



The SANCOR Estuaries Programme

1982 – 1986

Programme developed under the aegis of the South African
National Committee for Oceanographic Research

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PREFACE

The South African National Committee for Oceanographic Research (SANCOR) programme is one of a number of cooperative research programmes developed by the scientific community in South Africa and managed on their behalf by the Cooperative Scientific Programmes (CSP) of the Council for Scientific and Industrial Research (CSIR). These programmes depend upon cooperation between disciplines for the solution of many and diverse questions. They have also contributed to the increasing awareness by the scientific community of the value of such cooperation.

The objective of the SANCOR programme is to gain knowledge of the basic structures, processes and relationships in the marine environment around southern Africa in order to provide a fundamental scientific understanding and to facilitate:

- the efficient exploration, exploitation and conservation of living and non-living marine resources;
- the judicious management of the coastal zone;
- the fuller understanding of climate;
- improved utilization of environmental information in maritime activities.

The Estuaries Programme is one of a series of SANCOR programmes, and will be particularly associated with the Benguela Ecology Programme, Programme on Coastal Processes, Marine Pollution Programme, Marine Line fish Programme and a proposed Programme on Marine Sedimentology. Interaction between these programmes, the Agulhas Bank Studies of the National Research Institute for Oceanology (NRIO), and the programmes of groups such as the Estuarine and Coastal Research Unit (NRIO), Natal Town and Regional Planning Commission (NTRPC) and Inland Water Ecosystems will contribute materially to their future value.

The principles which have guided the establishment of earlier programmes have provided the framework for this Estuaries Programme. Its formulation has been the responsibility of scientists active in estuarine research, in consultation with the authorities who carry responsibility for the management of estuaries. In so doing they have adopted a holistic approach in the reasonable belief that this view focuses on research relevant to the problems of coastal areas.

The programme is intended to serve as a focus for such research over the next five years. As a consequence it will contribute towards the scientific base required for management in the coastal zone and particularly of estuaries.

ABSTRACT

Within the context of the Estuarine Programme that forms part of South African Oceanographic Research, an outline is given of environmental problems resulting from human activities in estuaries, of the current state of research, and of legislation that relates to South African estuaries. With this background, a programme framework is developed which outlines the types of research that will be needed over the next five years. While being aimed at obtaining a fundamental understanding of estuaries, such research will also aid in the rational management of estuaries. Estuaries on which research should be concentrated are identified and guidelines are given for project proposals and reporting.

OPSOMMING

Binne die raamwerk van die Getyriwiereprogram, wat deel uitmaak van Suid-Afrikaanse Oseanografiese Navorsing, word 'n beskrywing gegee van die omgewingsprobleme veroorsaak deur menslike aktiwiteite in getyriwiere, van die huidige stand van navorsing, en van wetgewing wat betrekking het op Suid-Afrikaanse getyriwiere. Met hierdie as agtergrond, is 'n programraamwerk ontwikkel wat die tipe navorsing beskryf wat benodig word vir die volgende vyf jaar. Terwyl die navorsing gemik is op die verkryging van 'n basiese begrip van getyriwiere, sal sulke navorsing ook bydra tot die oordeelkundige bestuur van getyriwiere. Getyriwiere waarop navorsing gekonsentreer behoort te word, word geïdentifiseer en riglyne vir projekvoorstelle en verslae word voorsien.

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INTRODUCTION

Estuaries have long been important to mankind. Harbours, towns and cities have frequently developed on their banks. They are under pressure, as prime sites for recreational use, as repositories for industrial effluents and domestic waste and sometimes as sites for infilling to create land for industry or agriculture. Biologists have stressed the natural functions of estuaries as vital feeding grounds for many birds, such as waders and wildfowl. They are important for coastal fishing and, because of their variability, are also fascinating areas which challenge our understanding of the adaptations of plants and animals to their environment. The estuarine environment is characterized by a constantly changing mixture of salt and fresh water. The estuarine substratum is typically dominated by sedimentary material, which accumulates both from the sea and from rivers.

It is important that the maximum benefit be obtained from estuaries without jeopardy to future options or continued use. To achieve this purpose it will first be necessary to acquire fundamental knowledge of their natural functioning and of how they are affected by human activity. Estuaries will vary in their tolerance to disturbance, but it may be possible to determine the resilience of individual estuaries by measuring the normal variability of their physical and biological characteristics.

In South Africa as elsewhere, the problem must be faced that degradation is taking place at such a rapid rate that unless attention is paid to management recommendations emanating from research findings, the efforts of scientists will be to no avail.

The distribution of estuaries along the southern African coast is as follows: In Natal 73 estuaries enter the sea along a 570 km coastline; Transkei has 56 estuaries over a distance of 430 km. In the Cape Province between the Kei River and the Orange River 167 rivers enter the sea over a distance of about 2 000 km. The total area of the estuaries in southern Africa (including Transkei and South West Africa/Namibia) has been estimated at between 500 and 600 km².

In South Africa, the limited water resources available for agriculture, industry and urban areas create special problems in estuaries. The inadequacy of water supplies has led to the development of extensive water impoundment schemes, both by the State and by farming activities, thereby affecting the natural flushing of the estuarine systems. As the physical and ecological equilibrium of estuaries is based on the interaction between run-off from the land and tidal exchange, reduction or even elimination of run-off and poor catchment management can have serious consequences such as infilling by sand, reed encroachment, and accumulation of pollutants (Grindley and Heydorn 1979). Table 1 shows how extensive the utilization of water resources will become over the next 20 years.

TABLE 1

Projected Water Resource Development by the Department of Environment Affairs (DEA) for the period 1980 to 2000

River System	Present (1981) remaining mean annual run-off ($m^3 \times 10^6$ per annum) **	Projected draw-off by the year 2 000 ($m^3 \times 10^6$ per annum)
Orange	6 100	2 000
Olifants	600	200
Berg	600	210
Rietvlei	40	20
Diep	40	20
Eerste	92	70*
Lourens	20	10
Palmiet	200	180
Breede	1 500	620*
Klein-Brak	35	6
Kromme	94	60
Maalgate	30	8
Sundays	Negligible	
Great Fish	230	230*
Mkomazi	930	186
Mgeni	350	315
Mdloti	270	50
Tugela	3 800	380
Mfolozi	780	80
Mkuzi	90	27

* Plus increase in mineralization.

** The present remaining mean annual run-off given in this table is smaller than the virgin mean annual run-off as the consumptive water usage has been taken into account.

In many estuarine areas there is not only a loss of ecological viability and aesthetic appeal, but there are also severe economic and sociological problems. It is difficult to reverse the developments which have led to this state of affairs. It is, however, possible to ameliorate the unfavourable situation which has arisen and to influence future developments through the application of appropriate environmental management. To achieve this, sound scientific knowledge will be needed.

The objective of the SANCOR Estuaries Programme is therefore to provide a scientific understanding of estuaries — in particular of the interactive physical, chemical and biological processes within them, of their interactions with their fringe areas and with their adjacent marine and terrestrial environments and finally of human impact upon them — thereby contributing information required for their wise management.

While it is easy to set such general objectives, a major consideration is that each estuary has its individual characteristics and problems. It has therefore been necessary to set research priorities very carefully and to identify the estuaries which require attention most urgently.

DEFINITION AND SCOPE

The Estuaries Programme is guided by the SANCOR Committee on Estuaries. Its structure and terms of reference are given in Appendix I.

For purposes of the Programme, estuaries are defined following Pritchard (1967) as modified by Day (1980): 'An estuary is 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 seawater with freshwater derived from land drainage'. Also included are coastal lagoons, such as Langebaan Lagoon, but excluded are coastal lakes, such as Lake Sibaya and Groenvlei, because these have become permanently separated from the sea. The estuarine environment includes underlying and surrounding features such as wetlands, swamps, dunes and other geological landforms, such as inlet channels, barrier bars, ebb deltas and other tidal deposits. River catchments fall outside the programme, but have to be taken into account when studying estuaries.

It is recognized that estuaries are dynamic systems. For example, at times of flood an estuary can become a river mouth without mixing occurring within the confines of the land. Similarly, under low flow conditions an estuary can become temporarily separated from the sea by bar development (blind estuaries). In some estuarine systems such as in the Kosi Lakes, St. Lucia or the Wilderness Lakes, lakelike bodies of water are separated from the true estuary by narrow channels winding through swamplands. Depending on climatic conditions these bodies of water may vary from fresh to saline.

The Programme will cover estuaries from the Orange River to Kosi including Langebaan, the Wilderness System, St Lucia and Kosi System but excluding the Transkei and Ciskei. If however, for comparative purposes in relation to research in a South African estuary, studies of estuaries in the Transkei or Ciskei are thought to be required, such proposals may be considered. In cases where a project leader has to work across the borders to complete his project, this should be indicated and the necessary permission can be sought. In addition, it has been suggested that negotiations be started to institute similar work to that proposed in this Programme in the Transkei, Ciskei and South West Africa/Namibia.

One of the inherent problems in the SANCOR programme structure is the difficulty of drawing precise boundaries between constituent programmes. SANCOR recognizes that all marine science is interrelated and that ideally the SANCOR programme should be one large, interconnected, interdisciplinary programme. However, for practical management purposes a division is necessary.

The Estuaries Programme will normally involve projects that have as their central focus the estuarine environment. It is, however, recognized that estuarine projects may overlap with other programmes such as the Programme on Coastal Processes. To ensure the necessary cooperation and integration, such projects will be referred initially to both the Committee on Estuaries and any other relevant programme committee, and funded by the programme most concerned with the research. Exchange of information between allied programmes will take place through meetings of the Chairmen of the various SANCOR programme committees and on an ad hoc basis as required.

In addition to interfaces with other parts of the SANCOR Programme, the Estuaries Programme will also interface with the National Programme for Environmental Sciences (NPES). The Nature Conservation Research Programme of the latter programme is surveying the conservation status of coast dune ecosystems and the conclusions drawn from this survey will determine the extent to which detailed ecological research will be conducted on these systems in the future. The Inland Water Ecosystem Programme of the NPES is involved with the study of fresh water ecosystems including catchments, impoundments, dams and coastal lakes and, in view of the fundamental importance of catchment management in the protection of estuaries, it is essential that cooperation occurs between scientists involved in the Estuaries Programme and the Inland Water Ecosystem Programme.

CONTROL AND LEGISLATION

The desire of all state departments to protect the coast and its estuarine resources is clear from the large number of Acts promulgated in this context. However, many of them were drawn up before adequate information on the sensitivities and interactions of components of the coastal environment was available and much damage has been caused simply because dynamic processes on the coast are not adequately understood. The large number of Acts is also very confusing to both planning and user agencies on the coast. Efforts aimed at rationalization of existing legislation are underway and will facilitate and streamline the implementation of the results of estuarine research into management decisions.

The major Acts and Ordinances relevant to the management of estuaries are discussed and summarized in Appendix II.

PAST AND PRESENT RESEARCH IN SOUTH AFRICAN ESTUARIES

Overviews or syntheses of existing knowledge on South African estuaries are provided by several recent publications: Begg (1978); Heydorn and Tinley (1980); Day (1981); the proceedings of a workshop on research in Cape estuaries, held in Stellenbosch on 23 April 1981, edited by A E F Heydorn (1981); Branch and Branch (1981).

The major facets of past and present research in South African estuaries are summarized below. They have been divided into various categories: biological, physical, chemical, sedimentological and aquacultural all of which are interrelated.

BIOLOGICAL

Initial work on South African estuaries took the form of overall surveys of larger systems such as Langebaan, Knysna, Durban Bay, Richards Bay and St Lucia. This work was carried out by the Zoology Department, University of Cape Town (UCT) mainly during the 1940's and 50's under the direction of Prof J H Day. Results were published in various parts in the Transactions of the Royal Society. Researchers at UCT have furthermore investigated numerous smaller estuaries in southern Africa. Most of these results are summarized in the book "Estuarine Ecology" (Ed Day, 1981). More detailed ecological studies in Langebaan are summarized in the proceedings of a symposium on Langebaan and Saldanha (Ed Siegfried, 1977).

This work has been extended by other universities and a number of allied research groups such as the Oceanographic Research Institute (ORI) and the museums. In developing more recent programmes cognizance has been taken of the importance of unravelling ecological processes. The work by UCT on the Bot River, Rhodes University (RU) on Swartvlei, University of Port Elizabeth (UPE) on Swartkops and University of Natal (UN) on Mhlanga and St Lucia are good examples of the immediate usefulness of this approach in providing effective solutions to a number of relevant environmental problems.

Besides these holistic projects, more specific studies of animals and plants have been underway for many years. Examples are the studies of plankton in South African estuaries undertaken at UCT, Port Elizabeth Museum (PEM), UPE and UN, of estuarine avifauna by the Percy FitzPatrick Institute for African Ornithology (PFIAO), of benthic invertebrates by RU, UPE and UCT, of east coast macrophytes by the University of Durban-Westville (UD-W) and of estuarine fish by the UN, ORI, UPE, PEM, RU, UCT and the Sea Fisheries Research Institute (SFRI). Mention must also be made of the intensive studies of various organisms occurring in St Lucia sponsored by the Natal Parks Board (NPB). Work on detritus has recently been initiated by RU, UCT and ORI. NTRPC is sponsoring a considerable amount of estuarine research in Natal, including the investigation of the nursery function of Natal's smaller estuaries and lagoons, the effects of pollutants and eutrophication on estuarine life, the ecology of aquatic plants and the role of detritus in Natal estuaries. In the Cape Province the Department of Nature and

Environmental Conservation, Cape Provincial Administration (CPANEC) is involved in studies of bait organisms in all Cape estuaries and surveys of birds and fish in selected estuaries. Investigations by PEM and UCT of juvenile fish in estuaries of the southern Cape have been undertaken.

PHYSICAL

Some physical work has been conducted in conjunction with the biological investigations already mentioned, including bathymetric surveys and the calculation of water movement and flow.

Techniques to determine catchment run-off using simulated flood hydrographs have been developed by the Hydrological Research Unit (HRU) of the University of the Witwatersrand (UW), who also developed a one-dimensional numerical model of river flow, applied to the St Lucia system. NRIO has developed one-dimensional numerical models for hydrodynamic computations, which can be easily adapted for many estuaries and have so far found application at Swartvlei, the Wilderness Lakes system, the Swartkops and Bushmans Rivers. This computational system has also been installed at the computers of RU and UPE.

Both the Fisheries Development Corporation (FDC) and NRIO have been involved in bathymetric survey work and investigations into the effects of engineering works on estuaries.

Such studies have included:

- investigations in larger systems such as Saldanha/Langebaan and Richards Bay in relation to harbour development (NRIO). A two-dimensional model for hydrodynamic and water-quality computations has been developed for Saldanha Bay and is available for further investigations;
- studies related to small craft/fishing harbours such as Berg River, Kowie River, Knysna (FDC, University of Stellenbosch (US));
- studies on the effects of bridge construction in estuaries such as Mgeni and Mzumbe rivers (NRIO).

NRIO is involved in ongoing research on the improvement of physical and numerical modelling techniques and is in the process of developing methods of determining inlet stability under various environmental conditions.

Attempts are being made by NRIO and US to establish ecologically sound engineering design criteria for South African estuaries. NRIO has also been involved in resolving management problems such as the artificial opening of estuary mouths and removal of building sand from various estuaries; hydrological/hydraulic studies in relation to long-term functioning of estuaries; and in collaboration with various groups in Natal, work on the restoration of degraded systems such as Siaya.

DEA has built up an extensive data base on freshwater flow into estuaries and is continuously involved, in collaboration with other groups, in long-term planning of water impoundment schemes with associated ecological impact investigations.

CHEMICAL

The CSIR, and more recently UPE, have done a substantial amount of research on the occurrence of trace elements in South African estuaries and their effects on various forms of estuarine life. NRIO is involved in pollution studies in estuaries, with initial emphasis on larger systems such as the Olifants and Breede and more recently rivers draining into False Bay. The National Institute for Water Research (NIWR) of the CSIR and the Department of Geochemistry of UCT are also involved in chemical research in rivers and estuaries. NIWR has paid much attention to the mineral content of river waters and UCT to physico-chemical studies in the Berg, Bot, Palmiet and Onrus. Work by SFRI aimed at the combating of pollution of estuaries by oil from the sea, also falls in this category. In Natal NTRPC has supported research (mainly by the NIWR) on estuarine pollution and eutrophication.

Except for work carried out within the Chemistry and Biology Division of NRIO, there have been no real cooperative projects linking chemistry and biology. Most of the chemical work has involved nutrient measurements done by biologists.

Howard-Williams and Allanson (1981) have, however, attempted a more integrated approach in their work at Swartvlei, which aimed at understanding the components of phosphorous cycling in the littoral of that system.

GEOLOGICAL/SEDIMENTOLOGICAL

The net deposition of marine and fluvial sediments represents one of the most serious individual problems in South African estuaries. Sedimentological research related to estuaries is being carried out by a number of groups:

- University of Pretoria (UP) : estimates of sediment load from major catchment areas;
- UPE : research on present-day sedimentation processes in south eastern Cape estuaries;
- Geological Survey (GS) : the history of sedimentary processes in estuaries with emphasis on the Bot River Vlei;
- UCT : bathymetry and geochemistry of estuarine sediments with present emphasis on Bot River Vlei, the Palmiet and Onrus and also the role of Callianassa in the bioturbation of estuarine sediments;

- NRIO : sedimentology of Saldanha/Langebaan, sediment dynamics in selected larger estuaries such as the Olifants and Breede and the fate of riverine sediments once they have been carried into the sea;
- NIWR : Estimates of sediment loads in the Siaya.

The Coastal Engineering and Hydraulics Division of NRIO is also intensively involved in work on sediment dynamics in estuaries as described above.

AQUACULTURE

South Africa's exposed and high-energy coastline renders it unsuitable for marine farming or aquaculture as is practised in the Far East, notably Japan. Aquacultural endeavour is therefore restricted to larger sheltered systems such as Langebaan, Knysna and Richards Bay. FDC has for many years been involved in the development of oyster culture techniques on a commercial basis at Knysna and Langebaan, and has experimented with the culture of prawns in concrete tanks at Amatikulu, Kwa-Zulu.

NIWR (sponsored by the NTRPC) has experimented with the culture of tilapia in the enriched water of sewage effluent in Richards Bay. The JLB Smith Institute for Ichthyology (JLBSII) in Grahamstown has investigated the feasibility of eel culture (with negative results) with financial support from the FDC. Under South African marketing conditions the economic feasibility of all the above ventures is, however, far from assured.

SYNTHESIS OF AVAILABLE INFORMATION

Although this cannot be regarded as a research activity per se, the synthesis of all available information on South African estuaries in a form which is understandable to decision-makers and those responsible for coastal zone management, is of the utmost importance. This work commenced at ORI, in 1976 under the sponsorship of the NTRPC and led to publication of the report "The Estuaries of Natal" (Begg, 1978), dealing with the 73 estuaries of that Province. Since 1979 NRIO has expanded this type of work to the rest of the South African coastline at the request of and with the financial support of DEA.

A report series under the general title "Estuaries of the Cape" dealing with the 2 000 km of coast of the Cape Province and its 167 estuaries, is in preparation at present. So far ten reports have been published and the series is scheduled for completion in 1986 (Heydorn and Tinley, 1980; Heydorn and Grindley, 1981). Another recent publication (Cooper and Hockey, 1982) provides valuable information on the distribution and numbers, habitat and other requirements of South African coastal birds.

An important aspect in assessing the impact of development on estuaries, is the evaluation of its socio-economic implications. Work with this aim is underway at UCT.

In conclusion, mention should be made of the management recommendations made for Natal estuaries by Begg (1979) and for South Africa's overall estuarine environment by Heydorn and Tinley (1980) and Day (1981). The principles on which these recommendations are based are unlikely to change, but they will need to be revised in the light of the results of the current estuarine surveys and the Estuaries Programme. Equally important, cognizance will have to be taken of the results of similar work underway in other countries. In this regard the paper "Coastal lagoon research, present and future" United Nations Educational, Scientific and Cultural Organization (UNESCO, 1981), is useful.

PROGRAMME FRAMEWORK

The principles of estuarine ecology as they pertain to South African estuaries have been comprehensively laid down by Prof J H Day and his collaborators in "Estuarine Ecology with particular reference to southern Africa" (1981). The national programme must take cognizance of the extensive and varied knowledge on South African estuaries which has been brought together in this volume. It provides the springboard for what is to be considered as the next phase of estuarine research. Past research has tended to focus on separate aspects of the structure and functioning of estuaries, but it is now recognized that a holistic, multidisciplinary approach is essential if we are to understand our estuaries. In particular, the overriding importance of understanding hydrodynamics and sediment movement must be stressed. River catchments play a vital role in the ecology of estuaries, but fall outside the scope of the SANCOR Estuaries Programme, being under the umbrella of the Inland Water Ecosystem Programme, with which links are being developed. Research workers are strongly encouraged to establish programmes which involve the cooperation of scientists from different disciplines and where necessary, other programmes, leading to a holistic approach and an amalgamation of results. It is recognized that through their geographical location, some researchers may find it difficult to participate in such multidisciplinary effort. They naturally are not precluded from participation providing that their work meets the objectives of the programme.

Without proper understanding of the ecological functioning of estuaries, including their surrounding wetlands and coastal areas, effective guidelines for their utilization and management cannot be drawn up. Research will therefore address both natural processes and the effect of disturbances brought about by man.

The natural processes within estuaries which will receive attention include:

- interactions between the physico-chemical environment and the organisms forming the estuarine foodweb;

- interactions between organisms, at and between various trophic levels;
- interactions between estuarine-, terrestrial- and marine environments via run-off from the land and tidal interchange;
- effects of perturbations as a result of natural episodic events such as floods or droughts.

Human activities often, directly or indirectly, degrade the estuarine environment, and part of the programme will be devoted to defining precisely the nature of this degradation, the rate at which change is taking place and the procedures (social, engineering or biological), needed to ameliorate such degradation.

Some estuaries have become so severely degraded as to have lost, to a greater or lesser extent, their natural viability. There is a need to develop techniques for the restoration of such systems. Restoration of degraded estuaries could then become part of management plans for South African estuaries.

Attention will also be paid to the probable effects of human manipulation of estuaries and their environs - manipulations such as:

- modification of hydraulic regime and hydrology through dam construction, agricultural, forestry, industrial and urban developments and soil erosion in the catchment and on the flood plains;
- artificial manipulation of estuary mouths and stabilization of the surrounding dune fields;
- bridge and road construction including their effect on hydraulics and aesthetics;
- water quality changes resulting from developments.

The remainder of this section identifies specifically the research likely to provide this knowledge. It is followed by a section setting out which estuaries should receive priority attention.

SPECIFIC RESEARCH REQUIREMENTS

River Catchments

Although river catchments fall outside the scope of the Estuarine Programme, it is widely recognized that the physical nature of catchments and associated human activities have a strong influence on estuarine processes. Few acceptable data are available upon which the deleterious changes in the catchment, and their effect upon estuarine deterioration can be assessed. In Natal, the pattern of deterioration has been described by Begg (1978) and a study of catchment restoration has begun. Poor agricultural practice and afforestation in areas such

as in the uplands of the Cape south coast, are being reflected in substantial changes in the physico-chemical nature and biology of the coastal lakes of this region. The implication is clear - there is an urgent need to establish the magnitude and rates of environmental changes in river catchments and their effect upon the quantity and quality of river inflows to the estuary. Attention should be given to:

- the geomorphology, geology and vegetation of river catchments;
- soil types and sediment yield of drainage basins;
- the hydrology of river catchments and its influence upon the pattern of river flow and sediment transport/deposition processes;
- the chemical components of river inflows;
- the influence of development in the catchment upon its hydrology, sediment yield and water quality;
- the effect of groundwater extraction on estuarine ecology.

Negotiations are being initiated to bring these research requirements to the attention of the Inland Water Ecosystem Programme in an attempt to have these requirements addressed by them in collaboration with the Estuaries Programme.

The Physico-chemical Structure of Estuaries

Hydraulics

Knowledge of the hydraulic behaviour of an estuary is essential for a complete understanding of estuarine processes and the ecology of its biota.

The development of one-dimensional numerical models has given the means whereby a simple description of hydraulics is possible. However, improvements and refinements in physical and numerical modelling techniques are needed, with specific emphasis on estuary mouth dynamics and on numerical modelling of water quality aspects. Bearing in mind that hydraulic studies will in most cases be specific to an estuary, work may be required in each case on:

- the effect of variation in freshwater inflow, from causes such as dam construction, upon the hydraulics of the system;
- a dynamic description of the tidal prism, including freshwater flushing rates, residence time and vertical stratification;
- modification to the hydraulic regime brought about by varying meteorological conditions, mouth configuration and engineering structures such as bridges, embankments, groynes and jetties;

- the effect of coastal processes upon the estuary mouth and internal hydraulics.

The Water Column

Our understanding of the physical processes within the water column, which deal particularly with the events at density interfaces (pycnoclines), is at best elementary. There is a need for accurate measurement of these features and the factors which bring about either turbulent mixing or stability in estuarine stratification and their effect upon estuarine processes.

Our understanding of chemical processes, particularly nutrient chemistry, needs to be improved. The relative contribution of river inflow, tidal input and natural biological processes to the nutrient load needs attention. Humic materials, both colloidal and in solution, are constantly being carried into and produced within estuaries; their chemical structure, role and contribution to the energy resources requires investigation. It is impossible to separate such chemical investigations from the biological or biochemical processes in the water column, macrophyte beds and superficial and buried sediments.

Research is specifically required on:

- thermal and salinity structure;
- particulate and dissolved organic and inorganic matter;
- the influence of light attenuation and suspensoids on the biota, particularly during flooding (for example the slow, apparently irreversible trend towards decreased transparency in coastal lakes and estuaries due to elevated silt loads of influent rivers);
- relative contribution of freshwater and tidal inflow upon nutrient chemistry including mechanisms which influence the removal or release of nutrients in estuaries;
- the role of benthic, planktonic and nektonic biota;
- sediment-water interactions.

Geology and Sediment Dynamics

It is of fundamental importance that the textural attributes, the composition and the dynamics of estuarine sediments are understood. Such knowledge is basic to the prediction of the effects of human activities. In addition, the study of estuarine sedimentary facies provides essential basic background information for all disciplines participating in the research programme. Such insight will also improve our capability to identify and interpret estuarine sequences in the geological record. Research is specifically required on:

- the geological evolution and setting of the estuarine basin (stratigraphy, structure and lithology);
- sediment sources, grain size distributions and primary sedimentary structures of estuarine deposits;
- bioturbation and its influence on sediment structure and chemistry;
- micro-sedimentology as an essential factor in understanding interactions between sediment and fauna;
- effects of water movement and wind on sediment dynamics with special attention to erosional and depositional processes;
- prediction of effect of human activities and man-made structures on sediment distribution.

There is also a need to determine the past geological history and palaeo-ecology of estuaries, and particularly the rates of erosion and sedimentation prior to human intervention. This should allow us to put into perspective the recent changes resulting from human activities and provide a more fundamental understanding of the present day ecology of estuaries.

The Biological Structure of the Estuary

The composition and diversity of estuarine macrofauna and macroflora are well understood and there is now an increasing emphasis upon research into the processes which occur within estuaries and that regulate the abundance and diversity of organisms. It must be recognised that few, if any, components of this ecosystem are resistant to the impact of man. The need to analyse this impact and its effect is urgent. Topics of prime importance are:

- the production and role of detritus and its associated microbial fauna and flora in energy transfer;
- the relative contribution of macrophytes, phytoplankton, periphyton and epipsammic communities to the productivity of the estuary;
- the role of zooplankton in estuarine biological processes;
- the relative roles of meiofauna and macrofauna in energy and nutrient transfer;
- the biomass and production of benthic invertebrate taxa, and their utilization by benthic feeding fish and birds;
- the role of avifauna as consumers as well as exporters and importers of nutrients;
- the utilization of estuaries by fish: their function as nursery and feeding grounds; in trophic relationships of these fish and their role in exchanging materials between estuaries and the sea;

- nutrient cycling and the "export-import" controversy surrounding primary estuarine energy and nutrient resources: or to what extent is the estuary a sink?
- the effects of man upon the estuarine ecosystem;
- the adaptations of animals and plants in estuaries;
- monitoring of the environment to enable the recognition of natural and man-induced changes and the rates of change. Research is needed to decide what sort of monitoring is required and how it should be done.

It is essential that attention is focussed on processes taking place in estuaries if ecological knowledge is to be advanced and relevant environmental issues addressed in the interest of wise management of estuaries.

Impact of Man

All forms of development will bring about some degree of alteration or manipulation of estuaries, necessitating research on human activities, including the effect of damming of rivers, dredging, erosion, pollution, canalization, opening of river mouths and other forms of engineering works on estuaries. Such research should result in quantitative data which will help attempts to predict the effects of proposed developments, and so assist sound management.

Since human use of estuaries may include such diverse activities as food production, recreation, aesthetic appreciation, exploitation of various kinds and conservation, there is a need for the development of techniques to evaluate the optimal use of an estuary and its environs to maintain the estuary in a viable state. The approaches required will include, inter alia the use of biological indicators, development of techniques to measure the "health" of estuaries, monitoring environmental conditions and socio-economic and ecological evaluations.

Restoration

Many estuaries have become so degraded as to have largely lost their natural viability. In North America and Europe much effort is being devoted to the restoration of such degraded systems, sometimes with remarkable success such as in the case of the Thames. The development of appropriate techniques for the restoration of selected South African estuaries requires research. This has already been attempted in certain South African estuaries such as the Siaya. Analysis of the causes is initially required, and restoration techniques, need to be developed. Indicators of the degree of success achieved in restoration need to be established.

PRIORITY ESTUARIES

It is obviously neither possible nor necessary to study every estuary in South Africa with equal intensity. It is therefore essential to set clear priorities as to which estuaries should receive attention, bearing in mind both research and management needs.

Because of the difference in the state of knowledge available in estuaries in the Cape and Natal, the setting of priorities was approached and is presented in different ways. Table 3 summarizes information on selected estuaries in the Cape and Table 4 lists specific problems in the estuaries of Natal. Table 5 summarizes information on the estuaries regarded as being of the highest priority in terms of research in the Cape and Natal.

The following considerations inter alia played a role in the preparation of these tables.

Research Considerations

From the point of view of research and of the researcher, certain priorities emerge. These are related to factors such as the ecological condition of estuaries, the data base already available on them, their type, their representativeness (for example geology, climate), their accessibility and in some cases their inherent suitability for providing answers to specific questions.

Management Considerations

The need for scientific information on which to base management decisions concerning estuaries has already been stressed. There are a number of current and projected developments which are affecting and which will in future profoundly affect conditions in many estuaries.

Industrialization and Urbanization: The Good Hope Plan for southern Africa (South African Department of Foreign Affairs and Information, 1981) scheduled for implementation in April 1982, sets out a regional development strategy and industrial growth plan for southern Africa. Many of the growth points, metropolitan areas and deconcentration areas identified are situated on the coast (see map on page 43).

Freshwater requirements: The proposed construction of dams to the year 2000 is summarized in Table 1. In each case it will be necessary to state at least the minimum freshwater requirements (quantity, flow characteristics and water quality) for maintaining ecologically viable estuarine conditions. Attention should be focused on the freshwater requirements of the following priority estuaries for the given time horizons.

TABLE 2

Freshwater requirements of estuaries : Research priorities

Period	Estuary	Remarks
next 5 years (1982/1987)	Diep Eerste Mgeni) Tugela)	NRIO is doing studies on physical aspects. Some biological input is probably also needed.
next 5 - 10 years (1987/1992)	Lourens Maalgate Mkomazi	
next 10 - 20 years (1992/2000)	Remainder of estuaries in Table 1	

Agricultural Development and Forestry: Agricultural developments and afforestation have had marked effects upon the physical, chemical and biological state of estuaries. In particular, soil erosion, changes in run-off and the use of pesticides and fertilizers all affect the quality of water entering estuaries. Stabilization of dunes modifies the movement of coastal sand and may influence the configuration of the mouth. Major irrigation schemes alter the characteristics of water entering estuaries. These factors underline the need for research in river catchments as described on page 10.

Recreation: The increased demand for recreational areas is inherent in the development of metropolitan areas. In various regions estuaries and their environs are ideally suited for recreational development. In many cases housing and the type of recreational activity envisaged (for example boating, yachting, angling) will influence the priorities for research.

Conservation: There is a need to conserve representative estuaries for posterity, for environmental monitoring and for research. In many cases it is also desirable to conserve surrounding terrestrial and marine habitats and the catchment. The establishment of conservation areas will also have an effect on recreational development. This Programme will contribute to identifying estuaries and adjacent areas suitable for this purpose. More detailed proposals may be found in Grindley and Cooper (1978) and Heydorn and Tinley (1980).

TABLE 3

OVERVIEW OF EXISTING INFORMATION ON SELECTED CAPE ESTUARIES AND COASTAL LAGOONS

Estuary	Projected development				Data base			Particularly suitable for research	Management problems
	Industrial metropolitan	Recreation	Proposed and existing reserves	Proposed dams	Rich data base	Moderate data base	Research underway		
Orange				x		x			
Groen		x	x			x			
Wadrifsoutpan			x						
Olifants		x		x		x		x	
Verlorevlei			x			x	x	x	
Berg	x	x	x	x		x	x	x	x
Langebaan	x	x			x		x	x	
Diep/Rietvlei	x	x	x	x		x	x	x	x
Sandvlei	x	x	x			x	x	x	x
Eerste	x			x		x			x
Lourens	x			x		x	x		x
Palmiet		x	x	x		x	x	x	x
Bot		x	x		x		x	x	x
Klein		x						x	x
Uilkraals		x				x			x
Heuningnes			x			x		x	
Breë		x		x		x	x	x	x
Duiwenhoks			x						

TABLE 3 (Cont.)

Estuary	Projected development				Data base			Particularly suitable for research	Management problems
	Industrial metropolitan	Recreation	Proposed and existing reserves	Proposed dams	Rich data base	Moderate data base	Research underway		
Kafferkuils		x							
Hartenbos		x				x	x		x
Klein Brak		x		x					
Groot Brak		x				x			x
Maalgate				x			x		
Touw		x	x			x	x	x	x
Swartvlei		x	x		x		x	x	x
Knysna		x	x		x			x	
Keurbooms/Bitou		x	x					x	x
Groot-Wes		x				x			x
Seekoei		x	x						x
Kromme		x		x	x		x	x	x
Kabeljous		x	x						
Gamtoos		x	x			x	x		x
Swartkops	x	x	x		x		x	x	x
Sondags		x	x	x		x	x	x	
Boesman		x				x	x	x	x
Kariega		x					x	x	
Kowie		x	x			x	x	x	x
Kleinemonde		x				x			x
Great Fish				x		x	x	x	x
Buffalo	x	x					x		
Nahoon	x	x					x		x
Gonubi	x	x							
Kwensura/Kei		x	x						

TABLE 4
ESTUARIES AND COASTAL LAGOONS IN NATAL - SPECIFIC PROBLEMS

Estuary	Incoming silt or sand	Dredging activity	Drainage diversions	Embankments	Breaching	Impoundment	Water area losses	Cropland pollution	Industrial pollution	Pesticide pollution	Nutrient enrichment	Faecal pollution	Disruption of wetlands	Disruption of riverine vegetation
Kosi	*		?							*			?	
Mgobezeleni					*	*							*	
St. Lucia	*	*	*										*	*
Mfolozi	*	*	*	*	*			*	*				*	
Nhlabane						*	*							
Richards Bay	*	*	*	*			*	*	*				*	*
Mlalazi	*	+		*									*	
Siaya	*		*				*	*		?			*	*
Matigulu	*													
Nyonl	*													
Tugela	*						*		*					
Zinkwasi	*				*		*	*				*	*	*
Nonoti	*				*			*	+		*		*	
Mdlotane					*			*					*	
Mvoti	*						*	*	*				*	*
Seteni	*		*		*			?					*	
Mhlali	*				*	*							*	*
Tongati	*		?	*			*	?	*		*	*		*
Mdloti	*	?		*	*		*		+	?			*	*
Mhlanga	*		*	*	*		*				*		*	*
Mgeni	*	?	*			+	*	*	*	?	*	*	*	
Durban Bay		*					*		*			*	*	
Sipingo	*	+	*				*		*		*	*	*	
Mbokodweni	*		*		*				*			*	*	*
Manzimtoti	*	*			*	*			*		*	*	*	*
Little Manzimtoti	*	+	*			*					*	*		

+ Past
* Present
? Probable

TABLE 4 (Cont.)

Estuary	Incoming silt or sand	Dredging activity	Drainage diversions	Embankments	Breaching	Impoundment	Water area losses	Cropland pollution	Industrial pollution	Pesticide pollution	Nutrient enrichment	Faecal pollution	Disruption of wetlands	Disruption of riverine vegetation
Lovu	*		*	*	*		*	*	*			?	*	*
Msimbazi	*		*	*	*		*							*
uMgababa	*		*	*	*								*	
Ngane	*				*			*				?		
Mkomazi	*			*			*		*				*	
Mahlongwana	?												*	
Mahlongwa	*				*		*	?					*	*
Mpambanyoni	*			*			*		*				*	*
Mzimayi	*					*		*				?	*	
Mzinto	*			*	*		*	*	+	+			*	*
Mkumbane	*							?			*	*		
Sezela		?			*			*	*		*			
Mdesingane	*					*		?						*
Fafa	*				*	*	*					*		
Mvuzi			*	*										
Mtwalume	*			*	*		*	?					*	
Mnamfu	*			*									*	
Kwa Makosi	*			*										
Mfazazana	*													
Mhlungwa	?			*										
Mhlabatshane	*											?		
Mzumbe	*			*			*						*	*
Intshambili	*						*	?						
Koshwana	?				*						?	*		
Damba	*			*	*		*	?			?	*	*	
Mhlangankulu	*													
Mtentsweni	*				*									
Mzimkulu	*			*			*		*			?	*	
Mbango									?			?		
Boboyi	*								?					

+ Past

* Present

? Probable

TABLE 4 (Cont.)

Estuary	Incoming silt or sand	Dredging activity	Drainage diversions	Embankments	Breaching	Impoundment	Water area losses	Crepland pollution	Industrial pollution	Pesticide pollution	Nutrient enrichment	Faecal pollution	Disruption of wetlands	Disruption of riverine vegetation
Zotsha	*			*										
Mhlangeni	*				*							*	*	
Vungu												?		
Kongweni	?				*							*	*	*
Uvuzana	*				*									
Bilanhlole	?				*							?		
Mvutshini	?													
Mbizana	*				*		*							*
Kaba	*					*								
Umhlangankulu	*	+												
Mpenjati	*	*			*	*	*							*
Kandandlovu	*													
Tongazi												*		
Ku-Boboyi	*							?				?		*
Sandlundlu	*						*				?			
Zolwane														
Mtamvuna	*													
TOTAL OUT OF 75	57	6	14	21	29	10	27	13	15	1	9	15	34	22

+ Past

* Present

? Probable

Source: Updated from "The Estuaries of Natal" NTRPC Report Volume 41, Begg (1978)

TABLE 5
PRIORITY ESTUARIES AND COASTAL LAGOONS

Estuary	Projected development				Data base			Particularly suitable for research	Management problems
	Industrial metropolitan	Recreation	Proposed and existing reserves	Proposed dams	Rich data base	Moderate data base	Research underway		
Verlorevlei			x			x	x	x	
Berg	x	x	x	x		x	x	x	x
Langebaan	x	x			x		x	x	
Diep/Rietvlei	x	x	x	x		x	x	x	x
Sandvlei	x	x	x			x	x	x	x
Palmiet		x	x	x		x	x	x	x
Bot		x	x		x		x	x	x
Touw		x	x			x	x	x	x
Swartvlei		x	x		x		x	x	x
Knysna		x	x		x			x	
Keurboom/Bitou		x	x					x	x
Kromme		x		x	x		x	x	x
Gamtoos		x	x			x	x		x
Swartkops	x	x	x		x		x	x	x
Sondags		x	x	x		x	x	x	
Boesman		x				x	x	x	x
Great Fish				x		x	x	x	x
Mtamvuna		x	x			x	x	x	
Fafa		x				x	x		x
Sezela	x						x	x	x
Sipingo	x	x				x	x		x
Durban Bay	x	x				x	x	x	x
Mgeni	x	x	x	x	x		x	x	x
Mhlanga			x			x		x	
Mdloti		x				x	x	x	x
Tongati	x					x	x	x	x

TABLE 5 (Cont.)

Estuary	Projected development				Data base			Particularly suitable for research	Management problems
	Industrial metropolitan	Recreation	Proposed and existing reserves	Proposed dams	Rich data base	Moderate data base	Research underway		
Tugela				x					x
Siaya						x	x	x	x
Mlalazi		x	x				x	x	
Mhlatuzi (Richards Bay Sanctuary)	x	x	x	x	x			x	x
Mfolozi			x	x					x
St Lucia		x	x	x	x		x	x	x
Kosi		x	x		x		x	x	x

LIST OF REFERENCES

- BEGG, G W 1978. The estuaries of Natal. Pietermaritzburg. Natal Town and Regional Planning Commission. Rep 41. 657 pp.
- BEGG, G W 1979. Policy proposals for the estuaries of Natal. Natal Town and Regional Planning Commission. Rep 43. 39 pp.
- BRANCH, G AND BRANCH, M 1981. The living shores of Southern Africa. Cape Town. C Struik. 272 pp.
- COOPER, J AND HOCKEY, P A R 1982. The Atlas and Site Register of South African Coastal Birds (in preparation).
- DAY, J H 1980. What is an estuary? S Afr J Sci 76. p. 198.
- DAY, J H (Ed) 1981. Estuarine ecology with particular reference to Southern Africa. Cape Town. A A Balkema. 411 pp.
- GRINDLEY, J R AND COOPER, K H 1979. Proposals for the establishment of estuarine reserves. A report by the Council for the Habitat and the Wildlife Society of South Africa. 35 pp.
- GRINDLEY, J R AND HEYDORN, A E F 1979. Man's impact on estuarine environments. S Afr J Sci 75, pp 554-560.
- HEYDORN, A E F 1979. Overview of present knowledge on South African estuaries and requirements for their management. S Afr J Sci 75, pp 544-546.
- HEYDORN, A E F AND TINLEY, K L 1980. Estuaries of the Cape, Part I. Synopsis of the Cape Coast. Natural features, dynamics and utilization. CSIR Research Report 380. 97 pp.
- HEYDORN, A E F (Ed) 1981. Proceedings of workshop on research in Cape estuaries. (Stellenbosch, 23 April 1981).
- HEYDORN, A E F AND GRINDLEY, J R 1981(Eds). Estuaries of the Cape. Part II. Synopsis of available information on individual systems. Reports 1 - 9.
- HOWARD-WILLIAMS, C AND ALLANSON, B R 1981. Phosphorous cycling in a dense Potamogeton pectinatus L. bed. Oecologia Vol. 49. pp 56-66.
- PRITCHARD, D W 1967. What is an estuary : physical viewpoint. In: Lauff, G H (ed.), Estuaries. Am Ass Adv Sci., Publ. No. 83, pp 3-5.
- A REGIONAL DEVELOPMENT STRATEGY FOR SOUTHERN AFRICA: as announced at a meeting between the South African Prime Minister and business and community leaders; Civic Centre Cape Town, 12 November 1981/Compiled by the South African Department of Foreign Affairs

and Information. Pretoria: Government Printer, 1981. Cover title: The Good Hope plan for southern Africa. 82 pp.

SANCOR 1978. Co-operative National Oceanographic Programme. Pretoria, CSIR. South African National Scientific Programmes Report No. 22. 19 pp.

SIEGFRIED, W R (Ed) 1977. Research in the natural sciences at Saldanha Bay and Langebaan Lagoon. (Symposium proceedings). Trans Roy Soc S Afr Vol. 42. Parts 3 and 4.

UNESCO 1981. Coastal lagoon research, present and future. Unesco technical papers in marine science. 32. 97 pp.

APPENDIX I**STRUCTURE AND TERMS OF REFERENCE OF SANCOR COMMITTEE ON ESTUARIES PROGRAMME**

The Committee consists of scientists actively involved in the Programme, independent assessors and representatives of the principal authorities concerned. The Chairman serves on SANCOR and is appointed on the advice of the Committee for a three year period.

The primary responsibility of the Committee is to manage the SANCOR Estuaries Programme on behalf of SANCOR by:

- monitoring the balanced development of the programme in relation to its objectives;
- annually reviewing the relevance of the programme to changing needs;
- remaining informed on national and international developments relevant to the programme;
- stimulating interest in the programme and its results among scientists and decision makers in related fields;
- drawing attention to aspects of the programme not receiving adequate attention and initiating projects thus required;
- ensuring close collaboration with other SANCOR programmes, that is Marine Pollution, Coastal Processes, Benguela, Line Fish;
- reviewing the progress of the work being done within the programme;
- evaluating project proposals for participation in the programme;
- recommending on funding priorities particularly where SANCOR funds are involved;
- annually providing a long-term (3 to 5 years) projection of financial requirements;
- dealing with specific matters relevant to the programme referred to it by any SANCOR Committee.

APPENDIX II

CONTROL AND LEGISLATION

Although there is considerable agreement between various State and Provincial Departments about the need to protect estuaries and other parts of the coast, there is a problem which is extremely difficult to overcome, namely, that of divided control. Furthermore, the situation changes continually as new regulations are proclaimed or old ones are revised. The notes which follow pertain to the situation at the time of writing.

The Seashore Act (No. 21 of 1935) determines that the State President is the owner of the seashore (including estuaries) and the sea inside the territorial waters of the Republic. The "seashore" means the land situated between the low-water mark and high-water mark of storm tides. In terms of the Act, the State President (that is the State) is therefore responsible for determination of the high-water mark and for the promulgation of regulations in connection with the utilization and control of the seashore. The Department of Community Development (Land Affairs Branch) is responsible for the administration of the Act. However, those estuaries alienated (for example to local authorities) before promulgation of the Act in 1935, are excluded from the articles of the Act except with respect to the making of regulations. All applications for development in estuaries (for example dredging, marinas, filling, landing jetties, roads, etc) are therefore controlled by the Seashore Act and in evaluating development proposals the Department of Community Development liaises with all relevant government departments and other bodies for their comment.

Furthermore:

- Certain powers under the Seashore Act have been assigned to the Provinces who in turn have delegated them to Local Authorities. This enables Local Authorities to make regulations and to carry out work pertaining to the seashore or estuaries within the areas of their jurisdiction, as long as these are not contrary to the provisions of the Seashore Act.
- The living resources of the sea and the estuarine portions of the Berg River, Langebaan and Knysna Lagoons (these are declared fishing harbours) are controlled in terms of the Sea Fisheries Act (No. 58 of 1973) while those of all other estuaries are controlled in terms of the Cape Provincial Nature Conservation Ordinance (No. 19 of 1974) and the Natal Parks Board Ordinance (No. 15 of 1974).
- Recreation in estuaries in the Cape is controlled by the CPANEC and by Local Authorities. Because of the dangers of speed-boating and water-skiing, the Department of National Education is, however, also drawing up regulations with regard to the zoning of waters (including estuaries) for recreational purposes. The Natal Provincial Administration is seeking authority to control

recreation in estuaries and along all beaches in order to provide consistent controls.

- Pollution, use and control of waters in rivers, estuaries and the sea, is controlled by a number of Acts and Departments, for example the Water Act, the Health Act, the Mines and Works Act, the Soil Conservation Act and the Atomic Energy Act. Control of pollution which is detrimental to the marine habitat and its resources is provided for in the Provincial Nature Conservation Ordinances, the Sea Fisheries Act and the regulations issued in terms of the National Parks Act.
- The Physical Planning Act (No. 88 of 1967) controls various activities on the coast adjacent to and in estuaries, for example land use control and the establishment of sand and gravel pits. These powers have largely been delegated to other departments and the Provinces for implementation. Natural areas (for example estuarine reserves) can also be declared in terms of this Act.
- The Lake Areas Development Act (No. 39 of 1975) as well as regulations promulgated under this Act, makes provision for control measures in estuaries. However, such regulations are applicable only in proclaimed lake areas such as the Wilderness Lakes area.
- The management of State Forests on the coast and adjacent to estuaries and the fixing of dunes by alien or other vegetation, is carried out according to the provisions of the Forestry Act. However, the Directorate of Forestry (DEA) can also hand over dune coast areas to Local Authorities for administration.

In addition, the DEA administers the Committee for the Coastal Zone with its objective to coordinate activities relevant to the planning and development of the coastal zone. Within these terms of reference, specific attention is also given to the management of estuaries, and a national policy proposal for South African estuaries is presently being considered by the committee. Apart from university grants and CSIR funds, the main source of funding for estuarine research is also provided by the DEA, CPA and NPA.

The Major Acts and Ordinances relevant to the management of estuaries are summarized in Table 6.

TABLE 6

SUMMARY OF MAJOR ACTS AND ORDINANCES RELEVANT TO THE CONTROL OF ESTUARIES

Function	Act/Ordinance	Department/Agency
1. Control over all developments under the highwater mark	Seashore Act (No. 21 of 1935)	Community Development (Land Affairs Branch)
Control over the Admiralty Reserve	State Land Disposal Act (No. 48 of 1961)	Community Development (Land Affairs Branch)
2. Control of Declared Forest Reserves adjacent to estuaries	Forest Act (No. 72 of 1968)	Environment Affairs
Water pollution	Water Act (No. 54 of 1956)	Environment Affairs
3. Combating of oil pollution	Prevention and Combating of Pollution of the Sea by Oil Act (No. 67 of 1971)	Transport Affairs (Marine Directorate)
National Roads and bridges	National Roads Act (No. 54 of 1971)	National Transport Commission
4. Sand and Gravel extraction	Mines and Works Act (No. 27 of 1956)	Mineral and Energy Affairs
	Mining Rights Act (No. 20 of 1967)	
	Precious Stones Act (No. 73 of 1964)	
	Delegated powers in terms of the Physical Planning Act (No. 88 of 1967)	
5. Public health (pathogens)	Health Act (No. 63 of 1977)	Health and Welfare
6. Control over proclaimed lake areas (Wilderness)	Lake Areas Development Act (No. 39 of 1975)	Lake Areas Development Board

Function	Act/Ordinance	Department/Agency
7. Control over utilization of living resources (only Berg River, Langebaan and Knysna lagoons)	Sea Fisheries Act (No. 58 of 1973)	Environment Affairs (Marine Development Branch)
8. Soil erosion	Soil Conservation Act (No. 76 of 1969)	Agriculture
9. Land use planning and control adjacent to estuaries	Physical Planning Act (No. 88 of 1967) (These powers have largely been delegated to the Provinces for implementation)	Office of the Prime Minister (Physical Planning Branch)
Natural Areas (Estuarine Reserves)	Physical Planning Act (No 88 of 1967) Environment Conservation Act (No. 100 of 1982)	Office of the Prime Minister (Physical Planning Branch) in consultation with Environment Affairs
10. Water sport control regulations	Delegated powers in terms of the Water Act (No. 54 of 1956)	National Education
11. Control over exploitation of living resources in all Cape Province estuaries, except Berg River, Langebaan and Knysna lagoons	Ordinance No. 19 of 1974	Cape Provincial Administration Department Nature and Environmental Conservation
12. Control over all living resources in enclosed tidal lagoons, estuaries and tidal rivers in Natal	Ordinance No. 15 of 1974	Natal Provincial Administration (Natal Parks Board)
Land use control adjacent to estuaries in Natal	Town Planning Ordinance (No. 27 of 1949)	Natal Town and Regional Planning Commission and Private Townships Board
13. Roads and Bridges		Department Roads

APPENDIX III

GUIDELINES ON PROJECT PROPOSALS AND REPORTING

Project Proposals

Within the guidelines contained in these pages prospective participants are invited to submit project proposals on special forms which are available for the purpose. These forms (NP10) are available from CSP/CSIR and also from University Registrars' offices.

Guidelines for completing project proposals are also available (CSP2, 1980). In summary, prospective participants are expected to be as specific as possible with their proposals by indicating clearly how they correspond with the objectives of and fit into the programme, providing a realistic list of key questions to be answered and preparing a well defined work plan according to which the project will be undertaken in a specified time (typically one, two or three years). Participants are expected to consider what they expect the final product of the project to be and to indicate this clearly.

In particular, first proposals should be accompanied by an appropriate summary of existing knowledge/literature survey. Where new or untried fields of activity are being proposed, proponents are advised to consider short (that is one year) feasibility studies to establish more definitive research programmes.

In completing the financial sections of applications, guidelines for salary scales are available from CSP, University Registrars and institute secretaries.

It is recognized that it may be necessary to import expert manpower for certain projects where the necessary expertise or capacity does not exist in the country. This is acceptable provided the normal CSIR/CSP policy regarding such matters is adhered to (for example, in the simplest case, this provides for part (maximum 20%) of the allocation for a specific salary to be spent on assistance for travel and the transport of personal effects).

Reporting

The following are guidelines on the format for annual progress reports and final project reports to SANCOR :

Annual Progress Reports

- (a) Identification : Title of project, names and addresses of project leaders and project researchers, date, period of report, maximum five keywords of contents for indexing purposes.
- (b) Objectives

(c) Background : Concise history of project to allow (b) and (d) to be read in context.

(d) Scientific progress : Scientific progress made since submission of last report, with emphasis on scientific findings and achievements during the year, as measured against the objectives and target dates provided in the project proposal.

(e) Publications : Full references to publications emanating from the project and which have appeared since submission of last report (including published, accepted for publication and unrestricted internal reports).

(f) Activities report : An activities report as an addendum to the main report, if it is felt that, for some reason, activities and not scientific progress have to be reported.

As a guideline, the length of the body of the report ((a) above) should be about three A4 pages (typed single spacing), although it has to be accepted that this varies from project to project.

Progress reports are required from all those supported in the programme by 30 June. Those not supported but who are engaged on projects which complement the work supported from the programme, are encouraged to submit reports on their work in the same format.

These progress reports, in addition to serving as the basis for the evaluation of progress with a view to continued support, are also compiled into a single volume entitled, "Progress Reports to SANCOR 19 " and distributed to all participants in the SANCOR Programme and its committees in an inexpensively reproduced form.

Final Reports

Participants are encouraged to publish their findings as soon as possible in reputable scientific journals of their choice. However, no project will be regarded as complete until a final report has also been submitted to SANCOR and all the data collected in the project have been lodged in the South African Data Centre for Oceanography as applicable. The final report, submitted at the end of the last year of the project, should cover:

(a) Background : Identification (as in annual reports), introduction, background and objectives of the project (refer to the relevant NP10 proposal).

(b) Methods : Description of procedures, methods, study areas and other aspects of relevance to the project or summary with reference to published descriptions.

(c) Findings : A synthesis of the findings of the project, with special reference to the realization of the objectives set.

(d) Conclusions and recommendations : Conclusions and recommendations on the work as a whole, including comments on future work to be undertaken or avoided, and any practical decision making implications.

(e) Publications : List of scientific publications and other documents arising from the work including a list of any data available and stored in the institute concerned.

(f) Project staff : List of participants and collaborators in the project.

(g) Acknowledgements : Including sources of funds and assistance.

Final reports are bound with the volume "Progress Reports to SANCOR" of the year concerned, but also serve to inform decision makers of the findings of the research done within the programme, some of which they may have supported.

APPENDIX IV**RELATED PROGRAMMES WITH WHICH THE SANCOR ESTUARIES PROGRAM HAS THE MOST DIRECT LINKS:****SANCOR Programme on Coastal Processes**

Those responsible for the Programme on Coastal Processes have declined to define strictly their geographical area of interest and have opted instead to limit the study to those processes which have direct bearing on coastal systems. The objectives of the programme are to understand the basic factors that control coastal processes and to contribute information required for the judicious development, management and conservation of the coastal zone and its resources.

SANCOR Marine Pollution Programme

The Marine Pollution Programme has as its general aim the study of the effects and influences of man's actions in the marine environment, particularly the discharge of effluents, as well as dredging and dumping activities.

SANCOR Marine Linefish Programme

The Marine Linefish Programme aims specifically to provide scientific information about this valuable component of the marine foodweb to aid the development of effective management strategies.

SANCOR Benguela Ecology Programme

The objective of the Benguela Ecology Programme is to provide scientific information on the structure and functioning of constituent ecosystems, to complement the scientific knowledge which is required for the management of the renewable natural resources of the Benguela System.

NPES Inland Water Ecosystem Programme

The Inland Water Ecosystem section of the National Programme for Environmental Sciences (NPES) has as its aims to develop the understanding necessary to predict the effects of natural events and planned development and management actions on inland water ecosystems, to improve the scientific base necessary for the wise use of the systems and to seek for solutions to particular environmental and management problems related to inland water ecosystems.

NPES Nature Conservation Research Programme

The Nature Conservation Research section of the National Programme for Environmental Sciences has as its objective to stimulate and coordinate research needed for the development of ecological principles and practices necessary for the conservation of indigenous species and communities, together with their habitats and life support processes for the long-term benefit of mankind.

NPES Fynbos Biome

The aim of the Fynbos Biome project is to investigate ecosystem functioning, especially in relation to plant nutrient deficiencies and water relations, and to study the effects of fire and invasive plants and problems such as threatened species and the nature, extent and causes of past vegetation changes.

NPES Programme for Human Needs, Resources and the Environment

The principal objective of this programme is to develop the capacity to assist in the understanding, measurement and prediction of relative effects of factors involved in the achievement of balanced socio-economic development and the satisfaction of human needs. The main objectives of the programme are to determine the most relevant and important socio-political, economic and ecological relationships involved in the satisfaction of human needs, to develop the capacity to measure and predict both the interrelationships and the outcome of planning policies aimed at balanced development and satisfaction of human needs and to monitor and evaluate developments.

NRIO Coastal Engineering and Hydraulics Division

The objective of the Coastal Engineering and Hydraulics Division of NRIO include undertaking basic and applied research required for coastal works, including beach and estuary improvement and marine disposal studies and to work in close collaboration with other disciplines to avoid duplication of effort and ensure an environmentally acceptable solution, and at the same time, endeavour to point out deficiencies in coastal planning and management to the relevant authorities.

NRIO Agulhas Bank Studies

The Programme represents a long-term, interdisciplinary programme of measurement and analysis on the Agulhas Bank. It is the first major research programme of this type to be carried out by NRIO, and will eventually incorporate all the divisions, that is marine biology, marine chemistry, marine geoscience, physical oceanography and coastal engineering and hydraulics.

Initial investigations have concentrated on the physical aspects, namely ocean dynamics on the shelf and at the inshore front of the Agulhas current, while the Sediment Dynamics Programme has started with the aim of identifying sources, transport routes and sinks of suspended sediment and bedload material. Weather stations have been erected, while limited biological sampling has started: it is anticipated that the biological and chemical components will grow, while the major interdisciplinary work will probably take place in the near-shore regime.

The major aim of the ABS is an understanding of the processes operating on the Agulhas Bank. Coastal sites will be selected for detailed study: it is then hoped to be able to transpose the knowledge gained to other sites with a minimum of additional measurements while building up an overall picture of conditions on the bank.

NRIO Estuarine and Coastal Research Unit

The Estuarine and Coastal Research Unit (ECRU) was established by NRIO in 1979. Its aims are to contribute information relevant to the development of a cohesive management policy for the South African coastline, to compile syntheses of all available knowledge on the 167 estuaries of the Cape between the Kei and Orange rivers, to identify gaps in information and to carry out or stimulate research at universities, museums and other institutions to fill these, and to contribute to ad hoc investigations carried out by NRIO on the impact 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.

Natal Town and Regional Planning Commission

The Town & Regional Planning Commission is responsible for advising the Administrator on all policies affecting physical plans and land subdivision. It is also responsible for advising local authorities on Town Planning, and may assist them with technical advice through its officials.

Natal possesses some 73 estuaries which have proved to be amongst the most valuable natural resources in the province because of their inherent biological productivity, and because of the opportunities which they and their surroundings provide for residential purposes, for industry, for agriculture, for recreation and for other uses. The Commission strives to ensure that there is an adequate understanding of the estuaries and the conditions under which they can be used. Only on the basis of this knowledge will the Commission be able to formulate appropriate physical planning policies for the estuarine environment, and to assist the various authorities with key advice on how to reconcile the often conflicting proposals for development so as to ensure that they do not jeopardise future options for the continuous use of our estuaries.

LIST OF ACRONYMS

CPANEC	Department of Nature and Environmental Conservation, Cape Provincial Administration
CSIR	Council for Scientific and Industrial Research
CSP	Cooperative Scientific Programmes
DEA	Department of Environment Affairs
FDC	Fisheries Development Corporation
GS	Geological Survey
HRU	Hydrological Research Unit, University of the Witwatersrand
JLBSII	JLB Smith Institute for Ichthyology
NIWR	National Institute for Water Research
NPB	Natal Parks Board
NPES	National Programme for Environmental Sciences
NRIO	National Research Institute for Oceanology
NTRPC	Natal Town and Regional Planning Commission
ORI	Oceanographic Research Institute
PEM	Port Elizabeth Museum
PFIAO	Percy FitzPatrick Institute for African Ornithology
RU	Rhodes University
SANCOR	South African National Committee for Oceanographic Research
SFRI	Sea Fisheries Research Institute
UCT	University of Cape Town
UD-W	University of Durban-Westville
UN	University of Natal
UNESCO	United Nations Educational, Scientific and Cultural Organization
UP	University of Pretoria
UPE	University of Port Elizabeth
US	University of Stellenbosch
UW	University of the Witwatersrand

TITLES IN THIS SERIES

1. *A description of the Savanna Ecosystem Project, Nylsvley, South Africa. December 1975. 24 pp.
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52. Structural characterization of vegetation in the Fynbos Biome. B M Campbell, R M Cowling, W J Bond and F J Kruger in collaboration with D P Bands, C Boucher, E J Moll, H C Taylor and B W van Wilgen. August 1981. 19 pp.
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68. The SANCOR Programme on Coastal Processes April 1982 - March 1988.
Edited by D H Swart. February 1983. 29 pp.

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