	*Xenopus laevis*	L	L
Raucous toad	*Bufo rangeri*	XP	L
Leopard toad	*Bufo pardalis*	XP	L
Tremelo sand frog	*Tomopterna cryptotis*	XP	L
Common river frog	*Rana angolensis*	L	L
Cape river frog	*Rana fuscigula*	XP	L
Spotted rana	*Rana grayii*	XP	XC
Striped grass frog	*Rana fasciata*	XP, XC	L
Common caco	*Cacosternum boettgeri*	XP	L
Bronze caco	*Cacosternum nanum nanum*	XP	XC
Rattling kassina	*Kassina wealii*	L	L
Golden leaf-folding frog	*Afrixalis brachycnemis knysnae*	L	L
Painted reed frog	*Hyporolius marmoratus verrucosus*	XP	XP
TORTOISES/TERRAPIN			
Mountain tortoise	*Geochelone pardalis*	L	XG
Angulate tortoise	*Chersina angulata*	L	L
Padloper	*Homopus areolatus*	L	L
Cape terrapin	*Pelomedusa subrufa*	L	L
LIZARDS			
Spotted gecko	*Pachydactylus maculatus*	XV	L
Marbled gecko	*Phyllodactylus porphyreus*	XV	L
Rock agama	*Agama atra*	L	L
Golden sand skink	*Acontias meleagris*	XV	L
Cape three-striped skink	*Mabuya capensis*	XV	L

APPENDIX VII: (Cont.)

Common Name	Scientific Name	3424 BB	3324 DD
Cape speckled skink	*Mabuya homalocephala*	XV	XV
Yellow-throated plated lizard	*Gerrhosaurus flavigularis*	XV	L
Short-legged skink	*Tetradactylus seps*	XV	L
Yellow-striped mountain lizard	*Tropidosaura gularis*	L	L
Green-striped mountain lizard	*Tropidosaura montana*	L	L
Delalande's spotted lizard	*Nucras lalandii*	L	L
Ocellated sand lizard	*Eremias lineocellata*	L	L
Common Cape girdled lizard	*Cordylus cordylus cordylus*	XV	L
Cape snake lizard	*Chamaesaura anguina*	L	L
SNAKES			
Pink earth snake	*Typhlops lalandei*	L	L
Black worm snake	*Leptotyphlops nigricans*	L	L
Dusky-bellied water snake	*Lycodonomorphus laevissimus laevissimus*	L	XB
Brown water snake	*Lycodonomorphus rufulus*	XB	L
Yellow-bellied house snake	*Lamprophis fuscus*	L	L
Aurora house snake	*Lamprophis aurora*	L	L
Olive house snake	*Lamprophis inornatus*	L	L
Brown house snake	*Lamprophis fuliginosus*	L	L
Cape wolf snake	*Lycophidion capense capense*	L	L
Southern slug-eater	*Duberria lutrix lutrix*	L	XB
Mole snake	*Pseudaspis cana*	XB	L
Many-spotted reed snake	*Amplorhinus multimaculatus*	L	L
Spotted skaapsteker	*Psammophylax rhombeatus rhombeatus*	XB	L
Cross-marked sand snake	*Psammophis crucifer*	L	L
Southern shovel-snout	*Prosymna sundevallii sundevallii*	L	L
Green water snake	*Philothamnus hoplogaster*	L	L
Western Natal green snake	*Philothamnus natalensis occidentalis*	L	L
Herald snake	*Crotaphopeltis hotamboeia*	L	L
Boomslang	*Dispholidus typus typus*	L	L
Common egg-eater	*Dasypeltis scabra*	L	L
Rinkhals	*Hemachatus haemachatus*	L	L
Coral snake	*Aspidelaps lubricus*	L	L
Cape cobra	*Naja nivea*	L	XB
Rhombic night adder	*Causus rhombeatus*	L	L
Cape mountain adder	*Bitis atropos*	L	L
Puff-adder	*Bitis arietans arietans*	XB	L

XC - Cape Department of Nature and Environmental Conservation herpetological specimen collection (1972-1985)
XB - Broadley (1983)
XG - Greig and Burdett (1976)
XP - Poynton (1964)
XV - Visser (1984)

APPENDIX VIII: Counts of waders (Charadrii) and other birds at the Kromme, Seekoei and Kabeljous estuaries (from Underhill and Cooper, 1983 unpublished). New Roberts numbers (Maclean, 1985) are given in the first column. Species listed in the South African Red Data Book (Brooke, 1984) are indicated with an asterisk.

New Roberts' No.	LOCALITY / DATE / TIME / TIDE / TYPE	Kromme 79.01.05 13h00-17h00 Low Estuary	Seekoei 79.01.06 09h30-14h00 Flood Tidal estuary	Kabeljous 77.09.25 - - Tidal estuary	Kabeljous 79.01.06 15h00-18h00 - Closed Lagoon	Kabeljous 83.01.28 14h45-16h00 - Closed Lagoon
244	Black Oystercatcher	4	2	4	1	8
262	Turnstone	18	2		7	8
245	Ringed Plover	82	14		3	59
246	White-fronted Plover	11	4	6		16
248	Kittliz's Plover	3	3		6	
249	Three-banded Plover	28	3			
251	Great Sandplover	4				
254	Grey Plover	110	5	8	6	64
255	Crowned Plover			2		2
258	Blacksmith Plover	4	17	2	9	31
272	Curlew Sandpiper	371	362	34	197	2 300
274	Little Stint	30	112		29	9
271	Knot	27				3
281	Sanderling	115	2	12		117
284	Ruff	72	4		4	10
264	Common Sandpiper	9	7		3	1
269	Marsh Sandpiper					16
270	Greenshank	45	25		16	33
266	Wood Sandpiper	8	4			
288	Bar-tailed Godwit	3				
289	Curlew		3			1
290	Whimbrel	47	3			2
295	Black-winged Stilt	4	2			2
298	Water Dikkop		2		4	
297	Spotted Dikkop				1	
	Unidentified Waders	10				
55	White-breasted Cormorant	13	31	2	28	37
56	Cape Cormorant		2			
58	Reed Cormorant	11	14	8	43	21
60	Darter		1			
62	Grey Heron	7	4		7	9
66	Great White Egret	1				
67	Little Egret	3	11	3	5	6
71	Cattle Egret				34	7
84	Black Stork*					4
91	Sacred Ibis	16				
94	Hadeda				2	
97	Lesser Flamingo*	4				
103	African Shelduck		390	2	8	
104	Yellow-billed Duck		32	1	22	35
108	Red-billed Teal		20		6	
112	Cape Shoveller		20		4	
148	Fish Eagle				2	1
228	Red-knobbed Coot		78		534	88
312	Kelp Gull	52	7	2	24	76

APPENDIX VIII: (Cont.)

New Roberts' No.	LOCALITY / DATE / TIME / TIDE / TYPE	Kromme 79.01.05 13h00-17h00 Low Estuary	Seekoei 79.01.06 09h30-14h00 Flood Tidal estuary	Kabeljous 77.09.25 - - Tidal estuary	Kabeljous 79.01.06 15h00-18h00 - Closed Lagoon	Kabeljous 83.01.28 14h45-16h00 - Closed Lagoon
316	Hartlaub's Gull	1				
324	Swift Tern				6	5
326	Sandwich Tern	2	1		18	15
327/8	Common/Arctic Tern	36				400
339	White-winged Tern	1				40
428	Pied Kingfisher	2	5			
429	Giant Kingfisher		2			
713	Cape Wagtail	29	24		16	4
	TOTAL NUMBER OF BIRDS	1 183	1 218	86	1 045	3 430
	TOTAL NUMBER OF SPECIES	35	35	13	29	33
	WADER NUMBERS					
	Migrants	951	542	54	265	2 623
	Residents	54	33	14	21	59
	TOTAL	1 005	576	68	286	2 682
	WADER SPECIES					
	Migrants	14	12	3	8	13
	Residents	6	7	4	5	5
	TOTAL	20	19	7	13	18

APPENDIX IX: Comparative bird counts for the Seekoei Estuary.

1965-1969 — Seven counts (no dates given) from the records of the African Wildfowl Enquiry. The average number of waterfowl counted was 267 birds with African Shelduck making up 57 percent and Yellow-billed Duck, 24 percent. The Red-eyed Pochard was observed on two occasions with a maximum of 120 birds, whilst 37 Cape Teal were observed at a time. Heyl *(in litt.)*, however, did not indicate the extent of seasonal fluctuations in these counts.

March 1970 — The Eastern Cape Wild Bird Society recorded *ca.* 100 Ringed Plovers, 2 Great-crested Grebes, 1 Dabchick, 20 Yellow-billed Duck, 4 Fish Eagles and hundreds of Red-knobbed Coot. A total of 621 birds comprising 12 species was counted.

June/July 1970 — The mean of six counts carried out was 87 birds. South African Shelduck comprised 56 percent and Yellow-billed Duck, 42 percent. However, these were winter counts which are normally low.

August 1979 - April 1985 — Monthly counts by the Cape Department of Nature and Environmental Conservation yielded a mean count of 146 birds. Waterfowl numbers often peaked in the period November to April with a maximum of 1 087 in January 1983. Egyptian Geese and Yellow-billed Duck were the dominant waterfowl species comprising on

APPENDIX IX: (Cont.)

average, 66 and 29 percent respectively of the total number of birds recorded during counts. The maximum count for South African Shelduck was 42 which was appreciably less than for the counts carried out before 1969. Spurwing Geese, Cape Shovellers and Maccoa Duck were also recorded. Flamingos and Red-knobbed Coot occurred irregularly with maximum numbers of 601 and 914 respectively.

From January to June 1983 relatively favourable conditions existed in the Seekoei. During this period Egyption Geese numbers peaked at 1 031, Yellow-billed duck at 191 and Red-knobbed Coot at 914. A relatively high number (523) of flamingos was also observed. The reasons for the increased use of the Seekoei by waterbirds from January to June 1983 are not clear, although this is normally the driest part of the year.

APPENDIX X: Mammal species which occur and are likely to occur in the areas covered by the 1:50 000 topographic sheets 3424 BB Humansdorp (Kromme, Seekoei and mouth of the Kabeljous) and 3324 DD Hankey (upper reaches and catchment or the Kabeljous) (P H Lloyd, CDNEC *in litt.)*. Species marked with V, R or I are listed in the South African Red Data Book - Terrestrial Mammals (Smithers, 1986).

Species recorded as occurring in either 3424 BB or 3324 DD

Common name	Scientific name
Schreiber's long-fingered bat	*Miniopterus schreibersii*
Cape fruit bat	*Rousettusa egyptiacus*
Spectacled doormouse (R)	*Graphiurus occularis*
Multimammate mouse	*Praomys natalensis*
Striped mouse	*Rhabdomys pumilio*
Bush Karoo rat	*Otomys unisulcatus*
Vlei rat	*Otomys irroratus*
Black rat	*Rattus rattus*
Vervet monkey	*Cercopithecus pygerythrus*
Chacma baboon	*Papio ursinus*
Grysbok	*Raphicerus melanotis*
Caracal	*Felis caracal*

Species which are likely to occur in 3424 BB or 3324 DD

Common Name	Scientific Name
Forest shrew	*Myosorex varius*
Least dwarf shrew (I)	*Suncus infinitesmus*
Dwarf shrew	*Suncus etruscus*
Red musk shrew	*Crocidura flavescens*
Reddish-grey musk shrew	*Crocidura cyanea*
Duthie's golden mole (I)	*Chlorotalpa duthiae*
Hottentot golden mole	*Amblysomus hottentotus*
Cape horseshoe bat	*Rhinolophus capensis*
Cape serotine	*Eptesicus capensis*
Cape hairy bat	*Myotis tricolor*
Egyptian free-tailed bat	*Tadarida aegyptiaca*

APPENDIX X: (Cont.)

Common Name	Scientific Name
Geoffrey's horseshoe bat	*Rhinolophus clivosus*
Egyptian slit-faced bat	*Nycteris thebaica*
Wahlberg's epaulleted fruit bat	*Epomophorus wahlbergi*
Woodland mouse	*Thamnomys dolichurus*
Namaqua rock mouse	*Aethomys namaquensis*
Grey pygmy tree mouse	*Dendromus melanotis*
Chestnut climbing mouse	*Dendromus mesomelas*
Cape pouched mouse	*Saccostomus compestris*
Cape spring mouse	*Acomys subspinosus*
Pygmy mouse	*Mus minutoides*
House mouse	*Mus musculus* (exotic)

Species which are likely to occur in 3424 BB and 3324 DD

Common Name	Scientific Name
South African pygmy gerbel	*Gerbillurus paeba*
Short-tailed gerbil	*Desmodillus auricularis*
Common molerat	*Cryptomys hottentotus*
Cape mole rat	*Georychus capensis*
Saunder's vlei rat	*Otomys saundersae*
Black rat	*Rattus rattus* (exotic)
African water rat (I)	*Dasymys incomtus*
Brown rat	*Rattus norvegicus* (exotic)
Verraux's rat	*Praomys verreauxii*
Egyptian mongoose	*Herpestes ichneumon*
Cape grey mongoose	*Herpestes pulverulentus*
Water mongoose	*Atilax paludinosus*
Yellow mongoose	*Cynictis penicillata*
African striped weasel (R)	*Poecilogale albinucha*
Striped polecat	*Ictonyx striatus*
Honey badger (V)	*Mellivora capensis*
Cape clawless otter	*Aonyx capensis*
Common genet	*Genetta genetta*
Large spotted genet	*Genetta tigrina*
Rock dassie	*Procavia capensis*
Scrub hare	*Lepus saxatilis*
Cape fox	*Vulpes chama*
Black-backed jackal	*Canis mesomelas*
Antbear (V)	*Orycteropus afer*
Porcupine	*Hystrix africaeaustralis*
Blue duiker (R)	*Philantomba monticola*
Common duiker	*Sylvicapra grimmia*
Bushbuck	*Tragelaphus scriptus*
Mountain reedbuck	*Redunca fulvorufula*
Steenbok	*Raphicerus campestris*
Vaal Rhebok	*Pelea capreolus*
Klipspringer	*Oreotragus oreotragus*
Oribi (V)	*Ourebia ourebi*
African Wildcat (V)	*Felis lybica*
Cape fur seal	*Arctocephalus pusillus*

Note: The status of Red Data Book species, according to Smithers (1986), is indicated as follows:

V - vulnerable; R - rare; I - indeterminate.

APPENDIX XI: Guide to available information

ESTUARY / RIVERMOUTH / LAGOON: KROMME/SEEKOEI/KABELJOUS

Group	Subgroup	Guide to available information / Sources of information	Articles on the St Francis Bay	Baird et al	Bickerton	Bickerton and Badenhorst	Binneman	Bond and Goldblatt	Broadley	Brooke	Bruton et al	Bulpin	Cape Provincial Administration	Cape Provincial Administration	Cowling	Cowling	Cowling et al	Day	Emmerson and Erasmus	Emmerson et al
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															*			
YEAR (DATE OF INFORMATION)			1985	1981	1986	1987	1985	1984	1983	1984	1982	1980	1970 - 1982	1973	1983	1984	1986	1981	1987	1982

APPENDIX XI: (Continued)

ESTUARY / RIVERMOUTH / LAGOON: KROMME/SEEKOEI/KABELJOU

Guide to available information / Sources of information		Esterhuysen	Fromme and Badenhorst	Gerryts	Greig and Bardett	Grindley	Grindley and Cooper	Hanekom	Hanekom and Baird	Hecht	Heydorn	Heydorn (ed.)	Heydorn and Tinley	Hydrological/Hydraulic Study	Hydrological/Hydraulic Study ..... (a)	Hydrological/Hydraulic Study ..... (b)	Jarman	Jezewski and Roberts	The Kromme Estuary
YEAR (DATE OF INFORMATION)		1982	1987	1985	1976	1976	1979	1982	1984	1973	1986	1986	1980	1985	1986	1986	1986	1986	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	*	*										*	*	*	*			

APPENDIX XI: (Continued)

ESTUARY / RIVERMOUTH / LAGOON: KROMME/SEEKOEI/KABELJOUS

Group	Topic	Lubke	Lusher (ed.)	Maaren and Moolman	Maclean	Marais	Marais	Mcdonald	McLachlan	Melville - Smith	Meredith (ed.)	Moll et al	Monthly Flow Records	Noble and Hemens	Pierce	Pitman et al	Poynton	Raper	Reddering and Esterhuysen
YEAR (DATE OF INFORMATION)		1985	1984	1986	1985	1983	1984	1985	1978	1981	1955	1984	1964	1978	1982	1981	1964	1987	1983
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													*		*			*

Guide to available information / Sources of information

APPENDIX XI: (Continued)

ESTUARY / RIVERMOUTH / LAGOON: KROMME/SEEKOEI/KABELJOUS

Guide to available information

Group	Subgroup	Topic	Reddering and Esterhuysen	River Flow Data	Rooseboom and Coetzee	Rust	Schneier	Schutte and Elseworth	Schoonees	Seagrief	Smith and Heemstra	Smithers	South Africa	South Africa	South Africa	Swart	Swart and Serdyn	Taylor	Tinley	Underhill and Cooper
YEAR (DATE OF INFORMATION)			1984	1978	1975	1979	in prep	1954	1986	1976	1986	1986	1935	n.d.	1977	1985	1981	1983	1985	1983
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 XI: (Continued)

ESTUARY / RIVERMOUTH / LAGOON: KROMME/SEEKOEI/KABELJOUS

		Guide to available information	Underhill et al	University of Cape Town, EEU	Van Veelen and Stoffberg	Visser	Watling	Watling and Watling (a)	Watling and Watling (b)	Wooldridge and Wallace
MANAGE-MENT		Historical								
		Conservation/Utilization		*						*
		Management/Planning		*						*
		Legislation								
		Water			*					
BIOTIC		Food webs/Ecosystems								
	Fauna	Mammals								
		Birds	*							
		Reptiles				*				
		Amphibians								
		Fish								
		Molluscs								
		Crustaceans								
		Other aquatic invertebrates								
		Terrestrial invertebrates								
		Zooplankton								
	Flora	Terrestrial vegetation								
		Semi-aquatic vegetation								
		Aquatic vegetation								
		Algae								
		Phytoplankton								
		Microbiology					*			
ABIOTIC	Chemistry	Pollution					*	*	*	
		Eutrophication								
		General Chemistry					*	*		
		Salinity								
	Physics	Circulation and mixing								
		Hydrology / Flood regime								
		Oceanography								
		Climate								
	Geology	Sedimentology								
		Palaeoenvironment								
		Geology								
	Physiography	Morphology								
		Dams/Obstructions			*					*
		Catchment characteristics								
YEAR (DATE OF INFORMATION)			1980	1986	1987	1984	1982	1982	1982	1977

Sources of information

PLATE I:

Kromme Estuary mouth with Marina Glades in the foreground. The seaward canal connecting the marina to the estuary, which has sanded up in recent years can be seen on the right of the photo. Alt. 300 m. (Photo: ECRU, 86-01-22).

PLATE II:

Seekoei Estuary with the Aston Bay swimming pool/ car-park complex with protecting embankment in the foreground. The penetration of marine sand into the lower reaches of the estuary (downstream of the causeway) can be seen. Alt. 500 m. (Photo: ECRU, 79-10-16.

PLATE III:

The Kabeljous Estuary. The massive sandbar separating the lagoon from the sea can be seen in the foreground. The holiday township of Kabeljous-on-Sea is in the left foreground of the photo. Alt. 400 m. (Photo: ECRU, 86-01-22).