

# Marine Research in Natal

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Proceedings of a symposium and workshop held at  
Durban, South Africa, 10 and 11 February 1986

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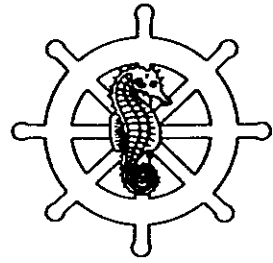
A P Bowmaker, D van der Zee and J H Ridder (Editors)

SOUTH AFRICAN NATIONAL SCIENTIFIC PROGRAMMES REPORT NO

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Symposium and workshop held under the aegis of the  
South African National Committee for Oceanographic Research  
(SANCOR)

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Cover : A typical Natal coastal scene. The dune stabilizing *Scaevola plumieri* in the foreground, sand and rock substrate, and the nearshore on an atypically calm day.

(Photograph: Natal Town and Regional Planning Commission)

## PREFACE

At a meeting of the South African National Committee for Oceanographic Research (SANCOR) held in November 1985, it was considered that there was a need for regional co-ordination of marine research and that it would be advantageous if a meeting of all marine scientists and engineers carrying out research in Natal be called, to allow an exchange of information. This is a first step, perhaps, to greater co-ordination in the region. Further, a need for interaction between management authorities and the scientific community was recognized.

The Oceanographic Research Institute (ORI) Durban, offered to arrange such a meeting with the support of SANCOR. The offer was accepted and a Symposium and Workshop were held on 10 and 11 February 1986. The aims of the meeting were to:

- Offer an opportunity to all marine research workers in Natal to inform others of the research they were doing.
- Attempt to list gaps in research and set research priorities for the Eastern seaboard of South Africa, bearing in mind management needs.

It was anticipated that there would be an enthusiastic response and it was decided that each contribution should be made as a strictly five minute oral presentation supported by a single page summary which should be suitable for publication. These presentations took the whole of the first day.

On the second day, the first session consisted of the summarization of the various sections by seven rapporteurs who had been asked to consider the previous day's contributions in the light of the aims of the meeting, given above. The second session was composed of four contributions from representatives of management bodies - the Department of Water Affairs, the Sea Fisheries Research Institute (SFRI), the Natal Parks Board (NPB) and the Natal Town and Regional Planning Commission (NTRPC) - followed by a general discussion.

**ABSTRACT**

A two day mini-symposium and workshop held in Durban in February 1986 and attended by 70 marine scientists from Natal and KwaZulu is reported on. Summaries of 84 presentations are given, separated into relevant sections. Each section is summarized by a rapporteur. Management needs are considered and the conclusions are given as problems, needs and priorities for research.

**UITTREKSEL**

Verslag word gelewer oor 'n twee-daagse mini-simposium en werkswinkel wat in Februarie 1986 in Durban gehou is en deur 70 mariene-wetenskaplikes van Natal en KwaZulu bygewoon is. Opsommings van 84 aanbiedings, verdeel in toepaslike seksies, word gegee. Elke seksie is opgesom deur 'n rapporteur. Bestuursbehoefte word in oorweging geneem en die gevolgtrekkings word weergegee as probleme, behoeftes en prioriteite vir ondersoek.

## **ACKNOWLEDGEMENTS**

Thanks should go to the following persons :

- Dr Tony de Freitas, Dr Allan Connell, Mr Rudy van der Elst, Dr Alan Ramm and Dr Mike Schleyer, who formed an organizing committee for the symposium.
- The staff of SANCOR, in particular, André van der Westhuysen, who provided the incentive for the symposium, and Annette Schnetler who helped in organizing and minuting the symposium and workshop.
- The Natal Town and Regional Planning Commission for providing the colour separations for the cover.
- The rapporteurs for their considerable contributions to the value of the meeting; Dr Tom Mason, Dr Harry Swart\*, Professor Richard Norris, Professor Trevor Steinke\*, Dr Mike Schleyer, Dr Norman Pammenter, Dr Tony de Freitas, Mr Rudy van der Elst, Dr Allan Connell, Dr Alan Ramm, Mr James Turner and Dr Derek Melton.
- The Chair persons of the various sections who are not listed: Professor Pat Berjak, Dr Tony de Freitas, Dr Allan Connell, the late Dr Julian Hemens and, particularly, Professor Jan Heeg, who chaired the morning sessions of the Workshop as well as the microbial ecology session of the Symposium.
- And all the participants, who produced their contributions at such short notice and presented them within the stipulated five minutes.

\* (Unable to attend, but commented on summaries as rapporteurs).

**TABLE OF CONTENTS**

	Page
<b>PREFACE</b> .....	(iii)
<b>ABSTRACT</b> .....	(iv)
<b>UITTREKSEL</b> .....	(iv)
<b>ACKNOWLEDGEMENTS</b> .....	(v)
<b>ACRONYMS</b> .....	(vii)
<b>RESEARCH SUMMARIES</b> .....	1
<b>GEOLOGICAL PROCESSES AND SEDIMENTATION</b> .....	3
<b>PHYSICO-CHEMICAL PROCESSES AND ENGINEERING</b> .....	11
<b>ALGAE/PRIMARY PRODUCTION</b> .....	29
<b>MANGROVE ECOLOGY</b> .....	45
<b>VEGETATION OTHER THAN MANGROVES</b> .....	55
<b>MICROBIAL ECOLOGY</b> .....	63
<b>INVERTEBRATE STUDIES</b> .....	75
<b>FISH AND FISHERIES</b> .....	99
<b>POLLUTION AND HUMAN EFFECTS</b> .....	117
<b>ESTUARIES</b> .....	137
<b>AQUACULTURE</b> .....	149
<b>DOLPHINS AND TURTLES</b> .....	149
<b>DATA CENTRE</b> .....	149
<b>MANAGEMENT NEEDS</b> .....	167
<b>DEPARTMENT OF WATER AFFAIRS</b> .....	169
<b>SEA FISHERIES RESEARCH INSTITUTE</b> .....	170
<b>NATAL PARKS, GAME AND FISH PRESERVATION BOARD</b> .....	171
<b>NATAL TOWN AND REGIONAL PLANNING COMMISSION</b> .....	173
<b>PROBLEMS, NEEDS AND PRIORITIES</b> .....	175
<b>RECENT TITLES IN THIS SERIES</b> .....	179

**ACRONYMS**

AECI	African Explosives and Chemical Industries
CDI	Community Degradation Index
CPUE	Catch-per-unit-effort
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environment Affairs
dwt	Dead-weight tonnage
EWT	Endangered Wildlife Trust
FRD	Foundation for Research Development (CSIR)
MSY	Maximum Sustainable Yield
NIWR	National Institute for Water Research (CSIR)
NPB	Natal Parks Board
NPRL	National Physical Research Laboratory (CSIR)
NRIO	National Research Institute for Oceanology (CSIR)
NSB	Natal Sharks Board
NTRPC	Natal Town and Regional Planning Commission
ORI	Oceanographic Research Institute
PEM	Port Elizabeth Museum
SAAMBR	South African Association for Marine Biological Research
SAASSPER	South African Association for Sport Science, Physical Education and Recreation
SADCO	South African Data Centre for Oceanography (CSIR)
SAICCOR	South African Industrial Cellulose Corporation
SANCOR	South African National Committee for Oceanographic Research (CSIR)
SAPPI	South African Paper and Pulp Industries
SATS	South African Transport Services
SDD	Sediment Dynamics Division (NRIO)
SDP	Scandinavian Design Practice
SEAL	Sedimentation in Estuaries and Lagoons
SEFREF	Sea Fisheries Research Fund
SEM	Scanning Electron Microscopy
SFRI	Sea Fisheries Research Institute
SFW	Stellenbosch Farmers' Winery
TEM	Transmission Electron Microscopy
UDW	University of Durban-Westville
UN	University of Natal
UND	University of Natal (Durban)
UNP	University of Natal (Pietermaritzburg)
UPE	University of Port Elizabeth
VPA	Virtual Population Analysis



**RESEARCH SUMMARIES**

**GEOLOGICAL PROCESSES AND SEDIMENTATION**

**RAPPORTEUR'S COMMENTS**

T R Mason

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**SEDIMENTATION IN NATAL ESTUARIES**

J A G Cooper, T R Mason and R Tavener-Smith

**HYDROLOGICAL/HYDRAULIC STUDY OF NATAL ESTUARIES**

D H Swart and J E Perry

**MARINE GEOSCIENCE CONTINENTAL SHELF RESEARCH, ZULULAND**

I L van Heerden, A K Martin and L Lenhoff

**MARINE GEOSCIENCE COASTAL RESEARCH IN ZULULAND**

I L van Heerden, A K Martin and L Lenhoff

**GEOLOGICAL PROCESSES AND SEDIMENTATION**

Rapporteur's Comments : T R Mason

Sedimentological research in Natal may be categorized under two headings:

- (a) Offshore seismic surveys of the ocean carried out by the National Research Institute for Oceanology (NRIO).
- (b) Onshore work carried out by NRIO, the Council for Scientific and Industrial Research (CSIR) and the University of Natal, Durban (UND).

The first is essentially baseline data collection on the continental shelf and has outlined important structures under the ocean. These include ancient aeolian dune ridges which act as sediment dams and cores for modern reefs and canyons which apparently act as conduits for transfer of shelf sediment into the deeper parts of the Indian Ocean. This work is of fundamental importance to geologists, marine geologists and oceanographers.

The second category embraces a more variable collection of research programmes. The NRIO onshore work currently concerns research in Richards Bay and Lake St Lucia. The CSIR, Durban estuarine research group is included here as this work involves the collection of physical data which are relevant to the sedimentation studies. Using the same criteria the NRIO hydro surveys should also be included here as they are also relevant to the sedimentological understanding of the Natal estuaries.

The research effort of the Department of Geology and Applied Geology at the University of Natal (UN) is currently limited to a preliminary study of sediment distribution in three chosen estuaries (Mgeni, Mvoti and Mhlanga). A baseline study of Mhloti Estuary is almost complete. This research was carried out as an Honours student's project using the same approach as the SANCOR funded programme. Preliminary work in the three estuaries is designed to establish sound sample collection procedures and to map sediment type and grain size distribution. The young scientist concerned is training as a scientific diver and has already attended a basic diving course. The Mgeni-Beachwood area has been sampled and a paper prepared for publication on washover sedimentation in the Beachwood mangrove area. This work is being presented to the Natal Parks Board as a report (SEAL report no. 1) on the status and management of the dunes which separate Beachwood from the ocean.

The estuarine research will be of considerable value to the entire scientific community in Natal as most scientists and organizations find that they are lacking basic earth science data. The work will proceed as fast as possible within the limits of current funding constraints. There is scope for at least one other researcher to operate under the aegis of the University and it is obvious that there is work for at least one other sedimentologist based in CSIR, Durban or at ORI. Trained personnel are scarce and may need to be recruited from overseas.

SANCOR's funding of this new programme has been timely and generous, but I must add that the work would not have proceeded as smoothly without the cooperation and collaboration of a number of people in different organizations. This is heartening and the help which we have received has enabled us to save a great deal of time in these early phases of the programme. The Departments of Surveying and Mapping, Chemical Engineering, Biological Sciences and Geography at the University of Natal, Durban have all provided help in various ways. The Department of Geology and the workshop at the University of Port Elizabeth (UPE) have provided expert advice gained by their own experience in the field. The Oceanographic Research Institute, Durban have lent us a boat and engine. NRIO, Stellenbosch have helped with literature and aerial surveys and advised about vibracorer construction. CSIR, Durban have allowed us to use their settling tube and Olivetti Africa and Anglovaal have donated computer equipment. I feel that if this sort of cooperation is possible between the different research organizations it should become routine and perhaps be made a condition of the SANCOR research grants that active collaboration and consultation be encouraged.



**SEDIMENTATION IN NATAL ESTUARIES**

Researchers : J A G Cooper, T R Mason and R Tavener-Smith  
 Organization : UND  
 Duration : 1985 - 1987  
 Funding : SANCOR

The aim of this research programme is to gain an understanding of sedimentation in Natal estuaries. We define estuaries rather broadly and three Natal examples representing different end members of the spectrum of estuarine types have been selected for detailed study. These are: the Mgeni Estuary (including Beachwood Creek); the Umhlanga Lagoon and the Mvoti River mouth. These three are thought to be good examples of different sedimentary environments. The processes of sedimentation and sediment distribution will be recorded and described for each estuary. Using old charts, historical records and aerial photographs, the development of each system will be reviewed, particularly with regard to the sediment history.

Sediment from each estuary will be sampled and analysed to determine the relative proportions of mud (diameter  $< 0.063$  mm), sand (diameter from 0.063 to 2 mm) and gravel (diameter  $> 2$  mm) and the amount of carbonate and organic material present in each sample. The grainsize distribution of the sandy sediment fraction will be determined using the CSIR-based NRIO-designed settling tube. The grainsize distribution of the sandy sediment fraction will also be plotted as a cumulative curve using a computer-driven ruby laser beam device belonging to the Department of Chemical Engineering at UND. Binocular Microscope- and Scanning Electron Microscope (SEM) studies will be made of the sedimentary grains including the important heavy mineral suite. These analytical methods will allow a detailed description of sediment from the three systems to be published along with sediment distribution maps which will establish baseline information for subsequent studies. The major sediment sources may also be recognized.

It is planned to make a bathymetric survey of the three estuaries for comparison with existing cross-sectional data to determine if there is a net sediment gain or loss with time. A study of subaqueous sedimentary structures will be made with the object of understanding sediment transport directions in the estuaries. At a later stage of the project it is planned to vibracore the sediments in the estuaries to study three-dimensional sedimentary facies patterns.

Research to date includes the development of an efficient and accurate sampling and analysis procedure. This has been developed in the Mgeni Estuary due to its proximity to Durban. Sampling in this estuary has been completed and laboratory analysis of material is in progress. The principal researcher is being trained as a scientific diver for underwater recovery of specimens and samples.

A study of the morphology, genesis and ecological effects of a recent large washover fan in the Beachwood mangrove area has been completed and a report is being compiled for the NPB. An ancillary study of Holocene fossils from the estuaries is also in progress.

**HYDROLOGICAL/HYDRAULIC STUDY OF NATAL ESTUARIES**

Researchers : D H Swart and J E Perry  
 Organization : NRIO  
 Duration : 1979 - 1990  
 Funding : NTRPC

A ten-year project is being carried out to obtain an understanding of the long-term functioning of the lagoon/estuary systems in Natal.

The study is moulded around the use of aerial photographs which generally cover a forty-year period and have been found to provide the best source of data. A classification sheet has been developed for recording and classifying the data from each estuary.

To date 22 estuaries have been studied extensively and clear indications are being obtained about the correlation between human interference (e.g. by bridge construction, farming practices and opening or closing of mouths) and the long-term behaviour of the estuaries.

Recently much effort has been devoted to an overview of hydrological factors affecting siltation in 71 Natal estuaries.

**MARINE GEOSCIENCE CONTINENTAL SHELF RESEARCH, ZULULAND**

Researchers : I L van heerden, A K Martin and L Lenhoff  
 Organization : NRIO  
 Duration : Ongoing  
 Funding : NRIO

The object of this project is to determine the modern sedimentary processes operative on the continental shelf in the vicinity of Leven Canyon. An initial geophysical survey has been undertaken of the shelf area from Richards Bay to the Natal/Mozambique border. In 1986 a detailed survey was made in the vicinity of Leven Canyon and a current meter placed on the edge of the canyon. In due course it is hoped to obtain cores from the canyon floor.

The canyon appears to be a major exit point for shelf sediments being swept south by the Agulhas current. Included are the biogenic sediments originating from the coral reefs within the Marine Reserve.

**MARINE GEOSCIENCE COASTAL RESEARCH IN ZULULAND**

Researchers : I L van Heerden, A K Martin and L Lenhoff  
Organization : NRIO  
Duration : Ongoing  
Funding : NRIO

The Marine Geoscience Division is involved in three projects in Zululand.

- Modern sedimentary processes in the St Lucia and Mfolozi Estuaries.

The initial phase of the project, performed in collaboration with our Sediment Dynamics Division, is now complete and led to the development of a management plan for St Lucia Estuary. Further studies are planned in collaboration with the St Lucia research section of the NPB to actively measure tidal currents and to monitor sediment movement in the estuary mouth.

- Geological evolution of Lake St Lucia.

This project is aimed at elucidating the evolution of the St Lucia lake complex specifically during the Quaternary period. In December 1985 a geophysical survey (side scan sonar, boomer, pinger, echo sounder), was undertaken in collaboration with the NPB, in the northern and southern compartments. This data has been supplemented by a vibracoring programme performed in 1986.

- Geological processes in the St Lucia Marine Reserve.

Recognizing that the corals encrusting a submerged aeolianite dune ridge form a fairly unique reef environment, the Marine Geoscience Division has initiated a research project on a 10 km section of the reefs north of Leven Point. The reefs have been surveyed with side scan sonar and echo sounder, sampled and extensively photographed. A distinct terrestrially-derived sediment facies hugs the surfzone while a biogenic sediment facies occurs in the immediate vicinity of the reefs. In 1986 a current meter with thermistor probe was placed on the outer edge of the reefs.

**PHYSICO-CHEMICAL PROCESSES AND ENGINEERING**

**RAPPORTEUR'S COMMENTS**

**D H Swart**

**PHYSICAL OCEANOGRAPHIC STUDIES**

**M L Gründlingh**

**RICHARDS BAY : POST-CONSTRUCTION MONITORING**

**D H Swart**

**RICHARDS BAY : SHIP MOTION STUDIES**

**J A Zwamborn**

**DURBAN BEACH IMPROVEMENT SCHEME**

**D H Swart**



**PHYSICO-CHEMICAL PROCESSES AND ENGINEERING**

Rapporteur's Comments: D H Swart

**1. GENERAL**

This report was written as a rapporteur's report, even though the author did not attend the workshop. The review covers processes in the sea, in the ocean and coastal areas, in estuaries and on land in the coastal zone. In preparing such an overview, one should realize that it is not really possible to study the processes in any given area such as Natal in isolation, since there is no clear division between zones and interactions take place across the grey areas between the zones. In addition, a review of physico-chemical processes is really meaningless if it is not read in conjunction with an overview of biological processes. Examples here are the phragmites research of the NIWR, which is intimately linked to the whole process of siltation in estuaries, as well as the classification of the estuaries in Natal according to biological data (species diversity and abundance etc.) on the one hand and according to physiological parameters (catchment size, simulated run-off, etc.) on the other hand. Research in the various disciplines is therefore frequently in support of each other and help build up a better understanding of the respective fields across disciplinary boundaries. The present overview should be read in this context.

One has to ask oneself why one is doing research. It could be to better understand certain detailed processes just for the sake of the better understanding or it could be to better understand the environment at large to allow one to give better answers. With this in mind it can be stated that physical processes can be studied at two levels:

1. **What is happening?** This implies that the **macrodynamics** of an area are studied and that on the basis of one's observations one is in a position to say what has happened. This is frequently the way in which contract-type studies are performed to allow one to give advice to a client. However, in some cases basic research is also tackled in this way. A good example is the prediction of on/offshore sediment transport where the basic phenomena are not fully understood as yet, but by comparing the results of numerous experiments and observations in nature, it has been possible to define a predictive framework which allows one to assess on/offshore sediment movement for given environmental conditions.

2. **How has it happened?** This implies that the **microdynamics** of a particular problem are studied, e.g. the specific movement of sand grains over irregular bed forms on the seabed. It is clear that the second approach allows one to understand more clearly the basic mechanisms operating in an area and it is also clear that such results could be used in support of advice-giving as discussed above. However, it is normally so that this second type of research takes much longer to complete (5 to 10 years perhaps) and therefore since there is frequently a need to give immediate advice, one is often forced to resort to the first method. Nevertheless I am of the opinion that both approaches should be used at the same time.

The NRIO coastal work in Natal is more geared towards studying the macro-dynamics, mostly for outside clients. Microdynamics-type physical studies are performed at the NRIO region site in the Western Cape which was established at Hermanus in Walker Bay in the beginning of 1986.

After a short overview of the various physico-chemical studies in Natal in the four regions referred to in Sections 2 to 5, data requirements are discussed in Section 6.

## 2. OCEAN PROCESSES

The involvement of the Physical Oceanography Division of the NRIO off the Natal coast over the past two decades has followed two "main-stream" approaches: Firstly, there have been localized, mesoscale studies of the coastal and shelf circulation in the area between Cape St Lucia in the north and Port Edward in the south. These investigations normally took the form of single-line transects or station grids occupied as regularly as possible. The second line of approach has been to investigate aspects of the circulation beyond the shelf edge in order to provide an input to the focus driving the shelf currents. These larger-scale studies have focused attention mainly on the Agulhas Current, but have also devoted some effort to the flow conditions beyond the Agulhas.

The years 1984 to 1986 have seen a decrease in shelf data collection exercises, mainly as a result of the movement of groups responsible for these activities to Stellenbosch at the beginning of the 1980s. The past few years have given this group the opportunity to review their activities off Natal and a comprehensive multidisciplinary treatise on this subject (Schumann, 1987) is in preparation.

The work further offshore has not been affected by the move to Stellenbosch to the same extent, and has continued over the 1984 to 1986-period. The effort was concentrated on the circulation beyond the Agulhas Current and in the deep-sea region of the SW Indian Ocean, although some cruises were also executed inside the Agulhas Current off Durban and Port Shepstone in 1986. Within the framework of limited resources, the possibilities of deep-sea work has been all but exhausted. Some important discoveries have been made in this field and they are presently being evaluated in terms of their effect on the circulation closer inshore.

Some relevant references are included to provide further insight into these activities.

## 3. COASTAL PROCESSES

A distinction will be made in this section between contract studies which mostly study macro-processes and more fundamental research, which could be on either micro- or macro-scale.

### Contract studies

The following is a short overview of ongoing projects in Natal as well as some which have been completed, to show the type of work which is being done and can be done. All of these contract studies were performed by the NRIO.

**Richards Bay sediment studies.** Over the last 20 years the Coastal Engineering Divisions of the NRIO have been actively involved at Richards Bay, during the design, construction and post-construction phases. The Sediment Dynamics Division (SDD) predicted the effect of the harbour breakwaters on the surrounding beaches and have subsequently co-ordinated the monitoring of beach and nearshore changes. A fairly comprehensive understanding was built up about morphological processes in the area which is being used by the South African Transport Services (SATS) to plan dredging operations.

**Richards Bay ship motion studies.** The NRIO Maritime Structures Division has studied ship motions in the Richards Bay entrance channel at three levels, namely, photographically in the prototype, mathematically and in small-scale hydraulic models and has produced a port-operation manual for ship entry and departure criteria and advises the SATS on these matters. Presently the design of a small-parcels facility at Richards Bay is also being investigated for the SATS.

**Durban beaches.** The NRIO/SDD designed a beach protection scheme for the Durban Corporation which consists of four key elements, an initial fill to re-establish the beaches, an ongoing replenishment to maintain the beaches, a series of up to 7 low-level or permeable groynes to regulate longshore losses from the Durban Bight and an underwater sand mound about 1,2 km offshore which reduces storm wave energy and consequently also beach losses. The SDD advises on matters pertaining to beaches and maintains a computer data bank on all relevant data. The Division was also involved in the design studies for the two new piers which replaced the old Paterson groynes.

**SAICCOR pipeline.** The NRIO/SDD and Maritime Structures Division jointly contributed to the design studies for the new SAICCOR ocean pipeline at Mkomaas. Refraction studies led to a comprehensive wave climate in shallow water, which was used to perform studies related to forces on the proposed pipeline, nearshore sediment dynamics and the burial of the pipeline through the surf zone.

**Beachwood mangroves, Mgeni.** The NRIO/SDD quantified the sediment budget in the area on the basis of mainly the Durban beaches studies and advised on a management strategy.

**Ballito Bay beach amenities.** The NRIO/SDD is involved in a study to determine the optimum structures needed to provide safe bathing at Ballito. The SDD produced a feasibility report and is now doing the simulations of sediment dynamics in the area on behalf of Geustyn, Forsyth and Joubert, Ing.

**Natal North Coast beaches.** In the 1970s the NRIO performed a comparative study of the beaches on the Natal South Coast related to bathing safety and available space, based on seasonal surveys over three years. Recently a statistically much sounder technique was evolved by the SDD for a few areas in the Cape Province, and is now going to be applied for the NTRPC on the North Coast of Natal as well. It utilizes long-term wave data (more than 60 year's ships data) to predict nearshore processes, which then provide the basis for an evaluation of bather safety and bather comfort.

### Basic research studies

Very few (too few) studies are performed in Natal at this level.

**Washover fans, Beachwood mangroves.** The Sedimentation in Estuaries and Lagoons (SEAL) group at the Geology Department, University of Natal, identified some very good examples of washover fans across the spit at the Mgeni mouth, studied these in detail and reported on their findings in the international literature.

**Relationship littoral drift/rainfall.** The NRIO/SDD is investigating the effect of broad climatic patterns on the rainfall and run-off in the rivers and on the littoral drift along the shore. It has thus far been established that littoral drift becomes less dominant towards the north during extended dry spells, which can have significance for the dynamics of the Natal estuaries, which is closely related to their mouth configurations.

**Sediment budget, broader Durban area.** A basic study by the NRIO/SDD is underway to collate all the information about sediment budgets and pathways in the broader Durban coastal area, to in this way, understand the fundamentals of the interactions in the area.

**NRIO regional research site: Walker Bay.** Although not in Natal, it is considered relevant to mention this work in the Natal context, since it is basic of nature and the results are presented in such a way that they can be applied elsewhere and these studies are the only such studies in South Africa. Ongoing measurements are made of wave characteristics and related phenomena (nearshore, currents and long waves/surf beat) in the breaker zone, as well as measurements at regular intervals of sediment dynamics. It is the intention to as of 1987 also measure sediment suspension continuously with the aid of a light-sensing device. A definite improvement in the understanding of nearshore water and sediment dynamics is achieved.

Studies of the nature mentioned above (contract/basic) focus heavily on prediction and measurement of quantities of sediment moved. Although routine techniques exist for this purpose the main aim of research is to improve these techniques as our fundamental understanding of the processes at work broadens.

#### 4. ESTUARINE PROCESSES

##### Contract studies

**CSIR Natal estuaries contracts.** The Estuarine and Coastal Processes Division of Dr A E L Ramm at the National Institute for Water Research (NIWR) is contracted by the NTRPC on behalf of the Department of Environment Affairs (DEA) to do research in the estuaries of Natal, aimed at furthering the work and data base of Dr G W Begg (Begg, 1978; 1984a) and at improving the understanding of the biotic component of the estuaries in general. At the same time the NRIO/SDD (Mrs J Perry) is performing a hydrological/hydraulic study of the estuaries in Natal. The NRIO reports have been produced for the following systems: Mpenjati (NS7), Mbizana (NS10), Damba (NS23), Mzumbe (NS26), Mtwalume (NS32), Fafa (NS34), Mzinto (NS38), Mpambanyoni (NS40), Mahlongwa (NS41), Mkomaxi (NS43), uMgababa



(NS45), Lovu (NS47), Mbokodweni (NS50), Sipingo/Mlazi (NS51/52), Mgeni (NN1), Mdloti (NN3), Tongati (NN4), Mhlali (NN5), Mvoti (NN7), Malotane (NN8), Nonoti (NN9), Zinkwasi (NN10), Siyaya (NN14), Mhlatuze (NN16). Currently work on the Tugela (NN11) and Mlalazi (NN15) is underway. Related to this hydro study has been the following tasks:

- (a) Special review of hydro factors affecting siltation in the "Estuaries" (Perry, 1985).
- (b) Compilation of basic physical geography/hydro data for Natal "Estuaries" (Perry, 1986).
- (c) Analyses of simulated run-off data for Natal "Estuaries".
- (d) Application of "Decorana" to physical/hydro data of Natal "Estuaries".
- (e) Lateral stability of the Mzambe (NS26).

It is possible to address *ad hoc* problems in the estuaries on the basis of the knowledge acquired through the contract. Examples are: Sipingo (NS51) fish kills, Damba (NS23) caravan park flooding - lateral stability, Lovu (NS47) February 1985, flood scour along channelling wall, Mgeni (NN1) coastline changes, Ohlanga (NN2) dune attack, Mlalazi (NN15) "Wards Berm" and mouth/spit progression and currently uMlanga (NS16) mouth movements/breaching.

**St Lucia/Mflozi after Domoina.** The NRIO/SDD and Marine Geoscience Division jointly performed a study after Domoina in 1984 to determine the physical processes operative in the estuarine and coastal areas and to, on the basis thereof, devise a management plan for the estuarine and coastal areas. A least interference policy was recommended and adopted. Monitoring of recovery and natural behaviour of the St Lucia mouth region is carried out regularly by the Natal Parks Board.

**Dam management policies.** The NRIO/SDD was involved over the last few years in the determination of release policies for proposed dams in the Mgeni (Inanda Dam) and Tugela (Mvumase Project) to minimize the impact on the estuary and adjacent coastal areas. The balance of flushing (river and tidal flows through the mouth) and blocking factors (fluvial and marine sediment deposits) is calculated on the basis of available wave and hydro data and used to design the release policy, after which a comparison with the expected post-dam ratio (balance) was made.

**Hydraulic design of bridges.** The capability exists within the SDD/NRIO and the National Mechanical Research Institute of the CSIR to perform hydraulic model studies to optimize pier alignment for bridges. Two examples where such studies were performed successfully are for the freeway bridges at Lovu and Mzambe. These studies were performed in the NRIO laboratories in Stellenbosch on behalf of consulting engineers acting for the Natal Roads Department and the National Roads Commission.

#### Basic research studies

The Natal estuaries contracts of the CSIR, referred to above, contain a substantial proportion of basic research, aimed mainly at a better inven-

tory of the available information and of the character(istics) of the estuarine systems in Natal, as well as the obtaining of a better understanding of the various processes operative in estuaries and particularly the interactions between physical, chemical and biological processes. On the basis of ordination techniques a classification was obtained for both physical and biotic factors which ties in well with a proper understanding of the physical behaviour and character of the estuaries. The NIWR and NRIO jointly chose, on the basis of physical and biotic ordinations, the following systems as representative of the types of "estuaries" in Natal:

System	Physical class	G Begg class	Species richness	Degradation index	Geography
<b>Mlalazi</b>	1	estuary	50	3	NC
<b>Siyaya</b>	5	-	15	~ 6	NC
MATIGULU	1	-	60	2	NC
<b>Zinkwasi</b>	3	outlier (L?)	64	2	NC
<b>MVOTI</b>	1	river mouth	17	8	NC
<b>Mhlanga</b>	2	est lagoon	24	6	NC
<b>Mgeni</b>	1	estuary	79	2	NC
Lovu	2	estuary	39	5	SC
Mkomazi	1	estuary	66	3	SC
MAHLONGWA	5	est lagoon	37	3	SC
MAHLONGWANA	5	fw lagoon	8	8	SC
Fafa	5	fw lagoon	10	8	SC
Mzumbe	2	est -> RM	14	8	SC
Tongazi	6	outlier (est)	5	7	SC
SANDLUNDLU	6	outlier (est)	25	1	SC

Notes: **Bold** - Joint choice  
 UPPER CASE - NIWR choice  
 Normal - NRIO choice

Physical class - NIWR preliminary categories  
 Degradation index - preliminary where  $0 < D.i. < 10$   
 NC - north coast  
 SC - south coast

**St Lucia research.** The Scientific Advisory Council for St Lucia critically re-assessed the processes and interactions operative in the system in the 2 years following Domoina and have come up with a cohesive research approach with sedimentation as the central theme. Research is being done by the Natal Parks Board, the Universities of Natal and Durban/Westville and the NRIO/Marine Geoscience and SDD. In time the research will lead to a management plan for the St Lucia area which is well researched.

**Sedimentation in estuaries and lagoons (SEAL).** The Geology Department at the University of Natal researches the geophysics and recent sediment dynamics of selected estuaries in Natal as a SANCOR project in response to an identified gap in geophysical work. To date reports on the Beachwood mangroves and the Mgeni have been prepared. Close liaison with the CSIR research referred to above and with the next project is maintained.

**Natal estuaries sedimentation rates.** The NRIO/SDD is as part of a SANCOR-funded project researching the sedimentation rates in selected Natal estuaries (Mzumbe\*, Mvoti\*, Mkomazi, Zinkwazi\*, Siyaya, Mbizana\*, Mzimayi, Mpenjata\*, Zolwane, Tongazi, Umhlangankulu, Damba\*, Ohlanga, Mdloti; \*indicates that work has already started). A proper hydrographic survey of the estuary, which is a prerequisite for any work in an estuary, precedes coring with a device which is a hybrid between vibro-coring and wash-boring, named the vibra-washer in the NRIO. It is anticipated that analysis of the cores in conjunction with long-term hydro-data and interpretation over a longer-term period in the past will supply quantitative data on sedimentation rates.

**Siyaya demonstration project.** Under the enthusiastic leadership of Dr G W Begg a catchment demonstration project was initiated in the late 1970s. The Siyaya was chosen because of the particular characteristics of the catchment. A number of government agencies and research organizations co-operated in doing research at a multidisciplinary level, with as aim to prove that proper catchment management can retard estuarine degeneration.

At present the Siyaya project is co-ordinated by Dr A de Freitas of ORI as an interim measure. Various key issues are still to be finally resolved, but at present plans are afoot to start a Natal catchment project where more emphasis will be placed on measuring catchment inputs to the estuaries and extending the results obtained in the atypical Siyaya to representative estuarine systems in Natal. This project will again be multidisciplinary, multi-institutional, which can only get off the ground properly if a cohesive funding policy can be worked out. The idea is that the same selected systems referred to above should be chosen for the catchment project.

## 5. COASTAL ZONE PROCESSES

The Regulations regulating development in a zone extending up to 1 000 m from the coast, which were eventually promulgated in the Government Gazette of 12 December 1986, call for developers/planners to supply a statement upon applying for a development permit which outlines the interactions between the elements/processes in the coastal environment and their proposed development. This necessitates a clear, fundamental

understanding of the various processes and interactions operative in the coastal zone. Of particular importance is the identification of sensitive zones and the role of wind-blown sand and vegetation cover on stability. In Natal research on these aspects is still sadly lacking.

### Contract studies

**Coastal environment *ad hoc* enquiries.** The CSIR (NRIO/NIWR) has geared themselves to in a similar way as done by ECRU at the NRIO, Stellenbosch answer queries on coastal environmental matters in a multidisciplinary way. Dr A E L Ramm of the NIWR and Mr I Rout, the NRIO engineer based in Durban, are the contact persons. Just for the record, since the NRIO in Stellenbosch developed the expertise to answer such enquiries from both the biological and the physical process/engineering point of view it has handled more than 320 such requests in a 7-year period, presently at a rate of 10 per month.

### Basic research studies

No basic research is being done in Natal on this front. It is a gap to be addressed, particularly since the coastal topography, vegetation and climate are distinctly different from the rest of the country. As an example of the type of work in this respect, one can quote Waenhuiskrans near Cape L'Agulhas. Vegetating of a sandy headland caused the cutting off of the wind-blown sand supply to the down-wind beaches, causing widespread erosion and a deterioration of bathing conditions. The Directorate of Forestry in a bold step decided to devegetate about half the headland in order to reinstate a sand corridor. The NRIO/SDD is monitoring sand and dune movement in vegetated and adjacent devegetated dunes and beach responses.

## 6. BASIC DATA

The above synthesis shows clearly that there is a shortage of scientists who are based in Natal and who study physical processes. This means that biologists who want to obtain physical data as input to their studies need to get it from available other sources or they have to record it themselves. This in itself is not a very healthy situation.

For the benefit of the coastal scientists in Natal a short summary is given below of available data sources and two straightforward data sheets are given which will help to standardize the recording of physical data.

Routine data sources

<u>Type of data</u>	<u>Source</u>
*Voluntary Observing Ship's data (wind direction and velocity, air and water temperature, rainfall over sea, wave height, period and direction).	1. "Real-time" data: with only short delay from Weather Bureau Pretoria. 2. Statistics: For period ~1920 to 1984 from the South African Data Centre for Oceanology (SADCO), Stellenbosch.
*Hydrological data (rainfall, run-off, discharge).	Weather Bureau (rainfall), Dept of Water Affairs (run-off discharge).
*Simulated monthly run-off (based on infilled rainfall records from 1921 - 1975)	Mrs J E Perry, NRIO/SDD Stellenbosch
*Waverider data (Richards Bay, Durban)	NRIO, Stellenbosch with permission from respective clients (SATS, Durban Corporation).
*Basic physical factors in Natal estuaries	Perry (1986).
*Nearshore, estuarine and beach bathymetry	
- St Lucia	. NRIO, Stellenbosch
- Ballito Bay	. Geusteyn, Forsyth and Joubert Ing., Stellenbosch
- Port Zimbali	. NRIO, Stellenbosch
- surveys of above-mentioned selected estuaries	. NRIO, Stellenbosch
- Durban	. NRIO, Stellenbosch
- SAICCOR	. NRIO, Stellenbosch
- 89 South Coast beaches early 1970s - 3 years' data	. NRIO, Stellenbosch
Permission for obtaining these data sets should be obtained via the respective clients.	
*Ocean currents (Richard Bay, Durban, Port Edward, Mkomazi)	SADCO, Stellenbosch

Physical parameters to be measured in bio-studies

This list is but a physical scientist/engineer's list but could form the basis for a more comprehensive list.

1. A short bamboo tube could be used to obtain sediment suspension data.

2. The bed level and/or the intertidal beach profile would be useful.
3. Visual estimates of wave height, period and direction at high- and low-tide.
4. The grain size distribution.
5. The nearshore current speed and direction by some simple method.
6. The wind speed and direction by means of a simple, hand-held anemometer.
7. The temperature of the seawater and air.
8. Humidity.
9. Barometric pressure.
10. The tide level at the time of measurements relative to high- and low-tide.
11. The turbidity.
12. The surface and bottom oxygen.

It would be useful to obtain the above-mentioned data regularly at each biological survey time but it may also be advantageous to have some of them at regular intervals throughout the study period, not necessarily only at times of biological measurements. In this way one could build up a description of the physical environment within which the biological measurements have been undertaken before going into an interpretation phase where an effort is made to link physical and biological processes.

If this is planned well in advance I am of the opinion that it would be possible for NRIO, NIWR, ORI and the universities to work together to make this type of approach a success.

A routine form has been developed at NRIO, Stellenbosch for the recording of pertinent physical parameters during a beach/site visit. The CLEO **Beaches** form (CLEO = Continuous Low-level Environmental observations) covers most of the items listed above and could be a useful starting point for such routine recording. A similar **CLEO Estuaries** form has also been developed.

## 7. IN CONCLUSION

At the end of this overview, I am left with the impression that what we as coastal scientists of all disciplines should do is to **discuss** our problems in research/data capture/interfaces, we should **co-operate** to find solutions/share work load and then our research will **grow** in structure.

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**PHYSICAL OCEANOGRAPHIC STUDIES**

Researcher : M L Gründlingh  
 Organization : NRIO  
 Duration : Ongoing  
 Funding : CSIR

The results of recent research in the open ocean aimed specifically at elucidating the origin and flow of the Agulhas Current and the Mozambique Ridge Current are contained in the following publications:

GRÜNDLINGH M L and PEARCE A F 1984. Large vortices in the northern Agulhas Current. *Deep-Sea Res.* 31: 1149-1156.

GRÜNDLINGH M L 1984. An eddy over the Northern Mozambique Ridge. *S. Afr. J. Sci.* 80: 324-329.

GRÜNDLINGH M L 1985. Occurrence of Red Sea Water in the Southern Indian Ocean. *J. Phys. Oceanogr.* 15: 207-212.

GRÜNDLINGH M L 1985. Features of the circulation in the Mozambique Basin in 1981. *J. Mar. Res.* 43: 779-792.

GRÜNDLINGH M L 1985. An intense cyclonic eddy east of the Mozambique Ridge. *J. Geophys. Res.* 90: 7163-7167.

Data collected off Port Edward in 1975 have been analysed and a publication entitled "Bottom boundary layer observations inshore of the Agulhas Current" has been submitted to the Journal of Physical Oceanography.

A volume entitled "Coastal Ocean Studies off Natal, South Africa", has been accepted for publication by Springer-Verlag, as part of the series "Lecture Notes on Coastal and Estuarine Studies". This volume will combine all existing knowledge on the currents and water properties of the region.

**RICHARDS BAY: POST-CONSTRUCTION MONITORING**

Researcher : D H Swart  
 Organization : NRIO  
 Duration : 1969 - Ongoing  
 Funding : SATS

Wave recording and measurements of shore and nearshore evolution at Richards Bay were continued after completion of the port in 1976. A

progress report on observations during the period June 1979 to May 1982 was submitted to SATS early in 1984, and a further progress report covering the period June 1982 to June 1983 has since been completed.

Recent field-work has been confined to the collection of wave data. Comprehensive shore, nearshore, hydrographic and aerial photographic surveys were carried out in 1985. In future these surveys will be undertaken on a biennial instead of an annual basis.

#### **RICHARDS BAY: SHIP MOTION STUDIES**

Researcher : J A Zwamborn  
 Organization : NRIO  
 Duration : 1978 - 1987  
 Funding : SATS

A study of ship motions in Richards Bay, aimed at establishing criteria for the safe allowance of deeper draught ships, was started in 1978. In 1984 the study was extended to investigate the possibility of two-way traffic (ships passing one another) as well.

The work includes field measurements to establish the relationship between ship motions and wave conditions in the entrance channel to the coal harbour.

Scale model studies include an extensive test programme to determine the behaviour of ships with dead-weight tonnage (dwt) of 150 000 and 270 000 as a function of wave direction and water depth. Two model ships built to a scale of 1:100, are used for this purpose. A basic test series with the 150 000 dwt model ship in beam waves has been completed to date. Model test in a 1:100 scale model of Richards Bay harbour is under way.

Another study involves the use of mathematical models to determine the motions of ships under the influence of waves. The test conditions are similar to those for the scale model tests to allow comparison of results. A sensitivity study has been carried out to determine the extent to which the shape of the ship can be schematized and what the effect is of damping coefficients for roll. Runs for the 150 000 dwt ship have been completed, while those for the 270 000 dwt ship have just started.

**DURBAN BEACH IMPROVEMENT SCHEME**

Researcher : D H Swart  
Organization : NRIO  
Duration : 1955 - Ongoing  
Funding : Durban Corporation

A database containing all available hydrographic and related data on the Durban beach area from 1957 is being established at the request of the Durban Corporation.

This database will provide an aid to the prediction of sediment transport and as such should be of considerable value in determining optimum locations for dumping sand for beach improvement works.

**ALGAE / PRIMARY PRODUCTION**

## RAPPORTEUR'S COMMENTS

R E Norris

## ECOLOGY AND TAXONOMY OF SELECTED INTERTIDAL AND SUBTIDAL ALGAE

G Lambert

BIOLOGICAL NITROGEN FIXATION ASSOCIATED WITH BLUE-GREEN ALGAL COMMUNITIES  
IN THE MGENI ESTUARY MANGROVE SWAMP

G Lambert, F Mann and T D Steinke

THE PRODUCTIVITY OF ALGAE OCCURRING ON *Avicennia marina* PNEUMATOPHORES

F Mann and T D Steinke

## EPIPHYTIC ALGAE IN MANGROVE SWAMPS AND ESTUARIES

G Lambert, Y Naidoo and T D Steinke

OBSERVATIONS ON THE REPRODUCTION AND ANATOMY OF *Sargassum heterophyllum*

A T Critchley

*Pavlova* SPECIES (CLASS PRYMNESIOPHYCEAE) FOUND IN NATAL INSHORE WATERS

D Fowles and R N Pienaar

## NATAL INSHORE DINOFLAGELLATES

T Horiguchi and R N Pienaar

## STUDIES ON THE CRYPTOPHYCEAE OF SOUTHERN AFRICA

S R Meyer and R N Pienaar

## THE BENTHIC MARINE ALGAL FLORA OF NATAL

R E Norris and R N Pienaar

NANOPLANKTON IN NATAL INSHORE WATERS WITH PARTICULAR REFERENCE TO THE  
CLASS PRYMNESIOPHYCEAE

R N Pienaar

REPRODUCTION IN THE *Sargassum heterophyllum* (PHAEOPHYCEAE) COMPLEX

R N Pienaar

NANOPLANKTON IN NATAL INSHORE WATERS WITH PARTICULAR REFERENCE TO THE  
CLASS PRASINOPHYCEAE

R N Pienaar and M E Aken

DIURNAL AND SEASONAL CHANGES IN THE PHYSICO-CHEMICAL ROCKPOOL PROPERTIES  
AND THEIR EFFECT ON THE PHENOLOGY OF THE BROWN ALGA, COMMONLY KNOWN AS*Sargassum heterophyllum*

P Tychsen

**ALGAE / PRIMARY PRODUCTION**

Rapporteur's Comments : R E Norris

As a botanist with particular interest in marine algae, but also in primary productivity, a basic phenomenon of all the systems that we study, I paid particular interest to these aspects in the reports of this session. I regard it as necessary to know the energy source of any organism, system or community that is important enough to demand the attention of research projects. This includes tracing such energy sources to the primary producers to gain a complete picture of the energy flow through the system being studied.

In the reports that I have heard, there have been very few projects on primary productivity. This may in some cases have been the result of the restricted time allowed for each report. To me, however, it also reflects a need for more cooperation between the zoologist and botanist to solve such interesting and important problems in each individual project. The botanist could be important in assisting the answering of many questions asked in research reports we have heard. For example, it could be that migration of many animals from the open sea into estuaries occurs because of important concentrated food supplies in such enclosed systems. This should be explored in detail and the phycologist could be of great assistance in this project. In similar systems in other regions of the world we know that benthic or planktonic diatoms may be the most important basic primary producers in such a system, often directly serving as food for marine animals, migrating from the open sea, that are important to humans.

Pollution detection on the Natal coast should involve the rather simple diatom indicators that have been so successfully utilized in other regions. Also, there should be research here to determine if more easily handled organisms, such as marine flagellates or cultures of other types of algae, could be used as quick indicators of certain types of pollution. Competent advice is available from botanists familiar with such flagellates. Algal indicators could give information on pollution in hours or days rather than weeks. Also, the small amount of space needed for such algal cultures, to say nothing of the simple uncomplicated equipment necessary for maintenance and utilization of the experiments, should be attractive to agencies involved. Algae can and should be utilized far more extensively for problems in South African pollution research.

In Natal there are some fascinating problems involving the primary producers that have been hardly examined and not at all researched. One that seems to be somewhat unique on certain Natalian beaches is the effect of sand cover on the growth and survival of certain types of algae and animals in intertidal as well as subtidal situations. It has been my experience on some beaches that sand cover actually enhances the growth of certain algal species, perhaps protecting them from grazing and retaining their reproductive structures to a habitat that is being protected from the rigours of the surf activity. Penetration of light through certain types of sand covers is surprisingly deep and many algal species thrive in such a reduced light intensity. I believe that intermittent sand cover may be essential to the formation of some turf

communities. Opportunities for such research seem to be somewhat unique here in Natal and should be further exploited.

The subject of algal detritus (compost of the sea) and its effects on the total ecosystems in Natal is one that I expected to hear more about in this symposium. There are vast amounts of drift algae on certain Natalian beaches and they must have some fascinating connections with several higher levels in the ecosystems. The studies that Dr M H Schleyer has done on micro-organisms that are involved in decomposition of such algal detritus should continue. An expert in the field, such as he, is very rare and should be exploited to the fullest. This type of study is basic and yet so rare in marine research programmes.

The study of marine benthic algae taxonomy is far behind such studies in vascular plants, undoubtedly because of the turbulent and often turbid aquatic veil that usually encompasses them. Many of the most interesting new taxa and new records that we have been able to reveal in our recent studies are through the kindness of thoughtful divers, some of whom are here, who bring us specimens found incidentally when they are diving for other reasons. We are very grateful, but it makes one wonder about the rewards that could be derived from a more pointedly directed diving programme, that included algal organisms as well as invertebrates and vertebrates, given to the study of certain subtidal reef systems in Natal. The primary productivity of such reefs surely must be as important, or more so, to some ecosystems in Natal as are the estuaries and mangroves.

Aquaculture in Natal should and must eventually include important marine algae. There are ways to control marine algal weeds, but research is needed to develop practical systems of aquatic farming in Natal. We can learn a great deal from our Taiwanese and Japanese colleagues on these methods.

There is plenty of motivation in South Africa for the study of marine algae. We have a Phycological Society of Southern Africa that is small but extremely active. Very good students are being trained in phycological research, and ecosystem research needs such well trained botanists. Studies in primary productivity, whether on the organismic, ecological or physiological level in Natal, are of utmost importance to this highly utilized coast. We already have a few regions in which primary productivity is almost absent, thereby preventing all but unnatural and unproductive habitats to be present. We cannot afford to allow such regions to proliferate, a point that seems to be the purpose of most marine research in Natal. In these interesting and essential research programmes in Natal **do not forget to include a thorough examination of the primary source of energy.**



**ECOLOGY AND TAXONOMY OF SELECTED INTERTIDAL AND SUBTIDAL ALGAE**

Researcher : G Lambert  
 Organization : University of Durban-Westville (UDW)  
 Duration : 1975 - Ongoing  
 Funding : UDW

A classification - ordination analysis of the distribution of intertidal communities on a rocky shore at Umdoni Park, Natal South Coast, has been completed. Three publications thus far have been produced and research continues for the preparation of two more on (1) energy flow relations within the intertidal ecosystem and (2) the role blue-green algae play in the supra-tidal region.

A taxonomic study is underway to compare the identity and distribution along the Natal Coast of the supratidal Bostrychietum (species of *Bostrychia*, *Catenella*, *Caloglossa* and *Murrayella*). The results link with the distribution of the same or related species in the mangrove dominated estuaries. An academic/taxonomic publication on fertile plants is in preparation.

A vegetation analysis of the distribution of sub-tidal algae on shallow, medium depth and deep rocky reefs is being planned.

**BIOLOGICAL NITROGEN FIXATION ASSOCIATED WITH BLUE-GREEN ALGAL COMMUNITIES IN THE MGENI ESTUARY MANGROVE SWAMP**

Researchers : G Lambert, F Mann and T D Steinke  
 Organization : UDW  
 Duration : 1985 - Ongoing  
 Funding :

The acetylene reduction assay is being used to measure nitrogenase activity and this provides an indirect measure of nitrogen fixation. Gases are analysed on a gas chromatograph. The assay has been modified to measure nitrogen fixation in the laboratory and in the field.

The nitrogen-fixing potential of blue-green algal communities is being studied in three sites : blue-green algae growing on the pneumatophores of *Avicennia marina*; blue-green algal mats growing on the wet mud surface below *A. marina* stands; and blue-green algal mats growing on dry mud surfaces in exposed areas on the periphery of the mangrove swamp.

The first objective is to determine the effect of certain environmental factors on nitrogen fixation. Light intensity, salinity, temperature and moisture content are regularly being monitored so as to determine their effect on nitrogen fixation. These assays are conducted under controlled conditions in the laboratory in a growth cabinet.

The second objective is to determine the seasonal variation in nitrogen fixation. Samples for determination of nitrogen fixation are collected bimonthly (the first sample was collected in October 1985) and incubated in the field for 24 hours. The samples are then analysed in the laboratory for nitrogen fixation. Simultaneously, samples are collected for determination of moisture content, salinity, nitrates, nitrites, ammonia, organic carbon and numbers of nitrogen-fixing organisms (bacteria and blue-greens). These will be related to rates of nitrogen fixation.

Results obtained so far indicate that nitrogen fixation contributes significantly to the nitrogen budget of the mangrove swamp.

#### THE PRODUCTIVITY OF ALGAE OCCURRING ON *Avicennia marina* PNEUMATOPHORES

Researchers : F Mann and T D Steinke

Organization : UDW

Duration : 1986 - Ongoing

Funding :

Productivity of *Bostrychia* and *Caloglossa* species collected from pneumatophores of *Avicennia marina* in the Beachwood mangrove swamp is being studied.

Photosynthetic and respiratory rates will be determined manometrically using a Gibson Respirometer. The algae will be subjected to a range of environmental conditions (temperature, light intensity, salinity and moisture content) and the effects of these on productivity will be determined.

Experiments will be carried out under exposed and submerged conditions and under average summer and winter temperatures.

**EPIPHYTIC ALGAE IN MANGROVE SWAMPS AND ESTUARIES**

Researchers : G Lambert, Y Naidoo and T D Steinke  
 Organization : UDW  
 Duration : 1981 - Ongoing  
 Funding : UDW

Algae epiphytic on mangroves have been studied qualitatively from 19 estuaries along 850 km coast from Kosi Bay in the north to the Nahoon River near East London in the south. St Lucia and Beachwood have been studied in the most detail. The most common substratum is the pneumatophore of *Avicennia marina* (Forsk.) Vierh. then the bark and knee roots of *Bruguiera gymnorhiza* (L.) Lam. and the bark and prop roots of *Rhizophora mucronata* Lam. Algae are rarely epiphytic on the bark of *Ceriops tagal* (Perr.) and *Lumnitzera racemosa* Willd., two mangrove species which occur naturally only at Kosi Bay. To date 37 taxa have been identified: 14 Rhodophyceae; six Chlorophyceae; 14 Cyanophyceae; three Phaeophyceae. Diatoms (Bacillariophyceae) are common but have not been studied. Dominant algae are species of *Bostrychia* and *Caloglossa* (Rhodophyceae); *Rhizoclonium* (Chlorophyceae); *Oscillatoria* and *Schizothrix* (Cyanophyceae). Future directions of this research are (1) to continue the taxonomic studies, particularly on the species of Chlorophyceae, (2) to undertake a quantitative algal vegetation analysis on these selected estuaries, starting at Beachwood, Mgeni Estuary, and (3) to investigate the relationship between the algal holdfast and the mangrove substratum to which it is attached.

**OBSERVATIONS ON THE REPRODUCTION AND ANATOMY OF *Sargassum heterophyllum***

Researcher : A T Critchley  
 Organization : Department of Botany, University of Natal  
 Pietermaritzburg (UNP)  
 Duration : 1985 - 1990  
 Funding : FRD, UN

The large brown alga *Sargassum heterophyllum* is a common member of the tidal pool flora of the Natal coast. The alga is being studied currently to determine its role and significance in the intertidal environment. Aspects of reproduction and anatomy of *S. heterophyllum* are important components of this investigation.

## REPRODUCTION

*Sargassum heterophyllum* is monoecious, probably self-fertile and has a gametic type of life history. The alga also exhibits the advanced characteristic of "incubation", whereby fertilized eggs remain attached to the parent plant and develop to a mature germling stage prior to release. The plantlet, upon leaving the parent, comprises a multicellular photosynthetic thallus together with protuberant sticky rhizoids. Thus, upon attachment to suitable substrata, the alga can begin immediate growth and development. The advanced morphological development of *S. heterophyllum* germlings is an important feature in the recruitment of the alga within pools of high energy wave action.

## ANATOMY

*Sargassum heterophyllum* is a perennial alga which annually produces primary laterals arising from a holdfast/main axis system. Anatomical studies have concentrated on this perennating base which comprises two major tissue types, namely a filamentous medulla and a parenchymatous cortex, the margin of the latter being delineated by the presence of a meristoderm. Seasonal activity of the marginal meristem contributes cells of varying cytoplasmic content to the cortex, thus depositing a series of centric zones. These "growth rings" are being studied as a possible means of determining the age of plants. Once age can be determined accurately, further demographic studies of *S. heterophyllum* will be possible.

***Pavlova* SPECIES (CLASS PRYMNESIOPHYCEAE) FOUND IN NATAL INSHORE WATERS**

Researchers : D Fowlds and R N Pienaar  
 Organization : Department of Botany, UNP  
 Duration : 1985 - 1986  
 Funding : FRD

The order Pavloales belongs in the class Prymnesiophyceae and contains 12 species assigned to three genera, viz. *Pavlova*, *Exanthemachrysis* and *Diacronema*. The genus *Pavlova* is taxonomically interesting as it contains features of members of both the Class Chrysophyceae and the Class Prymnesiophyceae. It is a common alga in tidal pool waters of the Natal coast. Most known species of *Pavlova* occur in brackish to marine water, although fresh water species do occur.

*Pavlova* is unicellular, biflagellate and has a short noncoiling, reduced haptonema. J C Green (1980) constructed a key for the known species of *Pavlova* on the basis of the presence or absence of a pyrenoid and stigma. This key has been used in an attempt to identify the six strains of *Pavlova* already in unialgal culture at the University of Natal, Pietermaritzburg. These, and further isolates, are being studied at the light and electron microscope level.

They form four natural groups, of which one is predominantly non-motile. Three of the four groups (including the non-motile strain) contain conspicuous pyrenoids and intraplasmidial eyespots, thus identifying them as one of three species. Further ultrastructural studies are required and comparisons with the recently acquired and named *Pavlova* cultures from Plymouth, UK, will help in this respect.

The cells in the fourth group are larger and contain a stigma, but no pyrenoid and hence do not fit into Green's key. These cells also contain a rhizoplast-like structure. A rhizoplast as such has not been recorded in *Pavlova* although *P. salina* does contain a striated haptonemal root.

To date not much work has been done on their cell divisions and/or life cycle. *Pavlova* species have been reported to produce a benthic stage. The cells settle, deposit mucilage and usually retain reduced flagellae. In some cases only the flagella bases are present. No other life cycle stage has been recorded. To study possible life cycle stages, the effects of various combinations of light (duration, intensity, quality), nutrients and salinity will be used.

#### NATAL INSHORE DINOFLAGELLATES

Researchers : T Horiguchi and R N Pienaar  
 Organization : Department of Botany, UNP  
 Duration : July 1985 - July 1987  
 Funding : FRD

This study commenced in August 1985 after initial observations by Pienaar had indicated that members of the Division Pyrrophyta were common in Natal inshore and tidal pool habitats.

To date twenty-four species belonging to twelve genera of dinoflagellates have been identified. These include the genera *Prorocentrum*, *Peridinium*, *Heterocapsa*, *Katodinium*, *Gymnodinium*, *Amphidinium*, *Glenodinium*, *Ostreopsis*, *Stylodinium*, *Thecadinium*, *Scripsiella* and *Thoracosphaera*.

One of these, a sand dwelling species, is currently being studied in detail using optical microscopy, scanning and transmission electron microscopy (TEM). The analysis of the thecal arrangement has revealed that this is a new species belonging to the genus *Scripsiella*. This is the first report of the occurrence of this genus associated with the interstitial spaces between sand grains. TEM studies have revealed some unique micromorphological features including the structure of the gelatinous apical stalk.

A morphological and life cycle study on the tidal pool dinoflagellate *Peridinium quinquecarne* Abe, has been studied with special reference to cyst formation and taxonomic position.

Eighteen strains (five genera) of dinoflagellate cultures have been established. Of these, 11 strains are members of the *Amphidinium carterae* -complex. This complex is considered to be a difficult taxonomic group. These cultures will be used in a comparative study of this species complex.

Besides the dinoflagellates, the genus *Heterosigma*, a member of the Class Raphidophyceae which has also been isolated from tidal pool localities is being investigated. Studies to date have indicated that this is a new species of *Heterosigma*.

#### STUDIES ON THE CRYPTOPHYCEAE OF SOUTHERN AFRICA

Researchers : S R Meyer and R N Pienaar  
 Organization : Department of Botany, UNP  
 Duration : 1985 - 1990  
 Funding : FRD

The Cryptophyceae are a class of unicellular, biflagellate algae. They stand isolated from other algal classes because they possess several unique morphological ultrastructural and biochemical features.

We are interested in both the taxonomic and phylogenetic aspects of this class.

The taxonomy is in a state of confusion. No natural groupings are obvious within the class, and the cells are subject to great morphological variation depending on culture conditions. No sexual reproduction occurs within the group and species are based on morphological and biochemical characteristics. Current workers suspect that many described species are various forms of the same ubiquitous species, and many species epithets will need to be sunk. At present we are investigating a group of blue-green eyespot - containing members of the genus *Chroomonas* to see if individual species, with genetically-fixed ultrastructural features, can be recognized.

The phylogeny of the Cryptophyceae has stimulated much interest since the discovery of the nucleomorph, a nucleus-like organelle associated with the chloroplast, in 1974. The nucleomorph has provided strong evidence supporting the theory of the endosymbiotic origin of the chloroplast. It has been suggested that the Cryptophyceae arose from an endosymbiotic relationship between a photo-synthetic eukaryote (possibly a red alga) and a colourless protozoan. At present we are focusing on aspects of cell division in members of the genus *Chroomonas*, e.g. the division of the nucleomorph, the open spindle, the association of the spindle microtubules with the flagellar bases, the non-synchronous movement of the daughter chromatin masses in telophase, and cytokinesis by the extension of an anterior cleavage furrow, to investigate further the feasibility of this hypothesis.

**THE BENTHIC MARINE ALGAL FLORA OF NATAL**

Researchers : R E Norris and R N Pienaar  
Organization : Department of Botany, UNP  
Duration : 1983 - 1987  
Funding : SANCOR

Studies on Natalian benthic marine algae have revealed a flora that has similarities with sub-tropical to tropical floras in other regions of the world. A strong element of a warm-temperate flora, however, is present in the southern parts of Natal, giving a varied and characteristic composite flora for this region.

The varied nature of the flora makes it necessary to be well acquainted with similar marine algal floras from similar regions of the world. In particular we have species that show a direct relationship with the marine algal flora of Australia and the eastern Asian coast, including Japan. In addition there are components of the Natalian algal flora that are found in the Caribbean and the eastern coast of South America and we also find species that were first known to occur in the Mediterranean. As a result of all these connections with distant marine algal floras, it is necessary that literature, specimens and knowledge of species from these regions be available to our investigation. Fortunately, R E Norris' library and experience in dealing with benthic marine algae covers these regions quite well and identification of species has been possible in most instances. Research in this project up to this time has followed investigations mainly on the marine red algae of Natal, the group having the most species in this region, and we estimate that there may be around 400 species of Rhodophyceae in our region. There are still major problem genera to be examined, such as the coralline red algae, but this is because the specialists on these groups still have not made some of the most important systematic decisions that affect our identifications. We are in contact with investigators on the problem groups and hope to have their assistance in the final diagnoses of our flora.

There are many new taxa being found in the Natal benthic algal collections, particularly in the ones that have come from the deep water dives from which we have received specimens in the past year. Publications on these and other collections are being produced as time allows. The most recent analysis is of the genus *Antithamion*. No species in this genus had been reported from Natal until 1984-1985, when two publications revealed probably three species. A more thorough study over the past few months has shown nine species to occur in Natal, four of which had previously been undescribed. Two of the known species have previously only been recorded from southern Australia, and one was previously known only from southern Japan. The remaining two species seem to be widespread in tropical to sub-tropical regions, but the closest to South Africa that they have been found is southern Japan and the Caribbean Sea. The data presented here exemplifies the work that we must do for each genus we study. There are few genera that have simple identification problems, unless they are monospecific.



**NANOPLANKTON IN NATAL INSHORE WATERS WITH PARTICULAR REFERENCE TO THE CLASS PRYMNESIOPHYCEAE**

Researcher : R N Pienaar  
Organization : Department of Botany, UNP  
Duration : 1985 - 1990  
Funding : FRD

The nanoplankton species occurring in Natal inshore waters are being investigated. Because of the small size of the cells they must be studied with the aid of a good optical transmission and scanning electron microscope.

Our work at present is being directed towards two classes of microalgae. These are the Class Prymnesiophyceae and the Class Prasinophyceae. This abstract deals with representatives of the former class of algae.

To date most of the work has revolved around the genera *Chrysochromulina*, *Pavlova*, *Prymnesium* and *Phaeocystis*.

The genus *Chrysochromulina* is represented by 10 species, all of which are new records for South Africa. Of these, four are new to science.

The genus *Pavlova* is to be reported on by Miss D Fowlds.

*Prymnesium*, an alga of some considerable economic importance due to the ichthyotoxin which some species are able to produce, has been found to be a common constituent of inshore, tidal pool and estuarine environments. To date two species have been identified, one of which is known to produce the ichthyotoxin. Work has also been done on ultrastructure and chemical composition of the cyst.

*Phaeocystis* is an unusual genus in that it produces a non-motile colonial stage and motile (zooid) haptonema-bearing phase. In addition to the small flagellate stage, a larger flagellate stage has been detected and it is this stage that is responsible for the production of the characteristic star-like structure which is considered to be so distinctive of the genus. Preliminary life cycle and development studies on this genus are proving most interesting.

In addition to the above genera we are also concentrating on the coccolith-bearing members of the class Prymnesiophyceae which are common in subtropical to tropical waters.

**REPRODUCTION IN THE *Sargassum heterophyllum* (PHAEOPHYCEAE) COMPLEX**

Researcher : R N Pienaar  
 Organization : Department of Botany, UNP  
 Duration : 1985 - 1990  
 Funding : FRD

The sexual reproductive cycle of the marine intertidal phaeophyte *Sargassum heterophyllum* has been studied with respect to its rhythmic production of egg and sperm as well as the various stages in development of the germling after fusion of egg and sperm.

The alga is commonly found in tidal pools along the Natal Coast. It produces reproductive laterals which have small sunken pits referred to as conceptacles. These conceptacles produce either antheridia or oogonia.

Studies have been undertaken on the formation of the eight-nucleate egg, the antheridia containing sperm, the release of sperm from the concentrate, and the subsequent fertilization and development of the zygote into the diploid germling.

Once the egg has been fertilized, the resulting zygote loses its distinctive eight-nucleate stage. A single sperm nucleus fuses with one of the egg nuclei, the remaining seven degenerate. Cleavage of the zygote commences + eight hours after fertilization. The first cleavage is unequal, resulting in the formation of a rhizoidal and apical pole. Subsequent stages of cleavage have been studied in detail using intact living germlings. Ultrastructural stages in the developmental process have also been investigated.

**NANOPLANKTON IN NATAL INSHORE WATERS WITH PARTICULAR REFERENCE TO THE CLASS PRASINOPHYCEAE**

Researchers : R N Pienaar and M E Aken  
 Organization : Department of Botany, UNP  
 Duration : 1985 - 1990  
 Funding : FRD

Members of the green algal class Prasinophyceae are particularly well represented in Natal. They have been found in inshore waters, tidal pool localities and estuaries.

The commonest genera that are presently being investigated include the genera *Pyramimonas*, *Tetraselmis* and *Nephroselmis*.

Genus *Pyramimonas*

To date nine species have been identified, and some isolated into unialgal culture. These include: *P. parkeae*, *P. pseudoparkeae*, *P. grossii*, *P. amyliifera*, *P. plurioculata*, *P. orientalis*, *P. disomata*, *P. obovata* and *Pyramimonas* sp. nov. These species have been investigated with respect to the scale covering (both cell and flagellar surface) and their ultrastructure. Developmental studies have also been undertaken on *P. pseudoparkeae*, a new species recently described from South Africa. These studies include life cycle stages, scale production and the chemical composition of the scale layers.

Genus *Tetraselmis*

This genus is particularly common in tidal pool and estuarine conditions and, as would be expected, they are euryhaline. This is a difficult genus to study and a great deal still needs to be done both with respect to collection, isolation and detailed study with the electron microscope. Work is also being directed towards the symbiotic species found occurring in the marine acoel worm *Convoluta* and certain species that are parasitized by a chitrid.

Genus *Nephroselmis*

This is a very common species in Natal waters and to date is represented by three species: *N. longigilis*, *N. astigmatica*, which we described a few years ago, and a new and as yet undescribed species here designated as *Nephroselmis* sp. This genus is also characterized by having species-specific scales that cover the flagellar and cell surface. It is hoped that work on the chemical composition of the scale covering will be undertaken so that one will be able to compare the two genera *Pyramimonas* and *Nephroselmis*.

**DIURNAL AND SEASONAL CHANGES IN THE PHYSICO-CHEMICAL ROCKPOOL PROPERTIES AND THEIR EFFECT ON THE PHENOLOGY OF THE BROWN ALGA, COMMONLY KNOWN AS *Sargassum heterophyllum***

Researcher : P Tychsen  
 Organization : Department of Botany, UNP  
 Duration : 1985 - 1990  
 Funding : FRD

The rockpool environment is a particularly harsh ecosystem, due to the reduced stabilizing effect of smaller volumes of water. Environmental severity is directly related to elevation of the pool above that of the sea. Thus pools at highest elevations experience the greatest fluctuations in physico-chemical parameters, which directly effect life patterns within the pool.

Phaeophyta of the genus *Sargassum* are macroscopic algae normally abundant in the Natal intertidal zone. The rocky character of this regional coastline creates opportunities for great variation in rockpool environment. This fact, in combination with substantial morphological variation characteristics of *Sargassum* species along South African coasts, is suggestive of the manifestation of a process of adaptive radiation. This is probably due to the variation in physico-chemical parameters within these pools.

Preliminary observations revealed such morphological variation to occur within *S. heterophyllum* in rockpools at Rocky Bay, Natal south coast. In an attempt to correlate the measured physico-chemical variation with the observed morphological variation of plants within individual pools, detailed phenological studies were conducted. Wave activity and light attenuation were observed to vary considerably between pools studied, as did pool water temperature over the diurnal period. The diversity of appearance of *S. heterophyllum* plants in the various pools could not be conclusively correlated to differences in any particular physical or chemical parameter. However, it was established that severe selection pressures occurred within the rockpools, and it is logical to assume that the process of adaptive radiation would occur to allow *S. heterophyllum* plants to occupy as many different ecological niches as possible.

**MANGROVE ECOLOGY**

**RAPPORTEUR'S COMMENTS**

T D Steinke

**ECOPHYSIOLOGICAL STUDIES ON MANGROVE ECOSYSTEMS**

G Naidoo

**STUDIES ON PRODUCTIVITY OF MANGROVES**

T D Steinke and C J Ward

**CONTRIBUTIONS TO THE ECOLOGY OF MANGROVES AND ASSOCIATED PLANT  
COMMUNITIES IN THE KOSI SYSTEM**

C J Ward, T D Steinke and M C Ward

**SALT RESISTANCE MECHANISMS OF TWO MANGROVE SPECIES**

N W Pammenter, P M Drennan, J M Gundry and P Berjak

**STUDIES ON SEED RECALCITRANCE : *Avicennia marina* (Forssk.) vierh.**

P Berjak, J M Farrant and N W Pammenter

**MANGROVE ECOLOGY**

Rapporteur's Comments : T D Steinke

Salt tolerance/resistance mechanisms are receiving attention in two institutions. This work could have an application in the future as it is only when we have information on the response of mangroves to these and other environmental factors that we shall be in a position to offer advice based on this knowledge to land-use planners, conservationists, civil engineers, etc. In my opinion this work has a long-term application. It is to be hoped that the staff members of these two institutions will pool their resources and cooperate more.

The studies on seed recalcitrance are to be welcomed, and this work is complemented by our own projects on propagule development and early establishment (not reported). Clearly an understanding of the establishment of mangrove propagules must have applications for management/conservation of estuaries. More still needs to be done in this field. This research also ties in with projects such as that reported in this Section on Kosi Bay, which involves a study of colonization and growth of mangroves, and also with the studies involving mangroves elsewhere on the coast (Section on Microbial Ecology).

The short abstract on litter studies does not present the complete picture of this work. Litter studies have been carried out in several mangrove communities along the coast and this work is being supplemented with gas analysis measurements to provide estimates of photosynthesis by mangroves under various conditions. As leaves form a major component of litter, the decomposition of leaf litter and recycling of nutrients are receiving attention. The role of crabs, especially *Sesarma meinerti*, in the degradation of mangrove litter is also being investigated. There is scope for more research on recycling of nutrients and their importation into and loss from estuaries. All these projects (see Sections on Algae/primary production and Vegetation other than mangroves also) contribute to our knowledge of the productivity of mangrove swamps, and this information is essential to land-use planners and for conservation and management.

More detailed studies on the mangrove vegetation in other estuaries is essential to establish their dynamics and their conservation status. Hydrological/sedimentological research is required, especially in conjunction with such studies as upper catchment utilization, and tied also to sea level changes.

While work has often been concentrated on the mangroves, other communities (seagrasses, samphires) and other organisms (crabs, fish) in these estuaries must also receive attention so that the inter-relationships between the various components can be understood. The information which is gathered should be such that it can be built into models to make possible predictions of effects of, for example, management and utilization. In this regard especially, it would be useful to be able to monitor and predict the effects of the increasing pressure to which our estuarine environments are being subjected.

There is thus a need for all interested in mangroves and estuaries to get together, not only to pool information, but more importantly, to ensure that future effort is meaningful, holistic and planned. Perhaps the time has come for the creation of a Mangrove and Estuarine Project, similar to the Fynbos Biome Project. Alternatively, a Mangrove Research Group, in which interested researchers from more than one institution can cooperate, could be given consideration.

My comment may seem to imply that the major effort should be directed towards research which will in future have some value for conservation or management. However, fundamental taxonomic or anatomical/ultrastructural research should never be ignored. Often the results of fundamental studies are found subsequently to have useful applications.

## ECOPHYSIOLOGICAL STUDIES ON MANGROVE ECOSYSTEMS

Researcher : G Naidoo  
 Organization : Department of Botany, UDW  
 Duration : 1979 - 1990  
 Funding : UDW

The research being undertaken on the ecophysiology of mangroves has the following major objectives:

- The relative salt tolerances of mangroves are to be established in quantitative terms using the criteria of dry matter accumulation, relative water content, stomatal resistance, leaf and root water potential, total nitrogen and reducing sugars. Data will also be obtained on the comparative patterns of dry matter and nitrogen allocation at the whole plant level in relation to salt stress.
- The abilities of mangroves to osmotically adjust under conditions of salt stress will be assessed by monitoring several parameters of leaf water relations and the concentrations of inorganic and organic solutes.
- The dependency of osmotic adjustment and solute accumulation on nitrogen supply and the nitrogen allocation patterns of mangroves will be evaluated.

The following are a series of papers that have already been published on mangrove research from our laboratory:

- LEWIS O A M and NAIDOO G 1970. Tidal influence on the apparent transpirational rhythm of the white mangrove. *S. Afr. J. Sci.* 66: 268-270.
- NAIDOO G 1980. Mangrove soils of the Beachwood area, Durban. *J. S. Afr. Bot.* 46(3): 293-304.
- NAIDOO G and NAIDOO D K 1981. Field studies on diurnal leaf diffusive resistance of mangrove leaves at various soil moisture tensions and photosynthetically active radiation. *J. S. Afr. Bot.* 47(4): 627-636.
- NAIDOO G and RAIMAN F 1982. Some physical and chemical properties of mangrove soils at Sipingo and Mgeni, Natal. *S. Afr. J. Bot.* 1: 85-90.
- NAIDOO G 1983. Effect of flooding on leaf water potential and stomatal resistance in the halophyte, *Bruquiera gymnorhiza* (L.) Lam. *New Phytol.* 93: 369-376.
- STEINKE T D, NAIDOO G and CHARLES L M 1983. Degradation of mangrove leaf and stem tissues *in situ* in Mgeni estuary, South Africa. In: H J Teas (Ed). *Tasks for Vegetation Science 8 : Biology and Ecology of Mangroves*. Dr W Junk Publishers, The Hague, pp. 151-161.



- NAIDOO G 1985. Effects of waterlogging and salinity on plant water relations and on the accumulation of solutes in three mangrove species. *Aquatic Botany* 22: 133-143.
- NAIDOO G 1986. Responses of the mangrove, *Rhizophora mucronata* Lam. to high salinities and low osmotic potentials. *S. Afr. J. Bot.* 52(2) (in press).
- NAIDOO G and STEINKE T D 1986. Nutrient recycling in the Beachwood mangrove area. (in prep).

#### STUDIES ON PRODUCTIVITY OF MANGROVES

Researchers : T D Steinke and C J Ward

Organization : UDW

Duration : 1978 - ongoing

Funding : UDW

Litter baskets placed within selected mangrove communities have made it possible to obtain estimates of productivity of mangroves in various estuaries and obtain a better understanding of the role of mangroves in estuarine ecosystems. The estuaries selected have been Mgeni, Richards Bay, St Lucia and, out of Natal, that of the Nxaxo/Ngqusi Rivers.

#### CONTRIBUTIONS TO THE ECOLOGY OF MANGROVES AND ASSOCIATED PLANT COMMUNITIES IN THE KOSI SYSTEM

Researchers : C J Ward, T D Steinke and M C Ward

Organization : UDW, KwaZulu Bureau of Natural Resources

Duration : 1972 - Ongoing

Funding : UDW, Bureau Natural Resources, NTRPC

There are five species of mangroves at Kosi, *Avicennia marina* (Forssk.) Vahl, *Bruguiera gymnorhiza* (L.) Lam. *Ceriops tagal* (perr.) C B Robinson, *Lumnitzera racemosa* Willd. and *Rhizophora mucronata* Lam. A natural closure of the mouth of the Kosi System from August 1965 until it was opened in January 1966 lead to the death of large numbers of mangroves throughout the tidal basin and lower lakes section of the system.

The recolonization and growth of mangroves since 1972 has been studied and mapped. The least affected was *L. racemosa*, one of the two that do not occur further southward. *C. tagal*, which also does not occur naturally further to the south was, however, severely set back. For this

reason, coupled to its limited distribution in the RSA, *C. tagal* received more attention than the others. A paper on *Ceriops tagal* has been published, and one on the mangroves of Kosi has been submitted. Other papers in preparation include ecological observations on submerged and peripheral plants; the tidal influence in the system and this related to vegetation and meteorological and astronomical conditions; and further contributions to mangrove composition and distribution.

#### SALT RESISTANCE MECHANISMS OF TWO MANGROVE SPECIES

Researchers : N W Pammenter, P M Drennan, J M Gundry and P Berjak  
 Organization : UND  
 Duration : 1981 - Ongoing  
 Funding : FRD

The two mangrove species, *Avicennia marina* and *Bruguiera gymnorhiza*, are of interest because they are common on the Natal coast and differ in their salt-resistance mechanisms. *A. marina* takes up considerable quantities of salt, which it excretes from the leaves, while *B. gymnorhiza* takes up far less salt, but does not excrete it.

The response of growth rates, leaf salt contents, excretion rates (*A. marina*) and water relations of the plants at different substrate salinities have been investigated, and ultrastructural studies have been undertaken to investigate details of the resistance mechanisms.

*A. marina* seedlings show maximum growth in 25 - 50 % sea water dilutions, with growth being suppressed at higher salinities. Once *B. gymnorhiza* seedlings are well established, growth does not appear to be affected by salinity. However, length of the establishment phase, which occurs at the expense of reserves stored in the enlarged hypocotyl, increases with increasing substrate salinity.

In both species, leaf salt content related to increasing substrate salinity shows a saturation-type response, with little increase in leaf salt at salinities greater than 50 % sea water. There is a regular increase in the salt content of *B. gymnorhiza* leaves with age, but in *A. marina* the salt content of mature leaves remains fairly constant.

In *B. gymnorhiza*, transpiration was highest in plants grown in fresh water; in *A. marina* highest rates were in plants in 50 % sea water - about double those of plants in 100 % sea water. Xylem sap salinities in *A. marina* in 50 % sea water were about half those of plants grown in 100% sea water, giving rise to approximately equal rates of salt loading into the leaves of plants grown at the two salinities.

Rates of salt excretion from leaves of *A. marina* vary with the rate of salt loading, being dependent upon both transpiration and substrate salinity, but maintaining leaf salt content below a maximum value. Thus in *A. marina*, leaf salt content appears to be regulated at the leaf level

by the excretion process, whereas in *B. gymnorhiza* there is more efficient exclusion at the root level, with leaves slowly accumulating salt throughout their lifespan.

Leaf water potentials of both species are always well below that of the substrate, indicating efficient osmoregulation. The NaCl content of leaves is generally insufficient to account for measured water potentials, implying that internally produced organic solutes contribute to this osmoregulation.

Anatomical studies show few gross effects of increasing salinity. In both species, Na and Cl are accumulated predominantly in leaf cell vacuoles and the presence of considerable quantities of tannins may be of significance in the salt resistance mechanisms. Excretion from mature leaves of *A. marina* occurs through glands and trichomes (hairs) on the abaxial surface. Detailed ultrastructural and cytochemical studies are yielding information on the mechanisms of excretion.

#### STUDIES ON SEED RECALCITRANCE: *Avicennia marina* (Forssk.) Vierh.

Researchers : P Berjak, J M Farrant and N W Pammenter  
 Organization : UND  
 Duration : 1982 - Ongoing  
 Funding : FRD, Department of Agriculture and Water Supply, Anglo/de Beers

Recalcitrant seeds do not undergo maturation drying on the parent plant and are consequently shed at a high moisture content, the absolute value varying amongst species. This makes impossible the use of conventional long-term storage practices. The seeds of all the local mangrove species fall into this category and our research on those of *Avicennia marina* (Forssk.) Vierh. is aimed at characterizing the phenomenon of recalcitrance. In this respect, we have concluded that none of the local mangrove species is viviparous and indeed, in some respects mangrove seeds are at an earlier developmental stage than e.g. bean seeds when they are shed. Our earlier work in this field (Berjak, Pammenter and Dini 1984) suggested that desiccation sensitivity of recalcitrant seeds may be due to the initiation of germination-associated events after shedding, and that such events will continue for a short time under certain storage conditions.

Subsequent investigations have shown that germination is indeed initiated shortly after seeds are shed from the parent tree (Pammenter, Farrant and Berjak 1984). The initial stages, characterized by an enhancement of subcellular organization and activity, can continue in the absence of additional water. However, with the onset of cell division and extensive vacuolation, additional water is required for the continuation of the processes leading to seedling formation (Farrant, Berjak and Pammenter 1985). As germination proceeds, the seeds become increasingly sensitive to desiccation and the amount of water loss tolerated declines (or the

minimum lethal water content is raised), until ultimately, even in seeds stored at a constant water content, water becomes limiting and viability is lost ([Fig 1]; Farrant, Pammenter and Berjak 1986).

In seeds which are immediately afforded sufficient water to complete germination, moisture content initially increases to reach a plateau after approximately 24 hours, this coinciding with root protrusion. The subcellular germinative events proceed as in stored seeds, but because of the optimum availability of water, they occur at a higher rate. As these events continue, the seeds (seedlings) become increasingly sensitive to desiccation, maximal sensitivity occurring once the root cells become fully functional. This coincides with protrusion of the roots from the covering hypocotyl tissue (Farrant, Pammenter and Berjak 1986).

Because of this increasing sensitivity to desiccation, the rate at which seeds are dried affects their viability characteristics. If rapidly dried, before they have proceeded to any great extent along the germination pathway, the seeds tolerate a greater amount of water loss and survive to lower moisture contents, than slowly dried seeds. In the latter case, the seeds are able to reach a more advanced stage of germination (the water level, although declining slightly, remains sufficiently high to allow this during protracted drying), but because of this, death occurs at higher moisture contents (Farrant, Berjak and Pammenter 1985).

The increasing sensitivity to desiccation has been suggested to be related to an increasing requirement for cytomatrical organization, in which water is intimately involved in a structuring role, as germination proceeds (Farrant, Pammenter and Berjak 1986a). We have proposed a model accounting for recalcitrant seed behaviour, and categorizing such seeds according to their rate of germination in the absence of additional water and their tolerance to water loss (Fig 2).

A three-phase production of roots during establishment of seedlings of *A. marina* has been documented, which we have related to desiccation-sensitivity of these structures, once they have penetrated the hypocotyl tissue, and seedling survival in the field (Farrant, Berjak and Pammenter 1986b).

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PAMMENTER N W, FARRANT J M and BERJAK P 1984. *Ann. Bot.* 54: 843-846.

FARRANT J M, BERJAK P and PAMMENTER N W 1985. *S. Afr. J. Bot.* 51: 432-438.

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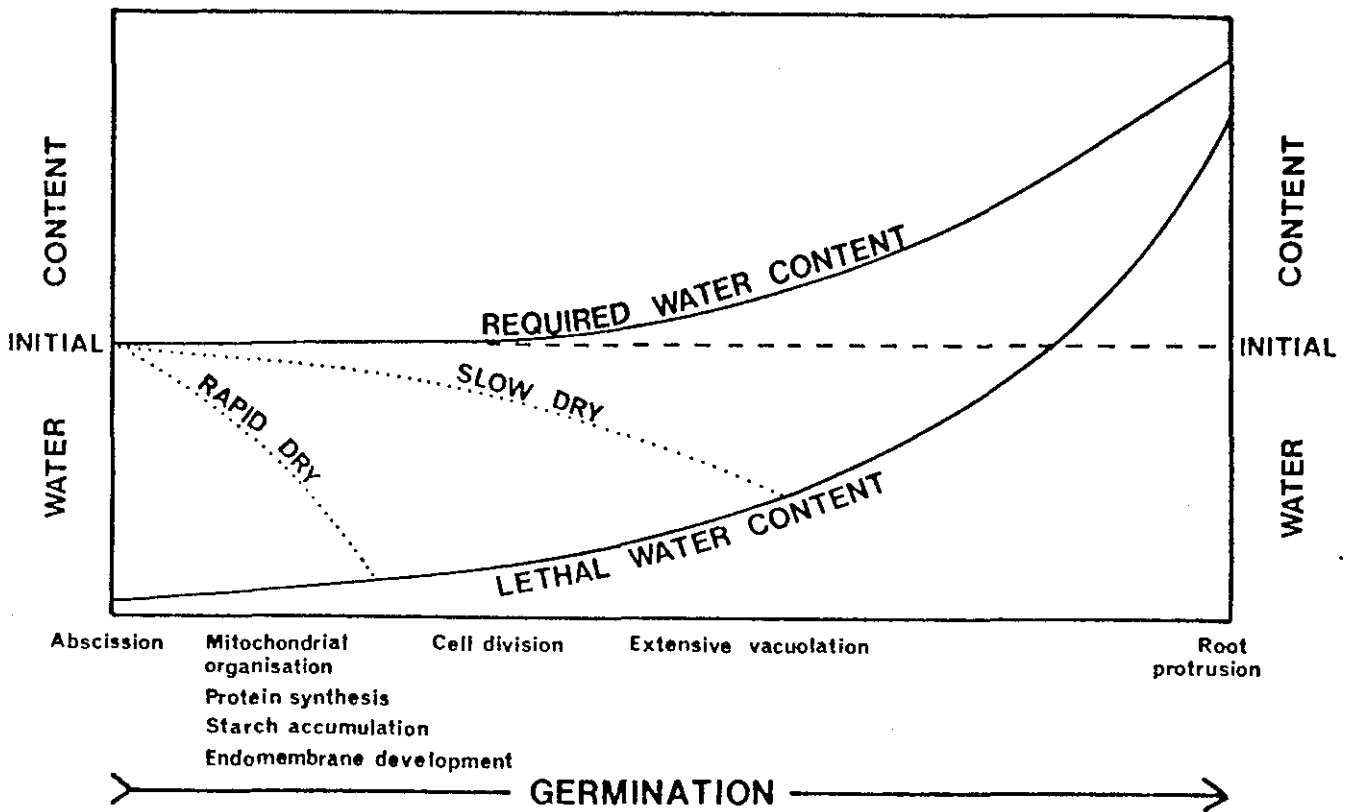


Figure 1. A model proposed to explain the storage and germination behaviour of recalcitrant seeds. Abscissa: developmental sequence in the embryonic axis during germination; Ordinate: axis water content. (Modified after Farrant, Pammenter & Berjak, 1986).

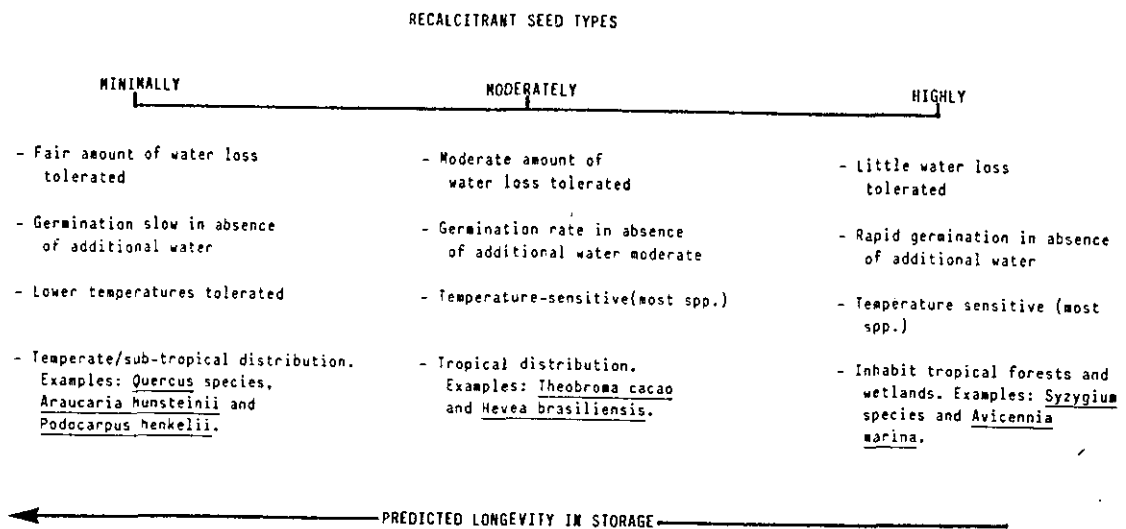


Figure 2. Continuum of recalcitrant seed types. From: Farrant, Pammenter & Berjak (1986a).

**VEGETATION OTHER THAN MANGROVES**

RAPPORTEUR'S COMMENTS  
N W Pammenter

STRUCTURE OF THE LEAF EPIDERMIS OF THE MARINE ANGIOSPERM *Halophila ovalis* (R. BR.) HOOK. F.  
A D Barnabas, Y Naidoo and T D Steinke

A COMPARATIVE STUDY OF THE PLANT ECOLOGY OF THREE ESTUARIES: MGENI, UMHLANGA AND MDLOTI  
F Raiman and C J Ward

THE ESTUARINE AND ASSOCIATED PLANT COMMUNITIES OF RICHARDS BAY  
C J Ward

ECOLOGICAL AND PHYSIOLOGICAL STUDIES OF COASTAL SAND DUNE FLORA  
N W Pammenter

NATAL COAST : SUMMARY OF CURRENT RESEARCH ACTIVITIES OF THE BOTANICAL RESEARCH INSTITUTE, PRETORIA  
P J Weisser

## VEGETATION OTHER THAN MANGROVES

Rapporteur's Comments : N W Pammenter

The work being carried out on the non-mangrove vegetation of the Natal coast can be divided into two groups in two different ways:

- (i) Studies on sand dune flora, and studies on estuarine vegetation.
- (ii) Studies with immediate management implications, and those more basic research projects aimed at an understanding of the functioning of species and systems.

I have chosen to divide them according to (ii).

### MANAGEMENT ORIENTATED RESEARCH

There are two programmes in this group; that of P Weisser on the vegetation of the Zululand dunes to establish conservation priorities, particularly with respect to dune mining; and that of C J Ward on the influence of development at Richards Bay. This latter programme is more a "What have we done?" type of exercise, but the information will be helpful in future management.

### BASIC RESEARCH

There are also two projects being undertaken in this group; that of N W Pammenter on the functioning of a coastal dune ecosystem; and similar programmes being undertaken by C J Ward, T D Steinke *et al* on the plant ecology of estuaries.

So little work has been done on the Natal coastal vegetation that it is easier to identify gaps that are being plugged rather than gaps in our knowledge.

With respect to management-orientated studies the top priority is to extend the work of P Weisser beyond the Zululand coast. Particularly on the Natal South Coast the pressures are recreational and urban development. These could have a longer-term impact than mining, and the identification of conservation priorities is essential.

With respect to basic research there is no major programme aimed at gaining an understanding of the structure and functioning of coastal ecosystems. Such an understanding is essential for successful long-term management. An inter-disciplinary approach is to be encouraged. I suspect that the major problem is a lack of manpower rather than a lack of expertise.

One other aspect has not been addressed. At the moment nobody is asking questions about the interaction between the marine and terrestrial environments - apart from the obvious ones of salt spray and sand movement.

**STRUCTURE OF THE LEAF EPIDERMIS OF THE MARINE ANGIOSPERM *Halophila ovalis* (R. Br.) Hook F.**

Researchers : A D Barnabas, Y Naidoo and T D Steinke  
Organization : UDW  
Duration : 1981 - Ongoing  
Funding : UDW

The marine angiosperms commonly known as seagrasses are adapted to life in sea water. They have a world-wide distribution and occur in shallow coastal waters and estuaries. Of the 49 known species of seagrasses, four occur along the South African coast.

Recently there has been tremendous world-wide interest in marine angiosperms primarily because of the high productivity of the ecosystems of which they form an integral part and their importance in contributing detrital material to marine food chains.

The increasing utilization of marine resources to feed an ever increasing world population makes it imperative that we understand the various components of these important ecosystems. To date little is known about seagrasses, especially their morphology, growth and physiology.

In view of the limited knowledge of these plants, a study was undertaken on the morphology of *Halophila ovalis* (R. Br.) (one of the four seagrasses that occurs along our coast). Initially, the study was focused on leaf structure, in particular the structure of the leaf epidermal cells. This tissue was investigated in detail because: i) preliminary studies have revealed that the major part of the photosynthetic apparatus in seagrasses is located in the leaf epidermis; (ii) the epidermis is the only tissue in direct contact with the seawater and probably plays a significant role in the uptake of solutes needed for growth and reproduction of the plant; iii) the ability of seagrasses to survive in a saline medium may be due to special anatomical and cytological features which leaf epidermal cells possess.

Epidermal structure was investigated at the light and electron microscope levels. Surface structural features of the leaves were examined under the scanning electron microscope. The presence of various chemical constituents in the epidermal cells was determined by the use of standard histochemical tests. In addition, ultrastructural changes occurring during the ontogeny of the cells will also be followed. The plant material for the study was collected from various localities along the South African coast and cultivated in aquaria in the greenhouse.



**A COMPARATIVE STUDY OF THE PLANT ECOLOGY OF THREE ESTUARIES : MGENI, UMHLANGA AND MDLOTI**

Researchers : F Raiman and C J Ward  
 Organization : UDW  
 Duration : 1982 - 1986  
 Funding : UDW

Estuaries are one of the most productive and sensitive of ecosystems and potentially the most open to abuse and degradation. Although much work has been done on Natal's estuaries, little has been published about their plant ecology.

The present research seeks to explain the fundamentals that govern estuarine plant life (and associated fauna) and particularly that of the three named systems. A preliminary investigation shows that there are marked differences which, because of the proximity of these areas, are not explicable by latitudinal differences.

A detailed investigation of major environmental factors has been undertaken. Vegetation analysis and classification was based on the Braun-Blanquet phytosociological approach and point centre quarter techniques. Transitions between communities were analysed by the transect method. The above provide for quantitative and semi-quantitative data which will be subject to statistical analysis and mapping. Successional trends are based on previously recorded aerial photographs. Physical and chemical measurements of water and soil are included. An attempt will be made to relate all variables to vegetation patterns.

**THE ESTUARINE AND ASSOCIATED PLANT COMMUNITIES OF RICHARDS BAY**

Researcher : C J Ward  
 Organization : UDW  
 Duration : 1974 - 1987  
 Funding : UDW, NTRPC, NPB

The construction of the deepwater harbour at Richards Bay led to considerable changes taking place in the conformation, hydrology and vegetation communities of the system. Briefly, the exclusion of the Mhlathuze River from the harbour by means of a berm and the creation of a new mouth for the river and excluded section of the former lagoon effected several changes. Basically the tidal amplitude in the former upper reaches of the Mhlathuze Lagoon was greatly increased and more saltwater was injected into the system. This set back the peripheral non-salt tolerant communities or those tolerant of only light salinity.

However, it favoured the landward spread of mangroves, especially the pioneering *Avicennia marina*. Herbaceous halophytes were similarly favoured. The berm also restricted the wide spread of deltaic deposits from the Mhlatuze. The sediments carried by the Mhlatuze, aided by canalization and poor catchment management, extended most markedly the former shoreline into the section south of the berm. These deposits have been mapped as has also the vegetation cover. More quantitative work is required, and it is anticipated that this will be completed during 1987.

#### ECOLOGICAL AND PHYSIOLOGICAL STUDIES OF COASTAL SAND DUNE FLORA

Researcher : N W Pammenter  
 Organization : Biological Sciences, UND  
 Duration : 1982 - Ongoing  
 Funding : FRD

Research is undertaken at two levels; ecosystem studies and details of physiology of individual organisms. The ecosystem research considers large scale processes - vegetation zonation/succession and flow of materials (water, inorganic nutrients, carbon) through the system. The physiological research involves studies of the detailed responses of the plants to constraints imposed by the environment.

Most of the field work has been conducted on the prograding dune system of the Mlalazi Nature Reserve. A permanent transect across the pioneer and scrub zone has been surveyed periodically over the last eight years. Dune growth is limited in drought years and formation of new dunes is probably an episodic event associated with severe floods. Vegetation zonation on the fore-dune is controlled by salt-spray, but succession in the sheltered scrub is possibly controlled by the rate of nutrient accumulation by the system from external sources. Long term growth studies have shown that the pioneer *Scaevola plumieri* grows throughout the year, with the winter rate about half that of summer. Net annual production is about  $600 \text{ g m}^{-2}$  and reproduction can account for up to one-third of the carbon resources. There is considerable spatial variation associated with both the degree of exposure and plant age. Detailed nutrient and water budgets at different sites across a dune transect remain to be done.

The physiological studies have concentrated on *S. plumieri*. Laboratory studies on water relations and photosynthesis have been completed and preliminary field data have been obtained. Nutrient cycling within the plant in relation to leaf senescence has been studied. These data suggest that *S. plumieri* has "conventional" gas exchange characteristics but it does appear to be very efficient at nutrient accumulation and utilization. More detailed field studies of water relations and photosynthesis are required, from which it is hoped to be able to model the productivity of the species.

**NATAL COAST : SUMMARY OF CURRENT RESEARCH ACTIVITIES OF THE BOTANICAL RESEARCH INSTITUTE, PRETORIA**

Researcher : P J Weisser  
Organization : Botanical Research Institute, Pretoria  
Duration : Ongoing  
Funding :

Ms A Stadler and collaborators are monitoring vegetation changes in the Siyaya Catchment Area and studying the behaviour of species that could be recommended for stream-bank rehabilitation. In this ongoing programme, individual trees are measured at regular intervals and survival recorded.

Dr P J Weisser is establishing conservation priorities of dunes along the Zululand coast, because dunes and their vegetation are threatened by mining for heavy minerals. This open-cast type mining entails the removal of plant cover and rehabilitation after mining. Whereas rehabilitation after mining is successful under the hot humid Zululand climate, it is not possible to restore complex primary dune vegetation such as dune forest. Therefore conservation priorities have to be established before mining commences. This is done by mapping vegetation at 1:10 000 or 1:20 000 scale using aerial photographs followed by an evaluation of importance for conservation. The study of the dune barrier from Mfolozi Mouth to Mlalazi Lagoon has been finalized and currently the dunes between Kosi Bay and Sodwana are being researched.

(This report was not delivered at the Symposium, but has been included for the sake of completeness. It has also been considered by the rapporteur - ed.).

**MICROBIAL ECOLOGY**

**RAPPORTEUR'S COMMENTS**

M H Schleyer

**FOOD AND FEEDING STRATEGIES OF *Macropetasma africanus* IN NATAL**

G A Roberts and M H Schleyer

**ENERGY SOURCES IN ESTUARINE WATER : SIYAYA CATCHMENT PROJECT**

M H Schleyer and G A Roberts

**MICROBIAL ACTIVITY IN THE DETRITUS FOOD CHAIN IN THE NATAL NEARSHORE SAND  
SUBSTRATUM ENVIRONMENT (N<sub>2</sub>S<sub>2</sub>)**

M H Schleyer and G A Roberts

**THE DECOMPOSITION OF *Bruguiera gymnorhiza* LEAVES AND THE ROLE OF FUNGI  
IN THIS DECOMPOSITION**

N Singh and T D Steinke

**MICROBIAL ECOLOGY**

Rapporteur's Comments : M H Schleyer

Research on microbial ecology and natural decomposition processes is being conducted at ORI, the Department of Biological Sciences of the University of Natal and the Botany Department of the University of Durban-Westville. The research at the University of Natal is undertaken in collaboration with ORI.

The research being carried out embraces a full spectrum of techniques, from traditional culture methods to modern approaches such as epifluorescent microscopy, gas chromatography and even the development of custom labelled degradation substrates for use as tracers in what is considered pioneering work.

Despite this being a rapidly developing and fertile field of research, it is largely to be discontinued in Natal as ORI has not been granted funds to continue this research. Within the concept of the detritus food chain comprising a "black box" with inputs and outputs, ORI's only effort will be focused on the latter, i.e. detritus utilization by detritivores, as part of a larger programme.

The role of heterotrophic microflagellates is emerging as an important factor in energy transfer in detritus food chains. As yet this is little understood and ecological work on these organisms would be complementary to the taxonomic work being undertaken at the Botany Department of the University of Natal in Pietermaritzburg. The need for this was emphasized by their spokesman.

## FOOD AND FEEDING STRATEGIES OF *Macropetasma africanus* IN NATAL

Researchers : G A Roberts and M H Schleyer  
 Organization : ORI  
 Duration : April 1985 - March 1987  
 Funding : SANCOR, South African Association for Marine Biological Research (SAAMBR)

### INTRODUCTION

*Macropetasma africanus* emerged as a major component of the animal biomass in the Natal Nearshore Sand Substratum (N<sub>2</sub>S<sub>2</sub>) environment, where it appears to play a key role in energy transfer in the detritus food chain.

The swimming prawn is generally associated with aggregations of detritus and forms an important component of the diet of several fish species. The digestive enzymes of this prawn, and its utilization of available food are, therefore, being studied.

### PROGRESS

Seasonal samples of *M. africanus* and the associated detritus are being collected off Durban beaches by beam trawling. The detritus is sorted, dried and the percentage composition calculated. The prawns are frozen for later dissection and removal of the hepatopancreas and proventriculus contents and these are then biochemically analysed for relative composition and enzyme activity by means of colorimetric tests using a spectrophotometer. Analyses for protein, carbohydrate, lipid and bacteria, as well as for proteolytic, amylolytic, cellulolytic and lipolytic enzyme activity are being carried out. Preliminary results indicate that the stomachs of *M. africanus* contain considerably more lipid ( $\bar{x}$  = 16,47 µg/gut) than carbohydrate ( $\bar{x}$  = 6,475 µg/gut) (see Table).

Total counts of bacteria and flagellates present in the water column off Durban beaches were determined during the N<sub>2</sub>S<sub>2</sub> programme; these constitute a potential food source for *M. africanus*. For this reason epifluorescence microscopy is being employed to quantify their numbers in the proventricular and hindgut contents of the prawns.

Examination of proventricular contents by interference contrast microscopy has revealed that animal matter comprises 32,2 % of the gut contents, compared with a mean of 6,3 % plant matter. Most of the animal remains consist of microscopic crustacea, therefore diurnal samples of prawns and zooplankton are being collected to establish whether the latter emerge and are eaten at night.

The combined results thus indicate that *M. africanus* tends to be carnivorous rather than detritivorous as originally suspected.

Dual labelling and scintillation counting techniques are to be employed to measure assimilation efficiency, gut retention time and feeding rate on live animals kept in the laboratory.

Table: Carbohydrate and lipid content of proventricular contents of *Macropetasma africanus* ( $\mu\text{g/gut}$ )

SITE	MONTH	ANALYSES	NO. OF GUTS (n)	RANGE	MEAN
ORI	OCT '84	CARBOHYDRATE	55	2.5-5.3	3.6
		LIPID	20	6.4-19.9	14.3
ORI	MAY '85	CARBOHYDRATE	87	3.3-15.3	6.1
		LIPID	58	5.9-51.4	13.5
SUNK	MAY '85	CARBOHYDRATE	24	2.2-14.9	5.4
		LIPID	21	9.1-23.5	14.1
ORI	JUN '85 (D)	CARBOHYDRATE	59	5.4-25.2	8.8
		LIPID	73	13.2-102.9	23.3
ORI	JUL '85 (N)	CARBOHYDRATE	94	1.7-29.6	7.8
		LIPID	59	6.1-100.9	20.9
ORI	SEP '85	CARBOHYDRATE	49	2.3-12.6	5.7
		LIPID	34	6.8-28.9	17.5
SUNK	SEP '85	CARBOHYDRATE	29	2.7-7.9	4.9
		LIPID	20	4.1-18.1	9.5
ORI	NOV '85	CARBOHYDRATE	38	2.0-24.1	6.4
		LIPID	20	9.5-14.3	11.4
SUN	NOV '85	CARBOHYDRATE	12	3.4-8.2	5.2
		LIPID	6	1.7-7.6	3.9
ADD	NOV '85	CARBOHYDRATE	4	4.7-5.2	4.9
		LIPID	4	4.5-6.7	5.6
ORI	JAN '86	CARBOHYDRATE	36	1.8-24.9	9.2
		LIPID	20	1.9-12.2	16.2
SUNK	JAN '86	CARBOHYDRATE	4	1.8-6.7	2.1
		LIPID	4	0-5.8	2.9
ADD	JAN '86	CARBOHYDRATE	46	1.9-13.4	6.1
		LIPID	21	8.0-14.8	11.2

## ENERGY SOURCES IN ESTUARINE WATER : SIYAYA CATCHMENT PROJECT

Researchers : M H Schleyer and G A Roberts  
 Organization : ORI  
 Duration : January 1981 - March 1986  
 Funding : NTRPC, SAAMBR

### INTRODUCTION

A characteristic of the water of the Siyaya Lagoon is that it is poorly oxygenated because of the degradation of large quantities of leaf litter originating from dense plant communities surrounding it. The leaf litter is broken down by micro-organisms and serves as the main basis for the food chain. This degradative process creates a high oxygen demand and the influx of fresh water is insufficient either to restore it or flush excess detritus out of the system. An understanding of the detritus food chain is thus fundamental to our knowledge of the system and its ultimate management. As the Siyaya catchment is presently being rehabilitated, improvements will in turn affect detritus flux in the system. The current project will thus form the basis for future comparative work which will assist in elucidating the role of the detritus food chain in these important ecosystems in Natal.

### PROGRESS

In collaboration with ORI and under the guidance of Prof P Berjak, students of the Department of Biological Sciences of the University of Natal have measured the rate of leaf litter input to the system as well as litter degradation in litter bags. They have also monitored successional stages in the microbial degradation of leaves and have compiled a leaf cell-structure atlas. This has been used to determine the persistence of leaves of different species in the environment. Of the three major contributors of leaf litter to the system, detritus from *Hibiscus tiliaceus* appears to be the most persistent. *Phragmites australis* contributes more material than the other species but is least persistent, and the other important species is *Barringtonia racemosa*.

Routine sampling on aspects pertaining to detritus flux at two stations in the lagoon (Big Bend and Public Beach) showed that organic matter and associated micro-organisms are concentrated in the surface sediments (see Table).

Labelled leaf cellulose derived from *H. tiliaceus* was thus used as a degradation substrate in surface sediment cores to measure the rate of detritus breakdown (see Figure). The combined results indicate that organic matter is accumulating in the sediments at a rate of approximately  $0.76 \text{ kg m}^{-2}\text{a}^{-1}$ .



Table Maxima, minima and seasonal and total means of data collected at Big Bend (BB) and Public Beach (PB) over a three year period.

	Temp. (°C)	Oxygen (ppm)	% Transmission of PAR light	pH	Bacteria in		Fine suspended and dissolved organic carbon (ppm)	Organic Material in surface sediment (kg m <sup>-2</sup> )
					water (x10 <sup>6</sup> ml <sup>-1</sup> )	cooze/sediment (x10 <sup>8</sup> g <sup>-1</sup> )		
<b>Big Bend Surface</b>								
Spring	22.5	4.3		7.21	0.77		9.7	
Summer	25.0	3.2		7.14	5.17		10.6	
Autumn	20.0	3.8		7.07	3.89		11.3	
Winter	15.2	6.1		7.50	2.04		5.7	
Mean	19.8	4.6		7.23	3.13		8.8	
<b>Big Bend Bottom</b>								
Spring	21.5	1.3	22 @ +/- 30 cm	7.18	0.22	13.3/1.3	10.8	10.84
Summer	23.3	2.3	-	7.14	4.78	33.2/52.0	7.7	9.97
Autumn	20.0	3.5	14 @ +/- 30 cm	6.95	3.54	83.6/231.7	3.4	10.00
Winter	15.2	5.5	11 @ +/- 30 cm	-	2.19	20.7/1.7	4.7	11.46
Mean	19.2	3.7	15 @ +/- 30 cm	7.09	2.93	39.3/86.7	5.9	10.57
<b>Public Beach Surface</b>								
Spring	24.5	5.7		7.41	1.76		9.5	
Summer	26.9	3.9		7.60	4.86		14.9	
Autumn	21.3	5.1		7.70	2.98		5.7	
Winter	16.6	5.7		7.30	1.52		3.6	
Mean	21.3	5.1		7.55	2.75		7.7	
<b>Public Beach Bottom</b>								
Spring	23.0	3.6	43 @ +/- 60 cm	7.37	1.60	- /0.3	11.1	1.94
Summer	25.9	2.5	67 @ +/- 60 cm	7.70	3.78	- /24.4	13.4	1.13
Autumn	20.8	4.8	48 @ +/- 60 cm	7.60	3.12	- /95.7	7.7	1.33
Winter	16.4	5.7	31 @ +/- 60 cm	-	1.63	- /8.1	3.0	0.98
Mean	20.7	4.4	45 @ +/- 60 cm	7.56	2.53	- /33.1	7.8	1.35
BB Max	26.5	8.0	22 @ +/- 30 cm	7.50	7.20	616.6	20.9	
BB Min	15.0	1.3	9 @ +/- 30 cm	6.95	0.22	0.2	1.7	
PB Max	27.2	7.0	67 @ +/- 60 cm	7.80	5.90	312.3	20.6	
PB Min	16.0	2.0	27 @ +/- 60 cm	7.30	0.15	0.5	0.9	
Annual Mean	20.3	4.4		7.36	2.83		7.5	

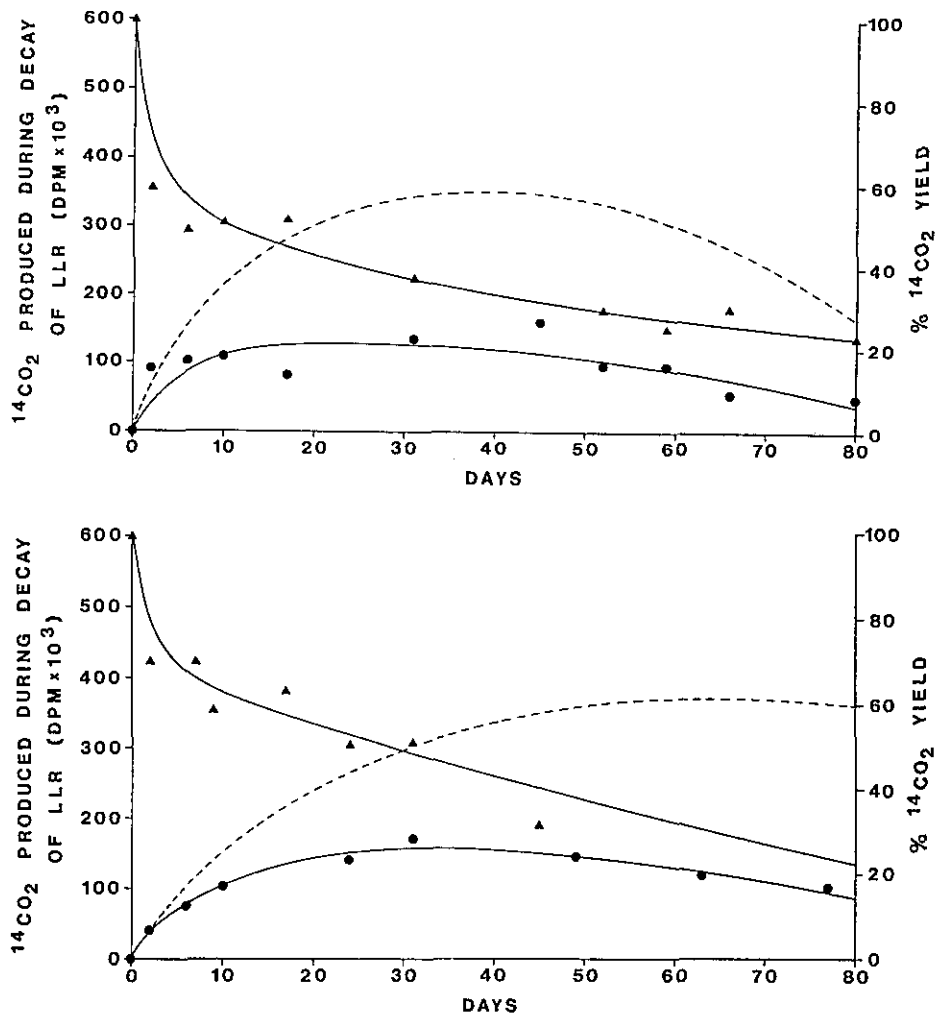


Figure Microbial degradation of labelled *H. tiliaceus* at summer (top graph) and winter (bottom graph) temperatures in sediment cores collected at Big Bend. Curves depict <sup>14</sup>CO<sub>2</sub> yield from decomposition of the labelled *H. tiliaceus* (●), the percentage yield of <sup>14</sup>CO<sub>2</sub> added to controls (▲), and the corrected curve for actual cellulose breakdown (broken line).

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- SCHLEYER M H. Decomposition in estuarine ecosystems. *J. Limnol. Soc. S. Afr.* (in press).
- SCHLEYER M H. Decomposition of labelled *Hibiscus tiliaceus* leaf litter in sediment cores from a Natal coastal lagoon. (in prep).
- SCHLEYER M H and ROBERTS G A. Detritus cycling in a shallow coastal lagoon in Natal, South Africa. (in prep).

**MICROBIAL ACTIVITY IN THE DETRITUS FOOD CHAIN IN THE NATAL NEARSHORE SAND SUBSTRATUM ENVIRONMENT (N<sub>2</sub>S<sub>2</sub>)**

- Researchers : M H Schleyer and G A Roberts
- Organization : ORI
- Duration : April 1983 - March 1986
- Funding : SANCOR, SAAMBR

## INTRODUCTION

In past research, ORI established that the heterotrophic processes of micro-organisms play a key role in energy transfer on Natal reefs. This project was similarly designed to examine the role of detritus and micro-organisms in the sand substratum environment adjoining the reefs. The experimental work is complete and the results are being written up.

## RESULTS (see Table)

Sediment and water samples were collected in the surf, shorebreak and backline off beaches at Addington and Sunkist in Durban. Bacterial counts, of the same order of magnitude as those obtained at ORI Reef, were recorded. The majority of the bacteria were free-living cocci and the counts obtained in water collected near to the sediment were slightly higher than those obtained in surface waters. Bacterial counts in the sediment were approximately three orders of magnitude higher than those found in the water, particularly in the relatively undisturbed sediment at Addington. DOC values were roughly half the concentration recorded in the ORI Reef programme and this was also reflected in considerably reduced (K+S) values obtained from Michaelis-Menten studies of uptake of a labelled algal extract (LAE). These studies proved useful during the ORI Reef programme and were applied to the N<sub>2</sub>S<sub>2</sub> in a study undertaken simultaneously at all stations at summer and winter temperatures. Despite the reduced dissolved substrate levels, V<sub>max</sub> values obtained with this technique were of the same order of magnitude as those measured adjacent to the ORI Reef even though it was disturbed from its normal

state.  $V_{max}$  is a measure of bacterial uptake considered equatable with production and, because it was high, the turnover time of the available substrate was relatively short.

Samples of debris were also collected by beam trawling at each station to establish the quantity and origin of detritus. This proved less abundant than that found on the ORI Reef and it consisted largely of seaweed and terrestrial macrophytic material.

The swimming prawn, *Macropetasma africanus*, constitutes a major component of the animal biomass on the  $N_2S_2$  and it appeared to play a key role in energy transfer in the detritus food chain. It is thus the subject of a continuation study.

This field of research has been discontinued because of lack of funds.

#### PUBLICATIONS

SCHLEYER M H. Microbial activity in the nearshore and sand substratum environment of Natal, South Africa. (in prep).

SCHLEYER M H and ROBERTS G A. Micro-organisms and detritus in the near-shore sand substratum environment of Natal, South Africa. (in prep).

Table: Comparative mean data on detritus and associated micro-organisms in the ORI Reef and  $N_2S_2$  environments.

	$N_2S_2$	ORI Reef
Detritus	217 mg m <sup>-2</sup>	>
% Seaweed	57.3 %	51.5 %
% Terrestrial macrophytes	33.5 %	36.8 %
	(n=32)	(n=6)
TOC	5.4 ppm	18.3 ppm
(POC)	-	14.8 ppm
(DOC)	-	3.5 ppm
Bacterial counts		
Surface water	1.88x10 <sup>6</sup> ml <sup>-1</sup>	-
Bottom water	2.32x10 <sup>6</sup> ml <sup>-1</sup>	
Total	2.10x10 <sup>6</sup> ml <sup>-1</sup>	2.02x10 <sup>6</sup> ml <sup>-1</sup>
% Cocci	82.6 %	89.5 %
% Free-living	92.8 %	79.0 %
Biomass	20.45 mg m <sup>-3</sup>	20.85 mg m <sup>-3</sup>
	(n=35)	(n=23)
In surface sediment	3.23x10 <sup>9</sup> g <sup>-1</sup>	-
	(n=38)	
Microflagellate counts	4.5x10 <sup>3</sup> ml <sup>-1</sup>	3.8x10 <sup>3</sup> ml <sup>-1</sup>
	(n=39)	(n=23)
Heterotrophic activity		
Commences	Immediately	(Not tested)
$V_{max}$	244 mg C m <sup>-3</sup> d <sup>-1</sup>	293 mg C m <sup>-3</sup> d <sup>-1</sup>
K+S	158 mg C m <sup>-3</sup>	402 mg C m <sup>-3</sup>
T	27.9 h	26.4 h
	(n=10)	(n=24)

**THE DECOMPOSITION OF *Bruguiera gymnorhiza* LEAVES AND THE ROLE OF FUNGI IN THIS DECOMPOSITION**

Researchers : N Singh and T D Steinke.  
Organization : UDW  
Duration : 1984 - Ongoing  
Funding : UDW

The condition of the leaf before decomposition will be determined. Studies will be made on freshly cut young, mature and senescent leaves and will include culturing (for phylloplane and endophytic fungi), scanning and transmission electron microscopy, nitrogen analysis and gas chromatography. These procedures will be repeated throughout the study period in order to ascertain the results.

On 28 January 1985 approximately 2 500 senescing *Bruguiera* leaves were collected and brought to the laboratory. The leaves were placed into 120 nylon mesh bags of two different sizes. All the bags were tightly closed (with nylon cord), secured to stakes and submerged in a stream at the research station at Beachwood for decomposition to occur. At each harvest eight large bags and four small bags were brought back to the laboratory. Material from each bag was cultured for fungi and remaining material was used for light microscopy and scanning and transmission electron microscopy.

Outside help with fungal identification may be necessary. A major part of the project will be determining the role the fungi play in the decomposing process i.e. working out the enzymes they secrete and what substances they digest.

Using gas chromatography, the amount of fungus and the amount of plant material of any given sample may be calculated. The theory behind this is that the principle steroid in the membranes of fungi is ergosterol, whereas that of plants is cholesterol. Thus the ergosterol, cholesterol ration of a given sample will be proportional to the amount of fungus is to plant.

In addition nitrogen content, dry mass and the carbon content of the harvested material will be determined.

Thus, the leaf will be described before decomposition. Step by step the decomposing process will be followed and information from the various analyses will be recorded.

**INVERTEBRATE STUDIES****RAPPORTEUR'S COMMENTS**

A J de Freitas

**NATAL CATCH STATISTICS (BAIT ORGANISMS)**

A J de Freitas and L Martin

**LAKE ST LUCIA : ENVIRONMENTAL STUDIES OF RIVER PRAWNS**

I B Bickerton

**THE TAXONOMY AND FUNCTIONAL ANATOMY OF SOUTHERN AFRICAN ECHIURANS**

R Biseswar

**BENTHIC MACROFAUNAL ECOLOGY OF THREE SUBTIDAL BEACHES**

P Fleischack, A J de Freitas, L Martin and R Jackson

**RECRUITMENT AND DISTRIBUTION OF PENAEID PRAWNS IN THE ST LUCIA SYSTEM**

A T Forbes, M C Benfield and J R Bosschieter

**ASPECTS OF THE BIOLOGY OF NATAL ZOANTHIDEA**

J Heeg

**NATAL COASTAL INVENTORY**

F J R Junor

**MARINE MOLLUSCS OF NATAL AND ZULULAND**

R N Kilburn and D G Herbert

**A STUDY OF THE EXPLOITED BAIT ORGANISMS OF NATAL**

L Martin, A J de Freitas and L Nayagar

**BIOLOGY AND ECOLOGY OF THE MANGROVE CRAB *Scylla serrata* (FORSKAL)**

W D Robertson

**ASPECTS OF THE BIOLOGY OF A NEW SPECIES OF SOUTH AFRICAN *Patella***

G Robson

**EXPLOITED INTERTIDAL ORGANISMS : OYSTER BIOLOGY AND FEEDING STRATEGIES OF BAIT ORGANISMS**

M H Schleyer

**THE HOLOTHURIAN FAUNA OF SOUTHERN AFRICA**

A S Thandar

## INVERTEBRATE STUDIES

Rapporteur's comments : A J de Freitas

During the symposium the reports on thirteen invertebrate studies were presented. These covered a variety of fields and as rapporteur it was extremely difficult to attempt to synthesize the research and then determine the gaps and establish priorities.

Taxonomic studies covered three groups of invertebrates, namely the holothurians, the echiurans and the molluscs. Crustacean studies included work on the river prawn *Macrobrachium* and on the recruitment and distribution of penaeid prawns, as well as a study of the biology of the mangrove crab *Scylla serrata*. Besides the taxonomic work on molluscs the succession in the *Perna perna* belt is being investigated; interesting work is being undertaken on a new species of *Patella* and a study of the biology of the Natal oyster *Crassostrea margaritacea* is being initiated. Information on the competition between the two main zoanthideans found in Natal is being gathered in a small long-term study. The feeding strategies of some ecologically important invertebrates such as the oyster, the penaeid prawn *Macropetasma africanus* and *Emerita austroafricanum* are being investigated. Finally data on the exploitation of various bait organisms are being analysed to assess the intensity of utilization of these.

With the variety of projects mentioned above it is difficult, if not impossible, to determine gaps and establish priorities. Each and every one of the scientists involved will identify gaps in his/her research. Some of these were actually mentioned during the presentations and some are even expressed in the one page abstracts.

The ultimate aim of this session of the workshop is the establishment of priorities and it seems reasonable to enquire: why is it necessary to establish priorities? Few will disagree that because of a limited availability of funds, funding bodies must determine what research they should or should not fund. If there were unlimited funds available all research projects could be funded and no priorities would be necessary. The difficulty for the funding body arises in trying to formulate a reasonable policy as a guide in the decision making process.

In reality, the ultimate responsibility must rest with the funding bodies themselves. They must look at their terms of reference and, as a first step, they must decide what type of research they should fund. This is no easy task as pressures from all quarters exist and will grow due to the ever increasing competition for funds.

Due to the difficulty experienced in setting the priorities for the study of marine invertebrates along the Natal coast it was felt that the best way to broach the subject was to attempt to establish an acceptable principle as a guide to a priority rating exercise.

All science is aimed at answering questions; questions which are motivated either A) by scientific curiosity or B) by existing or potential problems. However, to do justice to science it would be wrong

to totally reject one or the other of these motivations. Both are valid and completely acceptable and in principle, both should receive the necessary support. But to establish priorities does not mean the total rejection of either of the above motivations. Circumstances however, may dictate that preference be given to one or the other.

The above two sets of questions (A and B) are distinguished by another important element. Questions motivated by purely scientific curiosity (A) normally have no sense of urgency. Research based on questions motivated by existing or potential problems (B) usually have to be undertaken with considerable urgency to prevent the deterioration of a particular situation.

It must be stated that the usual controversy between basic and applied research has no place in the present argument. There is no competition between the two. All must agree that what is basic research today may easily be applied tomorrow. But the importance of the element of urgency must never be underestimated.

For the manager or user of a resource, be it a stock or an ecosystem, it makes no sense to wait until one has a complete understanding (if that is possible), before he is allowed to act. He wants his answers today (and sometimes yesterday). The important factor that should not be overlooked is time. As the population increases, more is demanded from our resources and ecosystems. These pressures are increasing at a rapid rate and the problems they pose need urgent answers.

The dilemma of what type of research (A or B?) should be supported still exists. There is no easy way out because both are essential. The reply to the dilemma must be that the right balance has to be found and that it must be left to the conscience of the administrators of funds how much to place in each pan of the balance.

Returning now to the task at hand and recognizing that everyone tends to be biased by his or her own inclinations, I believe that with regard to marine invertebrate research in Natal further work is necessary on the taxonomy of echinoderms, molluscs, crustaceans and sponges as these often form food items for a variety of fish. However, the degree of the study need not enter the investigation of sibling species or varieties and morphological forms. Funding bodies concerned with management orientated research should support projects of this nature to a limited degree.

The marine invertebrates found along the Natal coast and which are presently utilized by man are already fairly well known. The basic biology and life cycles of many have been studied but little is known of their population dynamics. Projects aimed at improving our knowledge on aspects such as recruitment, mortality and growth as well as utilization patterns of exploited invertebrates seem to me to rate fairly high on the list. The interaction between these organisms and their physical environment and associated biota also needs more attention, as does a better understanding of prey/predator relationships, feeding strategies and competition. In all of this the central figure must be the exploited organism and the central motivation must be resource management and not simply curiosity.

Finally most of the interest, so far, has been on species found in the intertidal zone. Notable exceptions are *Nephrops andamanicus*, *Panulirus delagoae* and penaeid prawns. There are alternative resources available in offshore waters which need identification and our attention. The prawn stocks on the Tugela are a small but worthwhile resource needing further consideration so as to guarantee its sustainability.

No data base is ever complete and no subject can ever be fully understood. Therefore, it is difficult for me to conceive that a worthwhile and meaningful project can ever be terminated. Tasks end and well defined objectives may be fulfilled but new questions are posed, new objectives formulated and new tasks set. Only in this way can scientific progress be made.



**NATAL CATCH STATISTICS (BAIT ORGANISMS)**

Researchers : A J de Freitas and L Martin  
Organization : ORI  
Duration : 1974 - ongoing  
Funding : NPB, SAAMBR

The coastal zone of Natal is being subjected to ever increasing pressures, and this requires to be followed by an equally increasing level of awareness and a more determined attitude to investigate and ascertain to what degree the exploited coastal resources can sustain these pressures.

The objective of this project, therefore, is to determine, as accurately as possible, the number of organisms being collected along the Natal coast. This is done by analysing the catch return forms completed by licence holders.

Collecting of intertidal organisms has been strictly controlled by the NPB and permitted only by holders of bait licences. Collectors are encouraged to complete and submit to ORI (via the Fisheries Licensing Office) simplified catch return forms on which they state the number of days spent collecting and the total catch.

Several thousands of these forms are received annually and analysed to obtain some idea of the level of exploitation to which this intertidal resource is subjected. The number of licences has increased from 9 175 in 1974 to 35 783 in 1985 (Fig 1). This increase has been mainly due to a 13-fold increase in the number of mussel licences, eight-fold increase in octopus licences and a five-fold increase in the crab licences (Fig 2).

The total catch in tonnes was roughly 275 tonnes in 1979, increased to 610 tonnes in 1983 (due to an exceptional 133 tonnes of octopus) and in 1984 was about 500 tonnes (Fig 3). The figure for 1985 has not been determined yet, but is expected to rise to about 570 tonnes. The estimated landed value of the 1984 catch, based on 1982 values, is roughly R 1.7 million.

Clearly, as the catch return forms are extremely simplified, the above figures can only be an expression of trends and if these data are to be of greater usefulness to management, or if one is to attempt to know more clearly the true magnitude of the catches, more detailed information is imperative. For this reason a group of volunteer holders of mussel licences has been found and these individuals have been supplied with forms requesting a better level of data. Small measuring boards have been constructed and supplied to them so that soon we will be able to determine the size range of mussels removed by collectors.

This step to obtain better catch and effort data of mussels must be extended to other bait organisms, so that the results obtained from the project will be more meaningful and, therefore, more meaningful advice can be given to managers of the resource.

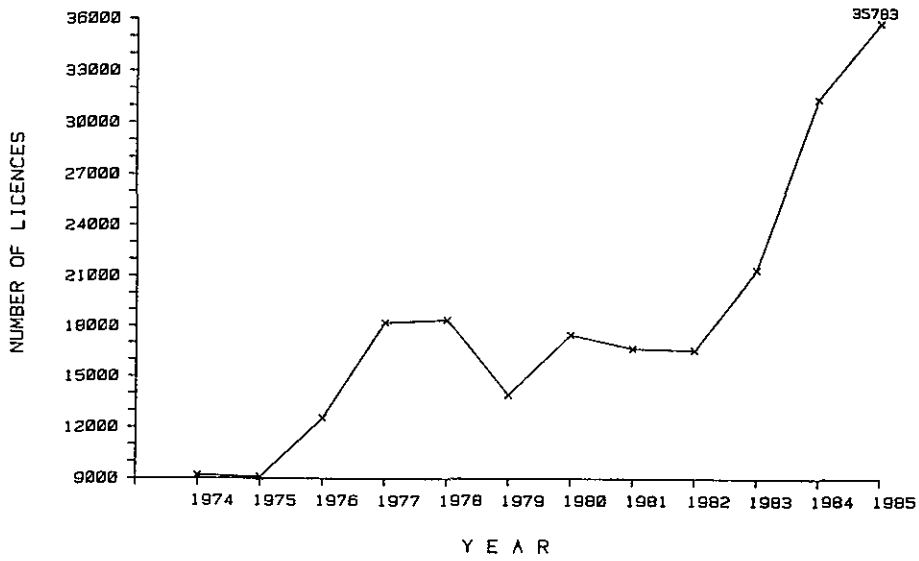


FIG. 1 - Number of licences issued per year.

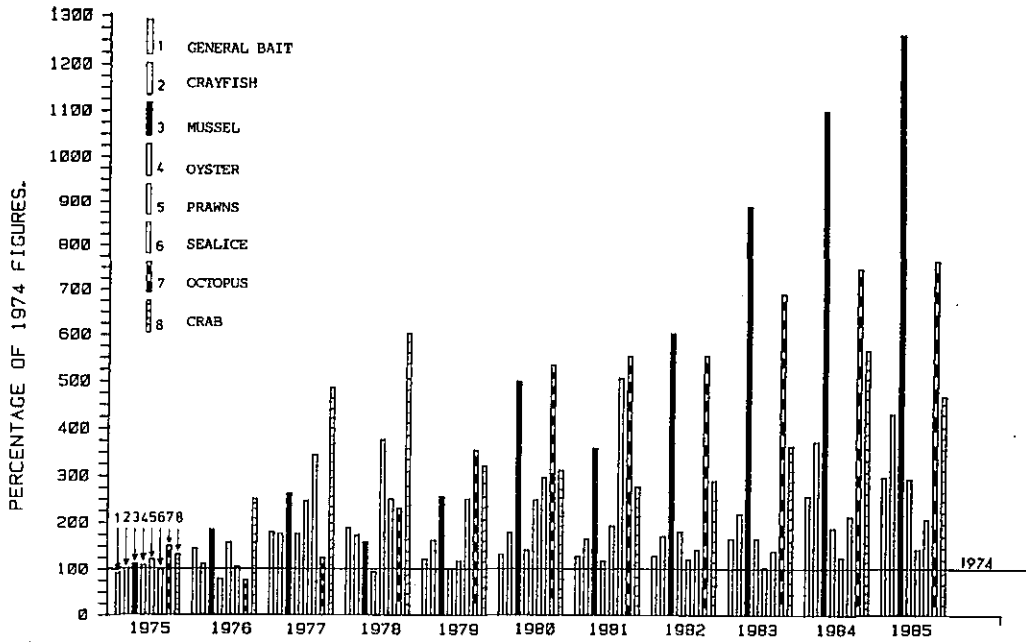


FIG. 2 - Licences issued as percentage of 1974 figures.

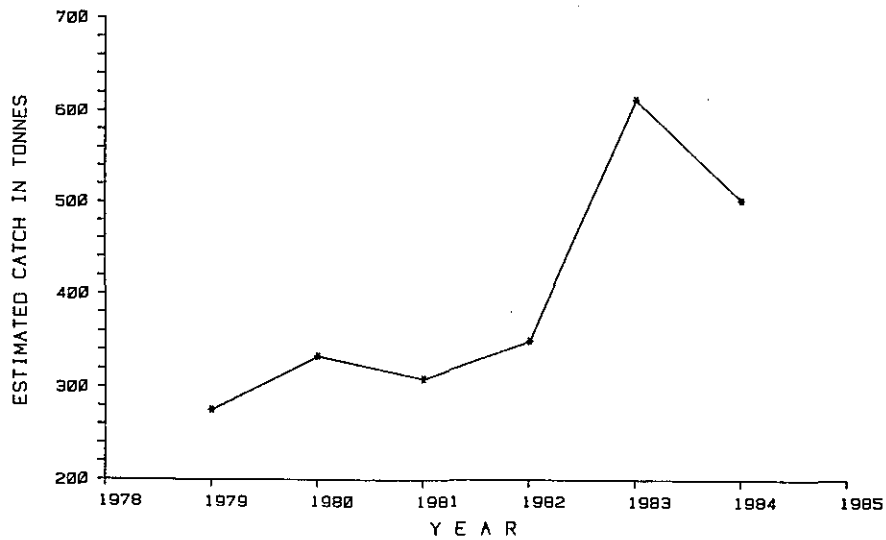


FIG. 3 - Estimated total annual catch of 'bait' organisms in tonnes.

**LAKE ST LUCIA: ENVIRONMENTAL STUDIES OF RIVER PRAWNS**

Researcher : I B Bickerton  
 Organization : NRIO  
 Duration : 1978 - 1985  
 Funding : NPB, CSIR

This project arises from invasion of the St Lucia Lake system by river prawns of the genus *Macrobrachium* after the floods early in 1976. Very little was known of the taxonomy and biology of these river prawns which became a dominant component of the system during the low salinity phase that followed the floods.

The study was commenced at the University of Natal in Durban but became an NRIO research project when the research worker concerned joined the Estuarine and Coastal Research Unit at the Institute (although still registered for degree purposes at the University of Natal).

The work has included demographic studies of the three species of *Macrobrachium* and investigation of the feeding ecology of the major species (*M. rude*) in relation to the dominant penaeid prawn species, which are the more common prawns associated with St Lucia (particularly during the more saline phases) and are the ones on which the Natal Parks Board Bait Fishery normally relies for stocks.

From the results of these studies a hypothesis which attempts to explain the role of *Macrobrachium* in the St Lucia system, and also the conditions under which they can exploit the lake and its environs from time to time, has been formulated. Invasions of the system appear to be largely related to the flood regime of the Mfolozi River, synchronized with the major breeding peaks of the *Macrobrachium* species, as well as the inability of the white prawn *Penaeus indicus* (the most common penaeid prawn species in the lake) to withstand salinities below 10 parts per thousand.

**THE TAXONOMY AND FUNCTIONAL ANATOMY OF SOUTHERN AFRICAN ECHIURANS**

Researcher : R Biseswar  
 Organization : Department of Zoology, UDW  
 Duration : 1983 - 1986  
 Funding : CSIR, UDW

At present, little is known about the echiuran fauna of southern Africa. There is no single comprehensive report on the recorded species or on identification of southern African species. The descriptions of a number of species, by the earlier authors, are extremely brief and lack critical

information which can be used to distinguish them. It is thus apparent that many species need re-examination and re-description.

In the present investigation, many species are re-described and/or diagnosed. The composition and zoogeographical implications of the fauna are discussed, partly from the published works and partly from surveys made along our coastline. Keys to the families, genera and species have been constructed for their identification.

Most of the species from this region have been recorded from shallow waters of the intertidal zone, and virtually nothing is known about sublittoral or bathyal forms. Exploratory expeditions and systematic dredgings in the future will most certainly advance our knowledge of an almost unknown fauna.

In spite of the recent interest shown by foreign researchers on the general biology and on aspects of the functional anatomy of echiurans, there is still scope for further research. Current literature, however, contains very few detailed reports on locomotion, burrowing and other movements in echiurans. The hydraulic mechanism of echiurans has not been investigated with the use of electronic recording techniques. It appeared worthwhile, therefore, to undertake such a study on *Ochetostoma caudex* and compare the findings with those of some other animals with continuous body cavities.

Although the mature and nearly mature eggs of some species have been studied intensively by cytologists and biochemists, the process of gametogenesis has not received a corresponding amount of attention. Also, there is very little information on the structure and location of gonads, and on breeding behaviour and spawning. Owing to a paucity of information in these areas, it was felt necessary to investigate some aspects of reproductive biology. There are several other aspects on functional anatomy that need investigation.

The above research projects were undertaken towards a Ph.D. degree in Zoology at the University of Cape Town, and the work is nearing completion.

#### **BENTHIC MACROFAUNAL ECOLOGY OF THREE SUBTIDAL BEACHES**

Researchers : P Fleischack, A J de Freitas, L Martin and R Jackson  
 Organization : ORI  
 Duration : 1981 - 1985  
 Funding : SANCOR, SAAMBR

Although a considerable amount of knowledge on the community structure of the rock reefs had been gained, little information on the subtidal sand communities, particularly with respect to the turbulent breaker zone, was available until recently.

With this in mind, the N<sub>2</sub>S<sub>2</sub> project was set up to determine: 1) the diversity, distribution and biomass of the subtidal faunal community; 2) the trophic relationships of the community; 3) the influence of physical parameters on the community; 4) the role of detritus and microbial activity (see report by Schleyer); 5) the influence of man (if possible).

The methodology, particularly with regard to ways of sampling within the breaker zone, took considerable time to develop. The main reason was our persistent efforts to find a method that would permit us to obtain as representative a sample as possible at each station. We finally settled on the beam trawl for demersal organisms and debris and the suction pump core sampler for benthic species (Fleischack *et al* 1985).

Samples were collected at stations along a 260 m transect through the swash, breaker and nearshore zones at each beach - Addington, ORI and Sunkist.

Physico-chemical characteristics of sediment were measured, and calculated wave, current and sediment transport parameters were obtained. These indicated the presence of two gradients, one increased northwards across the beaches, while the other decreased with distance offshore along each beach. Both these gradients were most clearly defined by wave and current parameters (Fig 1).

Biological gradients of species richness, faunal density and biomass were inversely related to the gradients of the considered physical parameters (Fig 1). Mean biomass and density were highest on the sheltered beach. While biomass was greatest in the swash zone, highest density occurred in the nearshore zone. Molluscs and crustaceans dominated the fauna in the turbulent breaker zone. Polychaetes and molluscs contributed the greatest relative biomass, while molluscs and crustaceans were generally the most common fauna in calmer zones. Biomass on the beaches in the study area was substantially lower, while species richness was higher than on other subtidal beaches studied in South Africa.

Eighty-six benthic species were collected in the study area. Three faunal assemblages were identified by ordination and cluster analysis techniques (Fig 2). The first occupied the swash zone or sublittoral fringe. The second occupied the breaker zone at two beaches, but was absent from the most sheltered beach where calm conditions generally prevailed. The third occurred offshore of the breaker zone (Fig 3). These zones were dynamic and the extent of each varied seasonally. At least one species *Tivela polita* demonstrated size related zonation. Turbulence was identified by gradient analysis as being the physical parameter having the greatest influence on zonation.

In the vicinity of the study area it has been calculated that on average 98 000 angler outings take place every year. The total catch of fish is estimated to be about 52 tonnes of which 13 tonnes (or 25 %) are composed of those species relying, to a large degree, on the benthic organisms dominant in the Durban sand substratum.

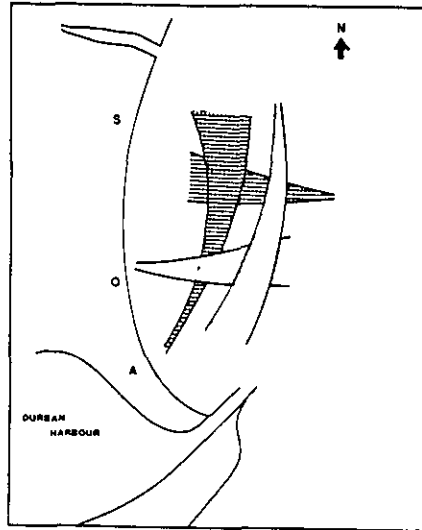




Fig 1: Diagrammatic representation of the gradients on beaches in the study area.

 = Biological parameters  
 = Physical parameters  
 A = Addington; O = ORI; S = Sunkist.

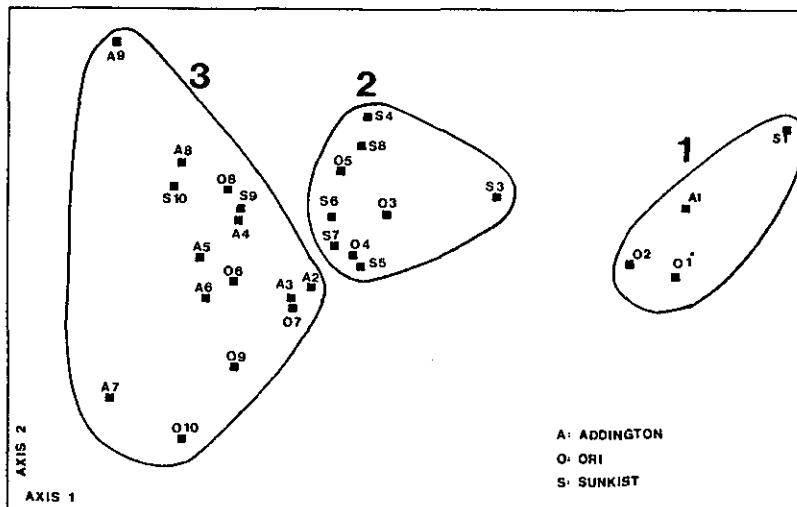


Fig 2: Ordination of the 28 stations by PCA using species presence. Groups 1, 2, and 3 correspond to the Swash, Breaker and Nearshore zones respectively.

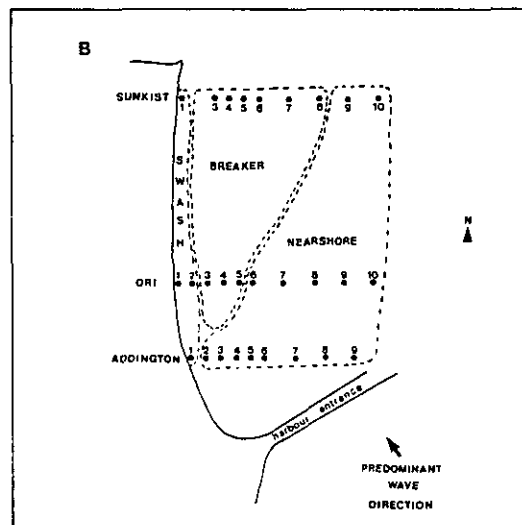


Fig 3: Situation of the faunistic zones derived from the ordinations. Swash, Breaker and Nearshore zones correspond to groups 1, 2, and 3 respectively.

## RECRUITMENT AND DISTRIBUTION OF PENAEID PRAWNS IN THE ST LUCIA SYSTEM

Researchers : A T Forbes, M C Benfield and J R Bosschieter  
 Organization : Department of Biological Sciences, UND  
 Duration : 1982 - 1984  
 Funding : SANCOR

Penaeid prawns have been exploited for bait purposes at St Lucia and Richards Bay for over 30 years. There is also a small bait fishery in Durban Bay and an industrial offshore fishery on the St Lucia and Tugela Banks. Not much work has been done on the biology of these prawns or on the fisheries, and even less has been published. This project was concentrated on the St Lucia system and the aim was to investigate the recruitment of penaeid post-larvae, their subsequent dispersal in the system and the relationship between recruitment and the bait fishery. The specific questions were as follows: When does recruitment occur? Are all species recruited at the same time? Is recruitment associated with any particular conditions of tide, current speed, salinity, temperature, moon phase or weather conditions? Can anything be inferred from catch data regarding the mechanisms of recruitment of post-larvae into estuarine systems? How does the species ratio of recruiting post-larvae compare with the species ratios in the bait fishery? Is there any relationship between post-larval recruitment levels and subsequent abundance of juveniles and size of the bait fishery catch? The second phase involved the post-recruitment biology of the prawns and posed the following questions: Were there any particular distribution patterns? Could these be related to conditions such as substratum, turbidity, depth, wave action or food availability? Were there any species specific distribution patterns? Answers or partial answers to some of these questions were obtained.

Monitoring of the bait fishery was maintained after the recruitment and distribution study was terminated and this is being continued. A preliminary paper on the penaeid fisheries of Natal has been published and a second on larval recruitment and the bait fishery has been accepted; a third on the tidal transport of post-larvae is in preparation. I intend to continue monitoring the bait fishery and re-work some of the earlier data. For financial reasons the St Lucia studies have been almost totally halted and I am considering investigations of the prawns in Durban Bay which appears to support a population of *Penaeus japonicus*.

**ASPECTS OF THE BIOLOGY OF NATAL ZOANTHIDEA**

Researcher : J Heeg  
 Organization : UNP  
 Duration : Long-term  
 Funding :

Zoanthids are a characteristic component of the Natal rocky shore fauna, with the genera *Palythoa* and *Zoanthis* represented on most shores. Both form extensive sheets in the infratidal fringe, but may extend upward into the intertidal in rock pools.

Where *Palythoa nelliae* and *Zoanthus durbanensis* occupy the same rock pool, competitive interactions may develop, with *Z. durbanensis* almost invariably the more successful, insinuating itself between the larger *P. nelliae* polyps and eliminating polyps thus isolated. However, both species are able to exist sympatrically in the higher rock pools due to intermittent sand covering, which is fatal to *Z. durbanensis* but not to the larger *P. nelliae*. This provides a classic illustration of Connell's "Intermediate Disturbance Hypothesis", as well as of the importance of sand movement as an ecological factor on Natal rocky shores. The synergistic action of sand and exposure are also being considered.

**NATAL COASTAL INVENTORY**

Researcher : F J R Junor  
 Organization : NPB  
 Duration : 1983 - 1986 (Phase 1)  
           : 1986 - ongoing (Phase 2)  
 Funding : NPB

**STUDY AREA**

The Natal coastal zone, for the purpose of the inventory, extends from the seaward side of the vegetated dunes for a distance of 2,5 km inland and then out to sea as far as the 100 m and 200 m isobaths.

**INITIAL OBJECTIVES (1983-1986)**

By combining original observations and reference to existing literature to broadly identify and inventorise:

- The extent of various habitats - inland, inshore and marine.



- Various biotic elements within each habitat type and establish their distribution limits.
- Threats/problems relating to various habitats and their biotic components.
- Research and management needs and finally to make recommendations regarding the implementation of appropriate conservation measures.

Aspects which have been covered in broad detail to date are:

- Offshore marine environment:  
Reefs and shoals
- Inshore marine environment:  
Sandy beaches  
Rocky shores
- Estuaries, estuarine linked lake systems, embayments, lagoons and river mouths.
- Indigenous vegetation complexes - not completed.
- Sensitive/important species:  
Turtles  
Fish  
Marine mammals  
Marine and inshore birds - not completed  
Marine invertebrates - not completed  
Terrestrial species
- Pollution.
- Urban areas and physical development - not completed.

#### FINAL OBJECTIVES (1986 onwards)

In collaboration with researchers expert in particular aspects of the coastal environment, compile a more detailed synthesis of the current state of knowledge in respect of the coastal zone on an inventorized form.

#### MARINE MOLLUSCS OF NATAL AND ZULULAND

Researchers : R N Kilburn and D G Herbert  
 Organization : Natal Museum  
 Duration : 1985 - ongoing  
 Funding : CSIR

The Natal molluscan fauna is the richest and most diverse in southern Africa, but is relatively poorly documented. Although the Natal Museum

collection is very extensive and dates from the end of the previous century, large areas are still poorly sampled, notably offshore reefs (such as Aliwal Shoal), the entire continental shelf and Zululand. The ultimate aim is to establish a regional inventory of species, although much taxonomic work remains to be done. To expedite this, wherever possible, material is "farmed out" to overseas specialists in different groups.

On our behalf this project was registered with the Natal Parks Board in 1984. A major aspect, the molluscs of Zululand, has been registered as a Foundation for Research Development project to commence in 1988 and end in 1990. However, it is hoped to begin dredging in this area during 1987.

At present we can undertake only low-key sampling, as both of us are still involved in a Transkei project and associated taxonomic research.

#### **A STUDY OF THE EXPLOITED BAIT ORGANISMS OF NATAL**

Researchers : L Martin, A J de Freitas and L Nayagar  
 Organization : ORI  
 Duration : April 1984 to March 1987  
 Funding : SANCOR, NPB, SAAMBR

#### **INTRODUCTION**

Mussels are intensively harvested with more than 7 900 licences sold last year. Although in Natal dense mussel beds are found on most rocky outcrops, their densities appear to vary from year to year. Bare mussel patches occur, either due to natural causes or to exploitation by bait collectors. The long-term objectives of this study are to compare the density, biomass and population structures of mussels on heavily and lightly exploited areas; to improve the present system of catch/effort statistics and to investigate succession in the mussel belt.

#### **RESEARCH**

Mussels are counted seasonally at Pennington, Rocky Bay, Umdloti and Cave Rock by placing gridded 0.0625 m<sup>2</sup> quadrats along transect lines set perpendicular to the shoreline. Occasional areas are cleared to count and measure the mussels and to calculate densities and size-frequencies. Results show that mussel densities are highest at Cave Rock, the least exploited area. Densities at all stations increased during Sept/Oct e.g. densities at Cave Rock increased from 2 090 m<sup>-2</sup> in July to 5 500 m<sup>-2</sup> in September and decreased to 2 775 m<sup>-2</sup> in December. This corresponded with the observed settlement of mussels. Dry flesh weights have been determined and biomass values are being calculated. Sex ratios indicate at least double the number of males to females at each site.

The influence of seasons on mussel settlement is being studied at Umdloti, where three 0.25 m<sup>2</sup> areas are cleared every two months. Samples from cleared areas are saved and weighed dry, and mussels are counted and measured. Mean sizes of newly settled mussels increased from 0.6 mm in July to 1.9 mm in September and to 6.5 mm in November. The percentage cover of all settling species in each cleared area has been determined monthly since May 1985, using the point-intercept method. Results so far indicate that *Enteromorpha* and *Ulva* species are the first to settle, but their percentage cover decreases with time. *Ralfsia expansa*, an encrusting red alga, remains dominant for at least six months, and coralline red algae (predominantly *Cheilosporum* and *Jania* sp.) appear after three months. On average, the total number of plant species present has trebled in the first six months. Mussels were first visible on the rocks in September although cleared samples revealed the presence of small mussels (0.4 mm) in June. Other organisms recorded monthly are limpets, barnacles and *Oxysteles tabularis*.

Three 0.25 m<sup>2</sup> areas adjacent to zoanthid and algal communities were cleared in May 1985 and are being monitored monthly to determine whether mussels recolonize the area or whether the surrounding communities take over. An algal turf comprising mainly *Ulva*, *Enteromorpha* and *Polysiphonia* species predominates in the areas adjacent to zoanthid beds. In contrast, a variety of red algal species appeared two months after clearing in the areas adjacent to algal beds. Mussels were observed in one of the latter areas in June, while zoanthids started to encroach into two of the former areas in September. The initial micro-organisms settling on cleared areas in the mussel zone are being examined under the SEM.

#### BIOLOGY AND ECOLOGY OF THE MANGROVE CRAB, *Scylla serrata* (Forsk.)

Researcher : W D Robertson  
 Organization : ORI  
 Duration : 1984 - 1986  
 Funding : SANCOR, SAAMBR

#### INTRODUCTION

*Scylla serrata* is an important component of the benthic community of estuaries and bays along the east coast of South Africa. Although the crab is of considerable economic importance in most of the Indo-west Pacific countries in which it occurs, it is not exploited commercially in South Africa.

Field studies on *Scylla serrata* in South Africa have been conducted in two eastern Cape estuaries (by B J Hill) and in St Lucia (B J Hill and D G Hay). Hill also studied feeding quite extensively in field and laboratory animals and A du Plessis conducted some preliminary investigations on growth, feeding, reproduction and larval rearing of *Scylla* in the laboratory.

The present study was designed to examine crab populations in Natal and to fill some of the gaps in our knowledge of the biology and ecology of this species.

#### RESEARCH APPROACH

Study sites have been established at the Richards Bay Sanctuary, the Alusaf Canal (flowing into Richards Bay), the Mlalazi Estuary and the Beachwood Creek (flowing into the Mgeni Estuary). Monthly collections of crabs from these four areas are providing data on population structure, sex ratios and growth rates. In addition, patterns of reproduction and recruitment are emerging. A tagging programme has recently been commenced to assist with determination of growth rates and population densities and to enable crab movements to be monitored.

#### RESULTS

Results for 1985 show a marked difference in the size composition of crabs caught in the four areas (Fig 1). Sex ratios also differed, with males being predominant at Alusaf (83 %), the Sanctuary (68 %) and Beachwood (58 %), and in the minority at Mlalazi (43 %). Mean catch per unit effort for the year was higher at Alusaf (0.9 crabs per trap hour) than at the other three sites (0.3 crabs per trap hour at each). Relative changes in the proportion of adult females and juveniles in monthly catches indicate spring to early summer spawning (September to December).

Juvenile recruitment and growth are to be investigated in more detail. Stock densities are also to be assessed in as many systems as possible.

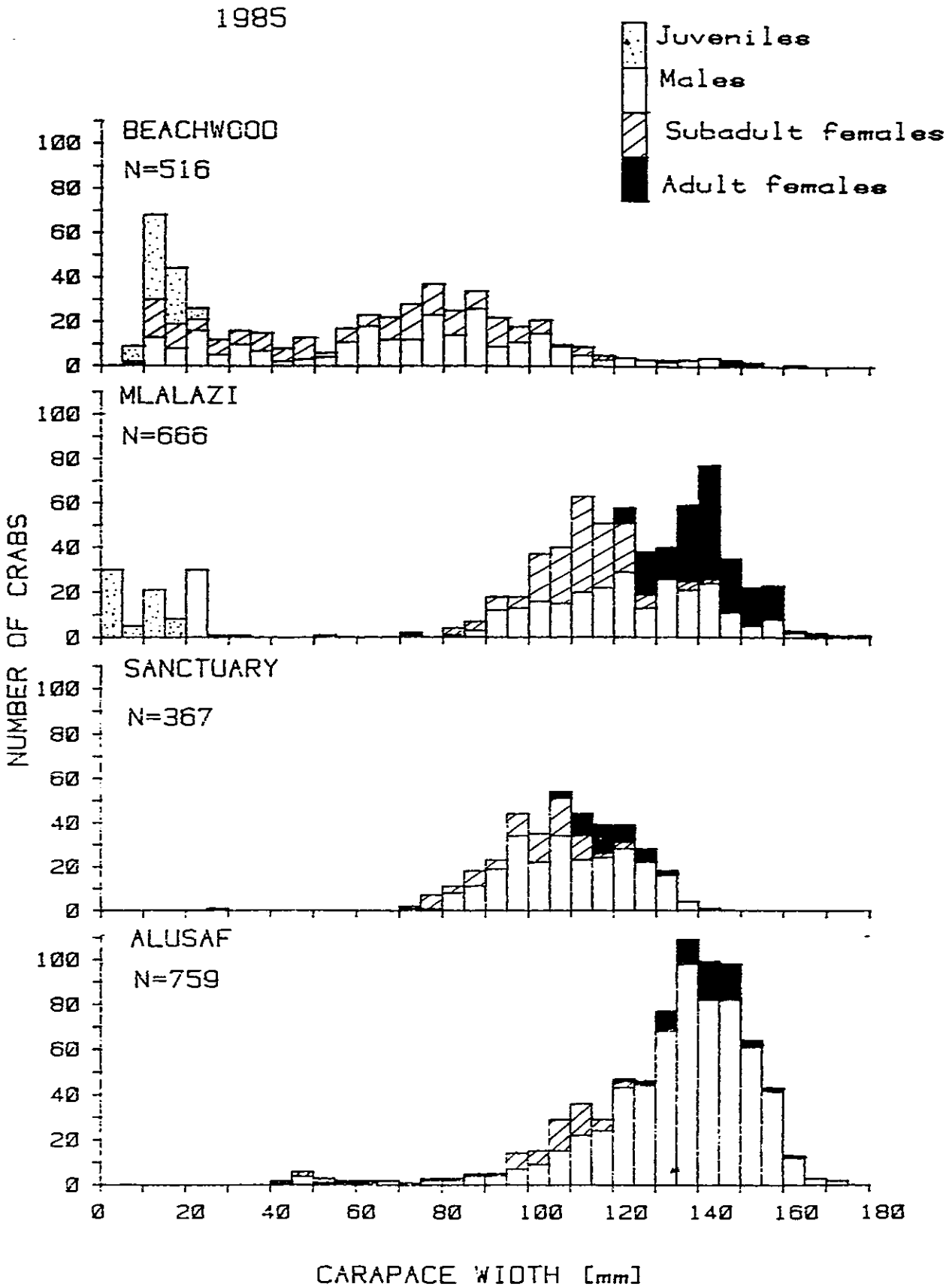


Fig.1: Size frequency distribution of all crabs caught during 1985 at each study site.

**ASPECTS OF THE BIOLOGY OF A NEW SPECIES OF SOUTH AFRICAN *Patella***

Researcher : G Robson  
Organization : UNP  
Duration : Oct 1985 - Oct 1986  
Funding : CSIR, UN

A new species of limpet from the eastern coast of South Africa is described, while *Patella obtecta* Krauss, 1848, is shown to be a valid species and is re-described. The new species is typically associated with *Lithophyllum*, on which it is a specialist feeder. The species exists as two ecomorphs, each with a characteristic shell sculpture and shape. The numerically dominant form occurs epizoically on the brown mussel, *Perna perna* L. (1758), while the second occurs on the adjacent rock. Both ecomorphs are restricted to the lower balanoid zone to areas which are constantly wet. The species is non-migratory and there is no adult/juvenile differentiation or size gradients. Individuals form well-defined home scars and territories which they defend aggressively, both intra- and interspecifically. No aggression is expressed towards predators. Densities on mussels are much higher than on the rock, probably due to lower adult induced mortality, and range from about 2 900 m<sup>-2</sup> prior to spawning to 7 600 m<sup>-2</sup> after spawning. Spawning occurs twice a year, in summer and winter; the species is protandrous, has a high gamete output (up to 50 % body weight) which is equal in males and females, while gamete output in mass per unit area is equal for the two sexes, even with sex ratio of 0.44 females per male. Growth is rapid with a maximum longevity of about 2.5 - 3 years. Home scar formation, territoriality and trophic specialization in the new species are typical for low-shore, non-migratory species with "k"-selected life strategies. However, growth, longevity and the reproductive strategy are typical of high-shore, migratory species, with "r"-selected life strategies. This "r" selected life strategy on the low shore probably results from the instability and unpredictability of the epizoic habitat on mussels, allowing the species to survive by continual recruitment.

**EXPLOITED INTERTIDAL ORGANISMS: OYSTER BIOLOGY AND FEEDING STRATEGIES OF BAIT ORGANISMS**

Researcher : M H Schleyer  
Organization : ORI  
Duration : Apr 1986 - Mar 1989  
Funding : SANCOR, SAAMBR

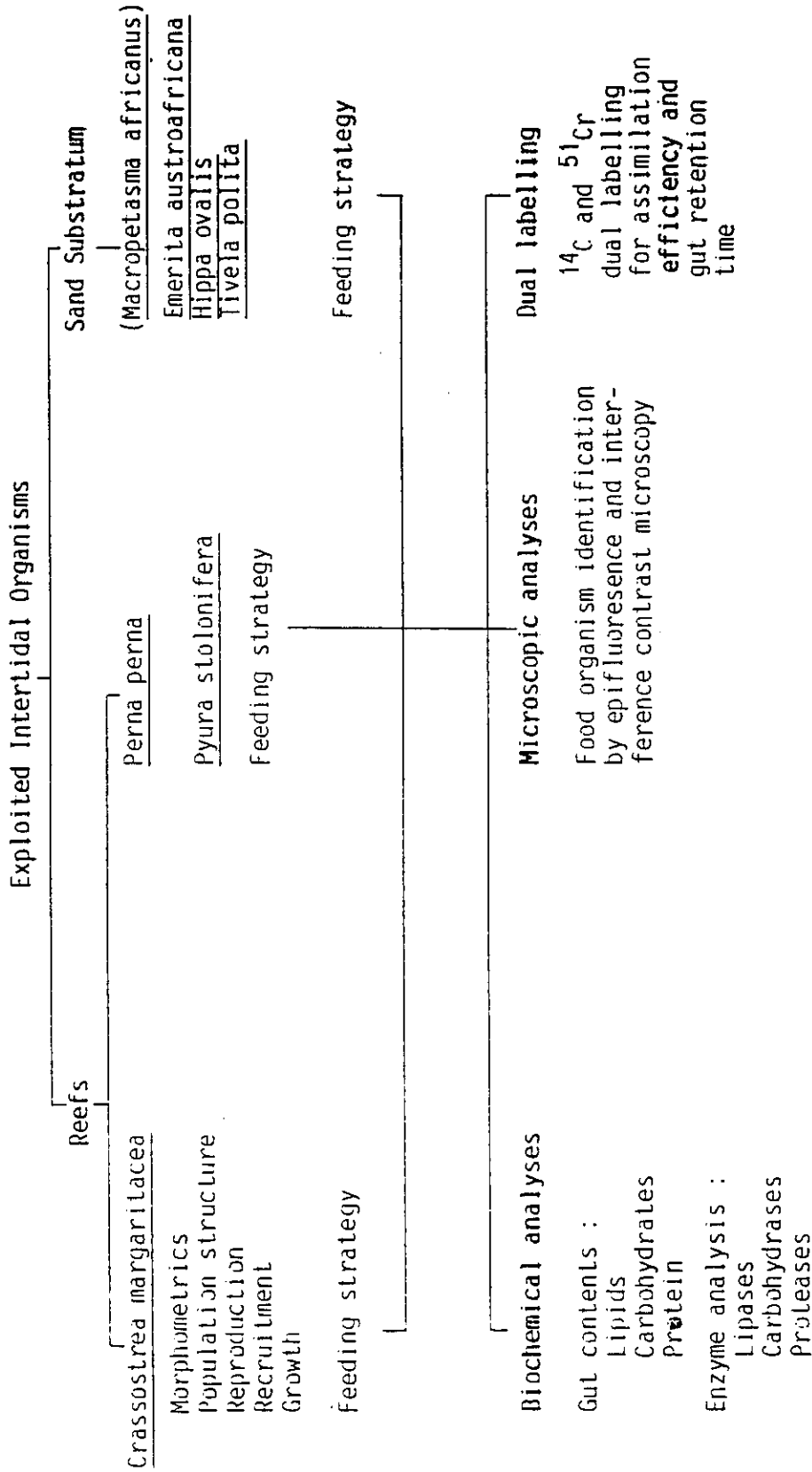
**INTRODUCTION**

ORI has undertaken considerable research on intertidal invertebrates used largely as bait or as food in Natal. Information useful for their management has been obtained on the brown mussel (*Perma perna*) and the hippids (*Emerita austroafricana* and *Hippa ovalis*), while some work has been done on the biology of redbait (*Pyura stolonifera*). Effectively no research has been carried out on *Crassostrea margaritacea*, the oyster of economic importance in Natal and the only species which may be commercially harvested. Exploitation of this species is carefully controlled and the 11 commercial licence-holders remove approximately 70 % of the recorded annual catch, which has a total value in excess of R 140 000. This mollusc is thus fairly important and, as little is known of its biology, a study is necessary to advise on its management.

Information on the feeding strategy of organisms is fundamental to a complete understanding of the ecological niche which they occupy and is the objective of a current SANCOR study on the swimming prawn, *Macropetasma africanus*. Other than measurement of the filtration and assimilation efficiency of *P. perna*, no work of this nature has been undertaken on the intertidal invertebrates mentioned above. ORI thus intends carrying out a programme in which this will be done in conjunction with a study on the biology of *C. margaritacea*. The feeding strategy of *Tivela polita*, the predominant sand mussel found in the sand substratum, will be included in the programme to round off the Natal Nearshore Sand Substratum project.

**RESEARCH APPROACH (see diagram)**

Oyster samples will be regularly collected by SCUBA divers at a suitable sampling site and analysed for morphometrics, population structure, reproduction, recruitment and growth. Crystalline styles and stomach contents of the species mentioned above will be collected for digestive enzyme analysis and biochemical analysis of the gut contents. Epifluorescence and interference contrast microscopy will be used where possible to establish the identity of food organisms. Dual labelling techniques will be used to assess food selection and measure the feeding rate, gut retention time and assimilation efficiency. The success of this technique is dependent on the maintenance of specimens in the laboratory and limited success is thus expected with organisms such as *T. polita*, which do not adapt to laboratory conditions.





**THE HOLOTHURIAN FAUNA OF SOUTHERN AFRICA**

Researcher : A S Thandar  
Organization : UDW  
Duration : 1978 - 1985, ongoing  
Funding : CSIR, UDW

A monographic revision of the southern African holothurian fauna was completed for a doctoral degree in 1985. The investigation, which lasted about six years, is based on the collections of the South African Museum and of the universities of Cape Town and Durban-Westville, and includes material stretching from the intertidal zone to the deepest reaches of the oceans yet explored within the limits of southern Africa. The last monographic revision of the holothurians appeared in 1948 and since then many new species have been described. Regrettably, however, many species are known by names given to them by their original describers. Hence a rigorous determination of the southern African species was undertaken on the basis of currently acceptable changes in classification and nomenclature. The erection of nine new superspecific taxa is one of the direct results of this investigation.

Included in the monograph are approximately 120 nominal species of which over 40 species are recorded from Natal, ranging from the intertidal zone to a depth of over 3 600 m. Of the latter as many as six are new to science, and another 11 new records. The monograph diagnoses all new or amended taxa, provides a key to all southern African species and discusses their zoogeographical distribution on the basis of our current knowledge of ocean currents and their effects along the coast. The monograph also considers the relationships of the various taxa, highlights several taxonomic and evolutionary problems and speculates on the possible origin of the fauna. One paper has already been published from this research, while two others are in press awaiting publication. Several other papers are in preparation.

The monograph by no means reflects a complete knowledge of the southern African fauna. Many new records or new species still await discovery, especially from Natal, where the deep water fauna has not received much attention, while several tropical stragglers from Mozambique have probably escaped the attention of collectors. Hence future research plans include continuing research on the holothurians, including their taxonomy, behaviour and reproductive biology and the invoking of cytotoxic techniques to separate closely related or sibling species. Other southern African echinoderm groups which have largely been neglected by South Africans also need attention, and to this end their taxonomy, behaviour, ecology and reproductive biology need be investigated.

**FISH AND FISHERIES****RAPPORTEUR'S COMMENTS**

R P van der Elst

**NATIONAL MARINE LINEFISH DATA COLLECTION - SPORT**

F Adkin, D Ballard and R P van der Elst

**NATIONAL MARINE LINEFISH DATA COLLECTION - COMMERCIAL**

J C Smith

**REPRODUCTION AND MIGRATION OF THE RAGGED-TOOTH SHARK**

G Cliff, B Wilson, J McKay and B Davis

**THE BIOLOGY OF *Solea bleekeri* IN THE ST LUCIA SYSTEM**

D B Cyrus

**THE BIOLOGY OF 14 SPECIES OF SHARKS CAUGHT IN NATAL'S SHARK NETS**

B Davis and G Cliff

**A STUDY OF THE DEEP REEF FISHES OF NATAL - SCIAENIDAE AND SERRANIDAE**

N Denton

**THE NATAL OFFSHORE REEF FISH PROGRAMME**

P A Garratt

**THE FISHES OF THE AMATIKULU AND OTHER KWAZULU ESTUARIES**

R Kyle

**ASPECTS OF THE ECOLOGY AND EXPLOITATION OF THE FISHES OF THE KOSI SYSTEM**

R Kyle

**FISH TAGGING**

R P van der Elst and E Bullen

**GAME FISH RESEARCH**

R P van der Elst and F Adkin

**FISH AND FISHERIES**

Rapporteur's comments : R P van der Elst

Much of the work reported on by fish biologists at this symposium form part of the national objectives of linefish research, as identified by SANCOR. For this reason it is neither prudent nor necessary to propose major new avenues of research in Natal. Indeed, I would suggest that linefish research in Natal is well advanced - although several distinct gaps can be identified.

Our most vulnerable target species are, or have been, studied. P A Garratt tackled the endemic sparid fishes (slinger, santer, Englishman and Scotsman) five years ago and this year will see publication of the life history of all these.

It was acknowledged some time ago that kob, geelbek and rockcod form an important component of catches too. Though funding only came to light in 1985, N Denton is investigating their life history - especially the important endemic *Argyrosomus thorpei*, that provides much food for the North Coast community.

Gamefishes have been studied since 1974. Though not all has yet been published, attention has been concentrated on vulnerable or target species, e.g. elf, leervis, queen mackerel, dusky and milk-shark. Complete species synopses on these and others, which will include stock assessment and proposals for their management, will be published during 1986.

The thrust of fish research is now very much quantitative in order to provide real management advice. This was also clearly highlighted by R Kyle in his Kosi studies. The interests of Tonga fishermen and visiting anglers are not likely to be incompatible, and his results will undoubtedly assist management in providing a sustained yield of fish from Kosi for all its users.

To become more quantitative does not only require studies on the growth and mortality rates, but especially needs major input from fishermen themselves. Consequently the data collecting programmes as discussed by J C Smith and F Adkin are most important. Their success has been exceptional. With the additional input provided by Natal Parks Board staff, we in Natal probably have the finest linefish data collecting system in the world - certainly involving sport fishing. Our records are channelled to FAO in Rome annually and we are playing a role in the development of a standardized worldwide species code list with FAO.

Much research has also been directed at the fishermen themselves. Through beach creel censuses, telephone surveys and fishing tackle production, trends in fishing effort and angler behaviour are now known. This data is critical to evaluation trends in the fishery and in planning for the future.

Another important project involving angler input is the tagging programme sponsored by Stellenbosch Farmers' Winery. With more than 1 000 anglers countrywide tagging some 5 000 top species per annum, sound quantitative data is now forthcoming - and will be available to all linefish workers.

Though linefish are important to the people of Natal, so too are many other species of fish to the ecosystem in which they live. Hence the continued input by D B Cyrus on important estuarine fishes. *Solea bleekeri* is undoubtedly a major species in all Natal estuaries and details on its life history have now almost been worked out.

Management of Natal's shark populations remains an important topic, whether for bather protection or ecological concern. Studies on the biology of 14 netted species by the Natal Sharks Board could, therefore, make a valuable contribution in this field. Extensive records dating back to 1978 have been computerized and, once analysis is complete, this information will be published.

It may be concluded that Natal fish studies are on a sound footing. Much of it is management orientated, with project emphasis on target species rather than ecological divisions. The various projects integrate reasonably well and most workers seem clear about their final objectives. Perhaps the most direct example of our success in fish studies was the management plan produced at ORI last year. This far-reaching approach to linefish management in Natal and South Africa was steered through various local committee stages and finally formed the basis for new national legislation approved by the Minister.

The single most important gap in our knowledge concerning Natal fish and fisheries are the early life stages, their distribution and dynamics. Egg and larval surveys are long overdue, not only to study their behaviour and abundance but especially to determine their distribution so that the origin of our fish stocks may be established. A similar need exists for prawns, crabs, crayfish and many other exploited organisms. More emphasis should also be given to understanding the annual sardine run, perhaps linked to a study of the Tugela Bank region. Serious attention must, therefore, be given to regular access of ship's time and suitable staff.

Future studies should investigate alternative resources that can provide food for Natalians, while reducing pressure on currently overexploited linefish stocks. Some need also exists to evaluate fishery enhancement techniques such as artificial reefs, fish aggregating devices and artificial re-seeding programmes.

There has been much discussion on the relative merits of fundamental and applied research, on the system versus direct approach and even on academic versus practical studies.

Linefish research in Natal, and indeed the rest of South Africa, has a firm basis in the practical, management orientated sciences. So it should be. Balancing energy equations and understanding a system may ultimately be most important, but I doubt if they can be attained before our fishery has collapsed. May I remind you that the ORI Reef programme was dictated to ORI, whilst the bronze bream disappeared from our coast, that the galjoen stocks totally collapsed during the Kelp Bed programme

(of which it is a major component) and that not a single scientist can advise on the impact of vehicles on beaches despite vast beach research programmes! Urgent studies are now underway to save the bronze bream, the galjoen and other neglected species.

In my opinion, system studies within the South African context are only justified if there are clear final objectives and not just 'understanding' of the system. Equally important should be the human component, either as predator or modifier of the environment. Perhaps our understanding of inter-relationships between Natal marine fishes and their response to environmental fluctuations is inadequate. Notwithstanding, Natal's fishermen are already reaping benefits of improved management, as in the case of elf, and the clear objectives identified by researchers these past two days give promise of even better prospects.

**NATIONAL MARINE LINEFISH DATA COLLECTION - SPORT**

Researchers : F Adkin, D Ballard and R P van der Elst  
Organization : ORI  
Duration : 1979 - ongoing  
Funding : SFRI, SAAMBR

The National Marine Linefish Programme received official recognition in 1979, but collection of catch and effort data had long been in effect. The Natal Coast Anglers' Union started recording their competitions in 1918. In 1974 ORI, through the NPB coastal zone officers, started to collect daily records of rod counts and catches on the Natal coast. All evidence led to the fact that fishing pressure was increasing markedly and sound management policies were needed. To formulate these policies, good catch and total effort data are essential - ideally total catch and total effort.

Data are collected throughout South Africa, but at present the bulk comes from Natal. In 1984, 96.8 % of a total of 138 991 angler outings processed were from Natal.

The shore data are received from three main sources, namely competitions, catch cards and NPB beach patrols. We receive all rock and surf competition records from Natal, with 8 569 angler outings being processed in 1984. As club anglers only make up 4 % of the angling fraternity, catch cards were introduced. This system only operates effectively if there is control over issuing and collecting of cards and, as a result, is only operational where there are fixed access points to the beach. The scheme was implemented at Beachwood four years ago and in 1984, 18 250 angler outings were processed - estimated to be 95 % of all angler outings on that beach.

The NPB beach patrols provide valuable information for the rest of the coast - 74 343 angler outings were recorded in 1984. Recently, with the aid of the Department of Mathematical Statistics at UCT, we have modified the forms to facilitate the calculation of the distribution of fishing pressure by locality and season. With their help, we have been able to calculate not only Catch-per-unit-effort (CPUE) trends, but trends in effort as well.

The skiboat data collection initially involved only the NPB tri-monthly catch rate sampling plus an annual estimate of total fishing effort, thereby providing an estimate of total offshore catch. Logbooks were then introduced at various clubs to supplement the data, but these were not very successful and a card system was introduced. These are now working very successfully at all major Natal clubs, with 22 081 angler outings processed in 1984.

Light tackle boat cards were introduced at St Lucia in 1984. These are providing extremely valuable information on the fish fauna in the St Lucia mouth. Records are also received from light tackle boat competitions, providing data on other Natal estuarine systems.

This highly successful data collection system relies greatly on angler/scientist cooperation. To promote this annual feedback, summaries are sent out to all concerned. The major problem involves the better monitoring of the non-affiliated anglers - perhaps a licensing system for anglers would solve this.

AN OVERVIEW OF TOTAL OFFSHORE LANDINGS OF LINEFISH; NATAL 1983

	Recreational Skiboats	Charter/Party Boats	Commercial Skiboats
N° boats operating	1647	21	61
Total catch	381.5 t	211.9 t	677.0 t
King mackerel	103.6 t	4.2 t	2.4 t
queen mackerel	60.3 t	2.5 t	2.8 t
tuna	83.6 t	101.1 t	5.8 t
dorado	4.1 t	1.6 t	?
billfish	5.6 t	?	?
reds	32.5 t	53.0 t	472.9 t
linefish	13.7 t	27.7 t	62.4 t
rockcod	12.3 t	9.8 t	32.5 t
snappers	0.8 t	?	?
carangids	63.2 t	2.0 t	30.4 t
sciaenids	1.8 t	8.5 t	48.0 t
others	-	1.6 t	19.8 t

NATIONAL MARINE LINEFISH DATA COLLECTION - COMMERCIAL

Researcher : J C Smith  
 Organization : SFRI  
 Duration : 1985 - ongoing  
 Funding : SFRI

The need for cooperative and coordinated linefish research was recognized by the Executive Committee of SANCOR in 1977. As a result, a working group was established to identify research priorities. This working group decided that research would be directed towards providing information suitable for the development of rational management strategies. One of the most essential components of the knowledge is data relating to the abundance and trends in abundance of stocks that are subject to exploitation. The collection of catch statistics for elf started in Natal by ORI in the early 1970s. Data collection was later expanded to all aspects of the sport and recreational linefishery in Natal. In 1980 this collection was extended to a national level. However, commercial catch statistics

were sketchy until 1985, except for data collected by Nepgen at SFRI on snoek, tuna and yellowtail. By 1985 catch data were being collected on a national basis by ORI, the Port Elizabeth Museum (PEM) and SFRI for the sport and commercial linefishery. In order to cope with the enormous volume of data and to allow access to all researchers in the field, a national database was created at SFRI. As most of the catch data were being collected by ORI, the first remote computer system was installed here in 1985.

A recent survey by FISKOR revealed the economic importance of the linefishery and the catch data pouring into the ORI revealed the state of the fishery. This resulted in new legislation governing the linefishery. A major aspect of this legislation was the division of the linefishery into three categories:

- a) Commercial
- b) Semi-commercial
- c) Sports and recreational fishing

All commercial and semi-commercial linefishermen are licensed with the Marine Development Branch. One of the conditions of this licence is that catch returns are submitted to SFRI on a monthly basis. Sports catch data are voluntary.

With the exception of Natal, all commercial catch data are submitted to SFRI in Cape Town. In Natal there are 82 A and 77 B category licences. In excess of 80 % catch returns from these two categories combined are received.

In order to supplement the catch statistic returns, length frequency measurements are taken at Richards Bay, Salt Rock, Park Rynie and Ramsgate once per month. When the lineboats were operating in Mozambique, length data were also collected from these.

#### REPRODUCTION AND MIGRATION OF THE RAGGEDTOOTH SHARK

Researchers : G Cliff, B Wilson, J McKay and B Davis  
 Organization : Natal Sharks Board (NSB)  
 Duration : 1978 - ongoing  
 Funding : NSB

Large female raggedtooth sharks, *Eugomphodes taurus*, undertake what is thought to be an annual migration between the winter pupping grounds off the eastern Cape and the mating grounds off Natal. Mating takes place in nearshore waters between September and November resulting in the capture of a large number of adult sharks in the shark nets.

Having mated, the females continue to move northwards and packs of up to 70 sharks have been seen on one particular reef in the St Lucia Marine Reserve. Despite reports of their presence as far north as Mozambique, virtually nothing is known of the movements of these sharks north of the Tugela River.



For a number of years divers from the Board have observed the sharks when they have been present on the reef. A method of marking the sharks with Floy dart tags, administered underwater by a speargun, was developed recently and to date a total of 51 sharks has been tagged.

Further tagging and the eventual use of telemetry should improve our knowledge of the migratory behaviour of the raggedtooth sharks, which is obviously important in the reproduction of this species.

### **THE BIOLOGY OF *Solea bleekeri* IN THE ST LUCIA SYSTEM**

Researcher : D B Cyrus  
 Organization : Dept of Zoology, University of Zululand  
 Duration : 1982 - 1987  
 Funding :

Data for this study have been collected over the past four years, with monthly sampling being undertaken for one full year during this period. Sampling within the St Lucia system has been restricted to South Lake and the Narrows. To date some 600 individuals have been netted, and of these just on 400 have been analysed for gut contents, gonad condition and parasite loading. The five major sections of this study are listed below with a brief statement on the results obtained to date:

#### 1) Diet

All samples except the fry (30 mm) have been analysed. Preliminary results show that the major food item taken by this benthic predator is the siphon tips of the bivalve *Solen cylindraceus*. All other food items including whole bivalves are of minor importance.

#### 2) Reproduction

Monthly data on the number of each size class present, as well as gonad condition, indicate that the gonads of adults are reaching maturity during July and early August. At this point they all move out of the system to spawn at sea. Seining results also indicate that few adults return to the system after spawning.

#### 3) Recruitment

Recruitment into the system begins during September and reaches a peak in October. By November individuals less than 50 mm comprise nearly 60 % of the population.

#### 4) Predation

Data on the gut contents of numerous other predatory fish species within the system have shown that *S. bleekeri* is seldom taken. However, the limited data on the diet of piscivorous birds show that *S. bleekeri* may form an important part of the diet of two species of cormorant.

5) Habitat preference related to turbidity and other factors

Field results show that turbidity is important in determining the distribution of this species in St Lucia. The favouring of high turbidity water is not related to food availability or any other physical factor which was measured.

6) Parasite loads

Analysis of collected specimens has shown a high loading of a gut-inhabiting *Acanthocephala*, the life cycle of which has recently been determined by a British parasitologist. This study is almost complete, only requiring the collection of a few more samples from selected localities and their analysis, along with that of the remaining collected specimens and additional observations on the diet of piscivorous bird predators.

## A NOTE ON OTHER RESEARCH PROJECTS

The study on "The influence of turbidity on fish distribution in Natal Estuaries" has been completed, the PhD thesis submitted and accepted. Publication of papers is underway.

A study on the "Feeding biology of *Monodactylus argenteus* in Natal Estuaries" has to date been carried out on an *ad hoc* basis but it is hoped to intensify this study in the future.

## THE BIOLOGY OF 14 SPECIES OF SHARKS CAUGHT IN NATAL'S SHARK NETS

Researchers : B Davis and G Cliff  
 Organization : NSB  
 Duration : 1978 - ongoing  
 Funding : NSB

Approximately 1 300 sharks, made up of 14 identified species, are captured annually in Natal's protective netting system. Information such as length, sex, mass, liver mass, reproductive activity and stomach contents from all sharks caught since 1978 has been computerized.

An analysis of these data has only just been initiated and once completed will provide an excellent understanding of the large shark community of Natal's nearshore waters.

The feeding habits of these sharks are particularly important in view of the concern expressed over the possible impact of the nets on the marine ecosystem. Consequently considerable effort has been expended in the sorting of gut contents. A vast number of cephalopod beaks and teleost otoliths have been collected and must be identified. A paper examining the importance of small sharks caught in the nets is in preparation.

Future contemplated projects include:

- i) Capture pattern analyses in relation to prevailing sea and other environmental factors, e.g. visibility, sea temperature, sardine runs, rainfall/drought.
- ii) The ageing of sharks.
- iii) Histological study of the reproductive organs.

#### A STUDY OF THE DEEP REEF FISHES OF NATAL - SCIAENIDAE & SERRANIDAE

Researcher : N Denton  
 Organization : ORI  
 Duration : 1985 - 1988  
 Funding : Sea Fisheries Research Fund (SEFREF), SAAMBR

Since the turn of the century offshore linefish of several species have provided Natalians with food for the table and a source of recreation. Although sciaenid and serranid fishes represent an important component of Natal linefish catches, their study has been neglected. As a consequence, this overdue project commenced in March 1985 with the following objectives: to determine the species composition of the catch; the size at maturity; growth rates; distribution of the species; their main dietary components and CPUE information.

Whereas both the sciaenid and serranid families comprise a large number of species, only a few attain major levels of abundance (Figure 1). As squaretail kob represent a major target species, skiboat launching sites were selected to optimize sampling for this species, notably Salt Rock, Tugela, Mtunzini and St Lucia. Fish are weighed, measured and sexed; gonads are staged and weighed; stomach contents are classified and otoliths are collected at each station.

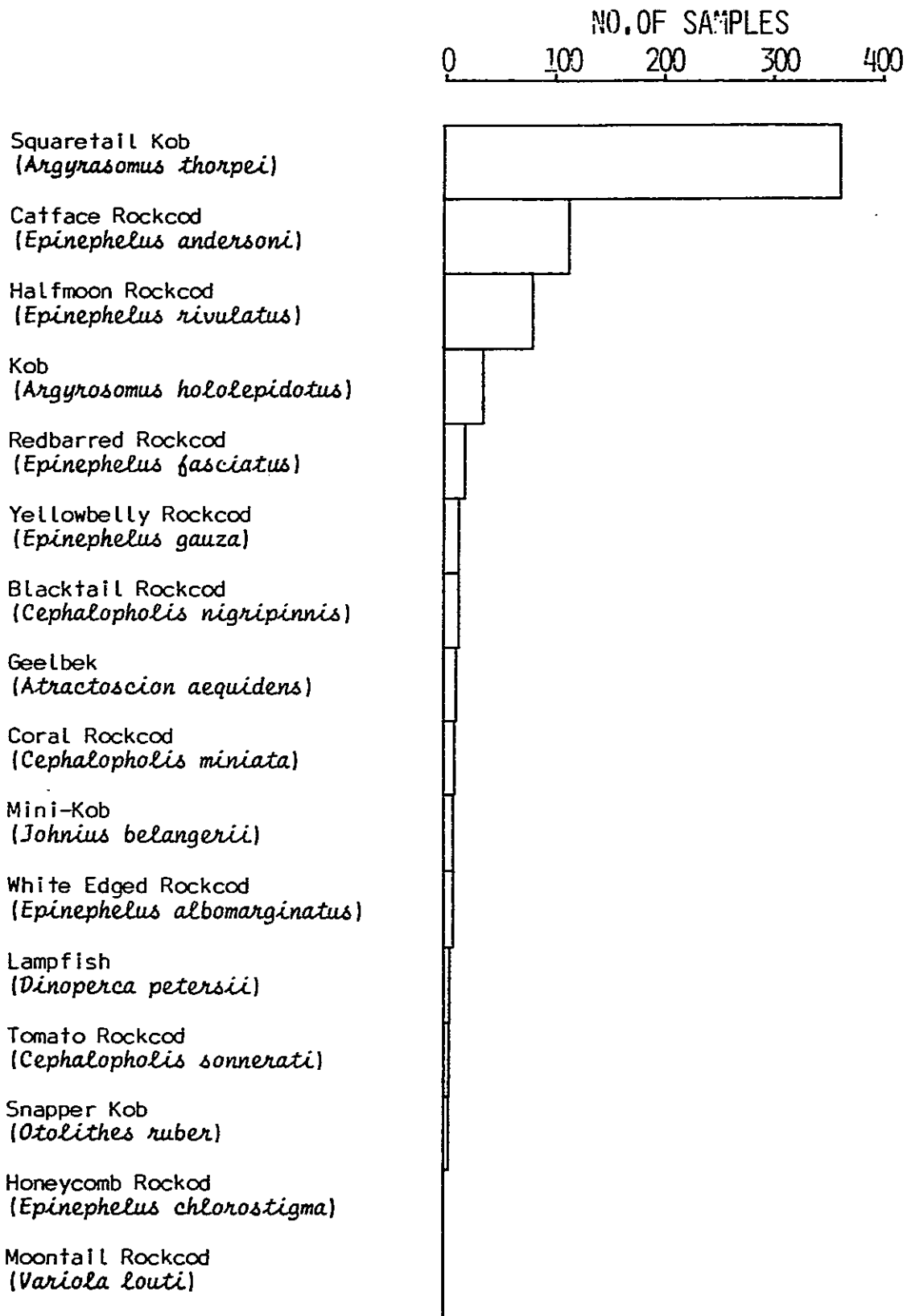
Morphometrics: Tentative length/weight relationships have been calculated.

Population structures: The length frequency data indicate that squaretail kob and catface rockcod are distributed polymodally and it may be possible to estimate growth by modal progression.

Sex ratios: Sex ratios for the sciaenids are: squaretail kob 42 % male (n=587), kob 52 % male (n=41), geelbek 50 % male (n=56) and blackmouth croaker 26 % male (n=158). Sex ratios for the serranid species are not yet estimable because, until September, male gonads were being mistaken for female and it is only since recently that the fish have been accurately sexed.

Spawning: It is evident that spawning of several species, notably the squaretail kob (August to October), geelbek and blackmouth croaker (November & December), occurs in Natal.

Figure 1: Abundance of each species sampled from skiboats on the Natal Coast.



Length at sexual maturity: 83 % of the sample of squaretail kob were mature and all blackmouth croaker examined were mature.

Feeding incidence: Squaretail kob appear to feed on Macrura and teleosts, the kob on teleosts, blackmouth croaker on teleosts and Macrura, and both the catface and yellowbelly rockcods on teleosts, Macrura, Brachyura and Cephalopoda.

During the first nine months of the project sufficient information has been collected on the squaretail kob, the most important sciaenid, to indicate that a comprehensive picture, suitable for managing this component of the catch, will develop in due course. The catface and halfmoon rockcods have also emerged as priority species, and with increasing success in sexing serranids, a thorough understanding of members of this family will result.

#### THE NATAL OFFSHORE REEF FISH PROGRAMME

Researcher : P A Garratt  
 Organization : ORI  
 Duration : 1979 - ongoing  
 Funding : South African Association for Sport Science, Physical Education and Recreation (SAASSPER), SAAMBR

In Natal the offshore linefishery yields up to 2 500 metric tons of fish per annum. It is not a big fishery by world standards, but it does support a large sportfishery and a smaller commercial one, both of which supply much needed protein to a rapidly expanding population.

The fishery itself is a multi-species one, which has two major components: reef fish and game fish. Reef fish make up the bulk of fish landed by both sport- and commercial fishermen; and two sparids make up the bulk of reef fish catches: the slinger, *Chrysoblephus puniceus* and the soldier (santer), *Cheimereus nufar*.

An investigation into the biology of these and two other dominant reef species has been in progress for almost seven years. Data on the slinger and soldier have been analysed and the most significant facts to emerge from the study are;

- 1) that the slinger is a protogynous hermaphrodite;
- 2) that an alteration in the population structure of this species in Natal has resulted in an unbalanced sex ratio; and
- 3) that the sex ratio of the slinger may be a means of assessing the state of these stocks in Natal and surrounding waters.

In recent years all efforts have been concentrated on the slinger, as it is by far the most important reef fish along our coast. A tagging programme was started in May 1984 and, to date, 4 111 fish have been tagged. So far we have tagged only in the St Lucia Marine Reserve, but from this year we shall be tagging along heavily exploited sections of the coast.

The aims of the tagging programme are:

1. To determine whether or not *C. puniceus* is migratory.
2. To determine the growth rate of *C. puniceus*. (Tagged fish are injected with tetracycline for this purpose).
3. To estimate mortality rates.

With data on mortality and growth rates we will be in a position to carry out stock assessment determinations. Knowledge of the populations sizes and how much can be removed from the system is what is needed to maintain the fishery in a healthy state.

#### **THE FISHES OF THE AMATIKULU AND OTHER KWAZULU ESTUARIES**

Researcher : R Kyle  
 Organization : Bureau of Natural Resources  
 Duration : ongoing  
 Funding : KwaZulu Government

This project takes the form initially of an inventory of the fish resources of the estuaries of KwaZulu. Check-lists are drawn up with notes on rare fish or fish threatened in other areas. Current levels of utilization and stocks are assessed with a view to recommending future exploitation techniques and levels.

#### **ASPECTS OF THE ECOLOGY AND EXPLOITATION OF THE FISHES OF THE KOSI SYSTEM**

Researcher : R Kyle  
 Organization : Kwazulu Bureau of Natural Resources/UN  
 Duration : April 1981 - February 1986  
 Funding : KwaZulu Government

The various human and natural fish off-takes at the Kosi system were identified, described and assessed. Tagging of fish was carried out in

order to establish the percentage off-takes of the human exploitation and obtain estimates of the populations of the larger marine species present. The traditional Zulu fish trap catches were monitored over a four year period and the data used to provide information on seasonal abundance, migrations and the influences of various climatic and other conditions on fish movements.

The project was undertaken to establish the size of the fish resource at Kosi and the current level of exploitation. Competition between tourists and local traditional fishermen was also examined, as well as that between human exploitation and natural predation.

The dependency of the fish on the various food resources and the stability of these was also investigated in order to make recommendations on various agricultural and other schemes which might affect the hydrology of the system. Factors influencing the productivity of the system, such as nutrient input and salinity changes, were monitored in order to make recommendations on the management of the area.

#### FISH TAGGING

Researchers : R P van der Elst and E Bullen  
 Organization : ORI  
 Duration : 1975 - ongoing  
 Funding : Stellenbosch Farmers' Winery (SFW), SAAMBR

Once the biology of an exploited fish is understood, increased attention must be paid to stock assessment and other quantitative parameters. Though many methods are employed to achieve this, few provide more direct results than the recapture of tagged fish. Such techniques are therefore an important part of the ORI approach to fisheries biology. Intense tag and release of several target species has been undertaken by research staff, resulting in valuable data. In order to provide an adequate data base for many more species, anglers are now recruited to assist with tagging a range of species countrywide. Stellenbosch Farmers' Winery sponsor this programme, which has provided some impressive participation and results to date.

Total membership	= 1 106
Total number of fish tagged	= 6 174
Total number of species tagged	= 155
Total number of fish recaptured	= 180 (2.7 %)
Longest time free	= 382 days
Longest distance travelled	= 890 km

Simultaneous capture studies are also conducted to evaluate tag quality and tag loss. These parameters are quantified in the overall Jones equation to calculate fishing mortality (F). Further improvements are made by determining the non-reporting of tags and tag mortality due to poor handling by anglers. Already a number of prime South African

linefish species have revealed enormously distant migration routes, e.g. galjoen, elf, lesser sandshark, etc. while others indicate very high fishing mortality e.g. longfin tuna, elf, etc.

The success of this project thus far has been striking - much of this is attributable to considerable feedback information that is provided to the angling community. Certainly this programme provides a major opportunity for fishermen to assist in the continued sustainability of their catches. It is intended that the programme be continued on a permanent basis, especially as it will then also provide relative results on a year-to-year basis.

#### GAME FISH RESEARCH

Researchers : R P van der Elst and F Adkin  
 Organization : ORI  
 Duration : 1975 - ongoing  
 Funding : NPB, SAAMBR

Natalians are blessed with a great diversity of linefish that represents a prime source of food and recreation. Many of these are gamefish species, actively pursued by a growing band of sport anglers for their prowess and eating. Though many have a widespread Indo-Pacific distribution and a high sustainable yield, others are less resilient to exploitation. These would include the leervis (*Lichia amia*) and especially the elf (*Pomatomus saltatrix*). The latter has been subject to strict management and has been under intense study since 1973.

Initial research indicated that elf migrate between the Cape and Natal, that the Natal shelf represents its main or only spawning ground, that juveniles adolcesce in Cape littoral waters and that its growth rate is relatively rapid - attaining maturity at 25 cm within three years. Sharply declining catch rates confirmed this species' reduced abundance and highlighted the need for factual stock assessment data. Such information is now at hand and historic catches reveal that levels of maximum sustainable yield (MSY) were exceeded prior to 1976. Logarithmic catch curves indicate considerable fluctuations in mortality, which eventually resulted in a much reduced age composition of anglers' catches. Tagging studies point to an annual Natal fishing mortality equivalent to 45 % under the present management regime. Virtual population analysis (VPA) confirm these trends and show that fishing mortality increases with age. Based on yield per recruit studies, it may be possible to improve the quality (size) of elf by manipulation of the minimum legal size, although the total yield is relatively insensitive to such changes. Whereas some data analysis remains outstanding, it would appear that elf are presently exploited quite close to their level of MSY. It seems probable though that some fine tuning of the management measures may further improve catches.



Studies on the leervis have progressed along similar lines as those for elf, though less precise data are presently available for this valued species.

Another important component of the gamefish fauna is the dusky shark (*Carcharhinus obscurus*), which has proliferated in numbers; this is believed to be attributable to reduced predation by other large sharks as a result of protective shark meshing in Natal. Intense stock assessment studies of the dusky shark juveniles relate this trend to emigration from the fishing area and various rates of instantaneous mortality. Supported with evidence from tagging studies, a detailed scenario of dusky distribution and migration has been compiled.

Adequate data now exist for many species caught by Natal fishermen, to determine their stock and potential yield. Attention must continue to be focused on quantitative aspects of fishery biology with results that directly benefit stock management.

**POLLUTION AND HUMAN EFFECTS****RAPPORTEUR'S COMMENTS**

A D Connell

**COMPARISON OF TOXICITY SENSITIVITY OF THE LARVAE OF URCHINS, MUSSELS, OYSTERS AND THE DOMINO *Dascyllus trimaculatus***

D D Airey

**THE USE OF MEIOFAUNA IN DETECTING POLLUTION**

J D D'Aubrey-Whitehorn

**INCIDENTAL CAPTURE OF HARMLESS ANIMALS IN THE SHARK NETS**

G Cliff, B Davis, B Wilson

**SHARK ATTACK FILE**

B Davis, G Charter, G Cliff

**TOXICITY TESTING**

A D Connell, D D Airey

**RICHARDS BAY PIPELINE PROJECT**

C Potter, R P van der Elst, D Arthur

**RICHARDS BAY PIPELINE BIOMONITORING**

A D Connell

**RICHARDS BAY PIPELINE SURVEYS**

A D Connell

**PESTICIDE STUDIES IN THE NATAL MARINE ENVIRONMENT**

B D Gardner

**BACTERIOLOGY STUDIES AT NIWR, DURBAN. SURVEYS MONITORING THE SEA AND BEACHES IN THE VICINITY OF DURBAN**

D J Livingstone

**SEA DISPOSAL OF SEWAGE : ENVIRONMENTAL SURVEYS IN THE DURBAN OUTFALLS REGION (THE SLUDGE EXPERIMENT)**

D J Livingstone

**POLLUTION SURVEYS**

T P McClurg

**STUDIES ON SPECIFIC TOXIC METALS IN POLLUTED AREAS ON THE NATAL COAST**

T P McClurg, R C Stanton

**OIL POLLUTION INVESTIGATIONS ON THE NATAL COAST**

R R Sibbald

**FLUORIDE DISCHARGE INTO MANGROVE AREAS : PROBABLE CONSEQUENCES**

P Berjak, D J Mycock, C A Frankland

**RICHARDS BAY : OCEAN OUTFALL STUDY**

J A Zwamborn, G Toms

## POLLUTION AND HUMAN EFFECTS

### MARINE POLLUTION RESEARCH IN NATAL

Rapporteur's Comments : A D Connell

Research of the past ten years has shown that Natal's pollution problems are confined to the two major coastal centres of Durban and Richards Bay, the malaria spraying areas (DDT) and the major pipelines. These latter include (in geographical order) the pipelines of the South African Industrial Cellulose Corporation (SAICCOR), S A Tioxide, Durban Southern Works and Durban Central Works, the South African Paper and Pulp Industries (SAPPI), Stanger and SAPPI, Mandini, the Felixton board mill (MONDI) and the Richards Bay complex. While it is important to recognize that marine discharge is an effluent disposal option, research must be aimed at ensuring that no detrimental environmental impact occurs, and that the assimilative capacity of the area surrounding the pipeline is not exceeded.

In Durban we are fortunate in having a well balanced (albeit small) group of research scientists, including bacteriologists, chemists in the fields of nutrients, trace metals and chlorinated hydrocarbons, and biologists with expertise in beach meiofauna, benthic marine fauna, zooplankton and toxicity testing. We also have access to the physical oceanographic expertise of NRIO, which from 1 April 1986 has been more involved in all aspects of marine research in Natal. We are also linked to, and actively participate in, SADCO based at Stellenbosch, which has facilities for storage of geological, climatological, physical oceanographic and chemical and biological data, for the use of the entire marine research community of South Africa. All research scientists in Natal should make use of the data base for information in their particular field.

It is becoming apparent that metals in the sea are in general not a problem. In Natal two areas may be worthy of study, namely copper at Richards Bay, and metals in general from offshore dumping of fine sediment dredge spoil. As signatories of the London Dumping Convention we have certain obligations regarding the impact of this material on the offshore environment. In Durban and at Richards Bay this is being looked at only by way of accumulation of metals in biological organisms such as mussels and oysters. By transferring them to areas under observation we can measure which metals increase or decrease, and thus draw conclusions on the bio-availability of the metals. Such studies should also be made offshore on the dump sites, but at present are confined to within the harbours and around pipeline discharges.

Speciation is an important field of study with regard to trace metals, and the fate of copper resulting from fertilizer manufacture at Richards Bay is being studied to establish whether the copper in the phosphate rock could become an environmental problem.

Metallothionein studies have been used to show that an animal is in an environment where some physiological handling of metals is necessary, but this is not directly of use in estimating the environmental concentration of that metal at which the animal is stressed to a point where it is disadvantaged. Therefore, our toxicity studies have been confined to looking at reproductive rates or fertilization/embryo development success

as a measure of the animal's ability to survive and reproduce in a stressed environment. Interestingly, these sensitive test methods reveal that at very low concentrations of effluent, the phenomenon of hormesis is observed, in which reproduction rate or hatch rate is better than that achieved in the control solutions of pure seawater.

Some interesting studies of petroleum hydrocarbons have been completed recently, one on a method of trapping the compounds in the surface micro-layer of the sea for analysis, and another on levels in mussels from sites near Durban. Reaction to these studies will be awaited before further research is contemplated.

The occurrence of dieldrin in Natal marine fauna continues to be studied. A recent (June 1985) collaborative study of dieldrin levels in a couple of mussel and mullet samples from the mouth of the Reunion canal and the Bayhead respectively, yielded:

- i) Good agreement on the concentrations of dieldrin from the four participating laboratories.
- ii) Confirmation that the compound being detected was dieldrin.
- iii) Relatively low results, of 2 to 7  $\mu\text{g kg}^{-1}$  in mussel (wet mass) and 13 to 37  $\mu\text{g kg}^{-1}$  for the mullet. These results suggest a drop in levels in the past 5 years, but more extensive surveys are in progress.

Methods of impact assessment used on the major pipeline discharges on the Natal coast include:

- i) Bacteriology (sewage discharges).
- ii) Chemistry of water and sediments.
- iii) Meiofauna of beaches.
- iv) Offshore benthic fauna surveys.
- v) Accumulator organisms analysis (mussels, oysters, fish).
- vi) Toxicity testing and microcosm impact studies.
- vii) Settling organisms studies.
- viii) Photographic surveys by Scuba diving.

The discharges with the greatest potential for environmental impact have been identified. Of major importance is research into means of assessing the extent of impact in the vicinity of the pipeline in order to ensure that all are functioning adequately and that any future pipelines be adequately designed to eliminate detrimental environmental impact.

**COMPARISON OF TOXICITY SENSITIVITY OF THE LARVAE OF URCHINS, MUSSELS, OYSTERS AND THE DOMINO *Dascyllus trimaculatus***

Researchers : D D Airey and A D Connell  
Organization : NIWR  
Duration : ongoing  
Funding : CSIR

During the past 5 years the eggs and larvae of the marine domino fish, *Dascyllus trimaculatus*, have been used for the short-term toxicity testing of effluents at NIWR.

Problems have been encountered with the dominos in that:

1. When a batch of eggs is urgently required, the fish lay their eggs in an inaccessible position.
2. If the breeding pairs are lost for some reason or another, it takes at least 6 months to establish another breeding pair.

Thus, to ease the dependance on one species of test organism, others equally or more sensitive are being sought.

The present project is being undertaken to determine and compare the sensitivities of the three invertebrates, which were selected for their ease of collection, large numbers and known breeding seasons. The development of reliable techniques of inducing spawning and determining the time required for exposure to the effluents for each test species are other objectives.

A large number of tests have already been conducted on various effluents using the eggs of the domino, to which the results of the invertebrates can be compared. The larvae of the three new test species appear to be many times more sensitive than the domino larvae. For example, the recommended dilution for use of a foam dispersant is between 1 : 1 000 and 1 : 5 000. The no effect level for the domino larvae is <1 : 50 000, whilst that of the mussel larvae is <1 : 500 000.

**THE USE OF MEIOFAUNA IN DETECTING POLLUTION**

Researchers : J D D'Aubrey-Whitehorn, J Delport, R C Stanton and  
A Lord

Organization : NIWR

Duration : ongoing

Funding : SANCOR, CSIR, SAICCOR, Smitchem, African Explosives  
and Chemical Industries (AECI)

**SUMMARY**

Interstitial beach fauna were first used by the NIWR to monitor pollution in the 1960s. In the 1970s the NIWR beach monitoring routine was adjusted to conform to the definition of meiofauna as animals between 45  $\mu\text{m}$  and 1 mm in length.

Counts are made of major invertebrate groups, including nematodes, copepods, ostracods, isopods, acarinids, gastrotrichs, kinorhynchs, annelids, turbellarians, nemerteans and tardigrads. Because meiofauna are small and cover so diverse a zoological range, their identification to species level requires electron microscopy and specialist taxonomists. Measures taken toward better identification include the compilation of a photographic reference catalogue of Natal meiofauna distinguishable at the magnification used in making counts.

Total meiofaunal density can indicate pollution - in the presence of a severe disturbance as few as 2 meiofauna per 10  $\text{cm}^2$  surface area have been recorded - while organic pollution is often accompanied by an increase in density to over 4 000 meiofauna per 10  $\text{cm}^2$ . The effects on meiofaunal abundance of various physical and chemical factors are being studied. Preliminary results suggest that, on Natal beaches, particle size moderates the counts of some meiofauna; while ostracod counts, for example, are more influenced by the concentration of dissolved oxygen in the interstitial water. The density of separate meiofaunal groups is also being compared with salinity, pH, dissolved organic carbon, oxygen absorbed, Kjeldahl nitrogen, ammonia and lignin values. Since various meiofauna may differ in their response to different factors (either natural or introduced) the sensitivity of pollution assessment is likely to increase with increase in the accuracy of meiofaunal identification.

**INCIDENTAL CAPTURE OF HARMLESS ANIMALS IN THE SHARK NETS**

Researchers : G Cliff, B Davis and B Wilson  
Organization : NSB  
Duration : 1979 - ongoing  
Funding : NSB

Records have been kept by the Natal Sharks Board of the species, size, sex (where possible) and fate of a wide variety of harmless animals caught in the nets since 1979.

All cetaceans are kept for examination by V Cockroft of the Port Elizabeth Museum. A small project has been initiated, involving several persons active in dolphin research and the staff of the Natal Technikon to develop sonic devices which may reduce the capture of dolphins in the nets.

The information on turtle captures is forwarded to Dr G Hughes of the Natal Parks Board.

Teleosts captured in the nets are predominantly members of the Kingfish (Carangidae), kob (Scianidae) and tuna (Scombridae) families; billfish (Istiophoridae) are rarely caught. These specimens may be examined merely to confirm their identity.

Batoids are the most common animals caught, and include representatives from the sawfish (Pristidae), guitarfish (Rhinobatidae), eagleray (Myliobatidae), stingray (Dasyatidae) and manta (Mobulidae) families. More than 50 % of these specimens are released alive from the nets. Since 1984 a small number of specimens has been examined and details of mass, liver mass and reproductive activity have been recorded. It is hoped that a means of tagging those specimens released alive from the nets will be implemented shortly.

**SHARK ATTACK FILE**

Researchers : B Davis, G Charter and G Cliff  
 Organization : NSB  
 Duration : 1974 - ongoing  
 Funding : NSB

The Natal Sharks Board assumed responsibility for maintaining the South African shark attack file in 1974. Since that time 41 incidents on the South African and Transkeian coasts have been documented; this figure includes 5 cases of sharks harassing surfboard riders without inflicting any injury and 13 cases in which sharks appear to have scavenged on the remains of the victims of drowning.

In each case details of sea and weather conditions prior to and at the time of the incident are recorded, when available. Descriptions of the victim's attire, shark's behaviour and the nature of any injuries, together with photographs, are provided. Attempts are made to determine the identity and approximate size of the shark involved. To this end the Board has started a collection of jaws of a representative size range from those species caught in the shark nets.

Due to the sensitivity of this subject, the reports are to be published in a respected medical journal.

**TOXICITY TESTING**

Researchers : A D Connell and D D Airey  
 Organization : NIWR  
 Duration : Ongoing  
 Funding : SANCOR, NIWR

**SUMMARY**

Marine toxicity testing at the NIWR was initially limited to long-term tests with the estuarine amphipods *Grandidierella lutosa* and *G. lignorum*. Shorter tests were developed using the eggs and larvae of the domino *Dasculius trimaculatus* and the clown fish *Amphiprion allardi*. The domino with a shorter laying interval and more numerous, although smaller eggs, became the prime test species. Comparison of the results of both long and short-term tests using the same effluent, showed them to be similar.

In the majority of tests, the embryo-larval sensitivity is the same as, or better than, longer, more costly complete life-cycle toxicity tests.



The short-term tests using the eggs of the domino are conducted in acid-washed glass beakers set up in a constant temperature water bath. The eggs are taken from the aquarium on the day after laying, and hatch three days later. On the fifth day the experiment is terminated when the control larvae are fully developed.

Modified proportional dilution dosers are used for the long-term studies, which are to determine the chronic, rather than the acute, effects of a toxicant. Two modified dosers are in use at the NIWR laboratory, one of them adjusted to give a regular dose of effluent, resulting in constant concentrations of effluent in the test aquaria. The second doser has been modified further to give one dose of toxicant in 12 hours, followed by sufficient doses of clean seawater to wash the effluent out of the aquaria over the next 12 hours.

In the future, shorter tests are to be developed using the gametes of mussels, oysters and sea urchins.

#### RICHARDS BAY PIPELINE PROJECT

Researchers : C Potter, R P van der Elst and D Arthur  
 Organization : ORI  
 Duration : June 1982 - March 1988  
 Funding : SANCOR/SAAMBR

ORI became involved in the field of marine pollution in order to evaluate the biological responses to particular discharges. This was achieved by attempting to detect sub-lethal effects in organisms which colonize off-shore rafts. Should pollution make the environment unacceptable to these colonizing larvae, then their rate and intensity of settlement will be influenced. Subsequent growth, species composition and reproductive output of the settled biota are also likely to be influenced by environmental conditions.

Bi-monthly sampling of the rafts compares strategically placed control sites outside the impact area with impact sites deployed in the 'boil' of both pipelines. This then defines the total impact area identified by the two possible extremes. Preliminary results of this study showed that the increase in biomass with time was less for stations in the 'boil' than for those slightly further away. The greatest increase in biomass was found at the control sites situated 5 km away. There was, however, no apparent increase in the mean size of individual species or in species diversity. Subsequent colonization followed distinct patterns, mostly related to a successional series. *Balanus* showed the most distinct pattern of increasing abundance with time, reaching a density of 3 800 m<sup>-2</sup> at seven months. The goose barnacles *Lepas* and *Conchoderma* peak in numbers at four months and thereafter decline. Polychaetes become abundant after three months. It would appear that the most significant changes in the relative abundance of dominant species occur three to four months after immersion. The mean biomass on panels also shows a similar

rapid increase from  $470 \text{ g m}^{-2}$  after one month to an average mass of  $8\ 250 \text{ g m}^{-2}$  after seven months. It was found that the number of species settling on test panels at Richards Bay increase with time, but that, after about 4,5 months, the species richness stabilizes or drops slightly.

An important feature of this programme has been the development of a standardized pollution monitoring system which could be tested at Richards Bay. This system was to be versatile enough to withstand rough sea conditions, permit frequent sampling routines and still be realistically priced. With this objective having been achieved and sampling routines ongoing, it is envisaged that similar monitoring strategies may be used at other known impact areas in the future.

#### RICHARDS BAY PIPELINE BIOMONITORING

Researchers : A D Connell, J W D Turner and D D Airey  
 Organization : NIWR  
 Duration : 1985 - 1990  
 Funding : Mhlatuze Water Board

#### SUMMARY

This project is designed to establish a laboratory facility dedicated to monitoring the quality of effluent discharged from the two pipelines at Richards Bay.

The monitoring function is divided into:

- a) A fish biomonitoring unit.
- b) Short-term toxicity tests of integrated samples.
- c) Longer-term (1 - 3 month) tests of the impact of the effluent on selected biota, at the concentrations being discharged.

a) The Fish Biomonitoring Unit. This consists of a number of isolated aquaria each containing one fish of a suitable species. We are currently testing *Therapon*, *Ambassis* and *Acanthopagrus* for this purpose. Each fish is under constant electronic surveillance, and the resulting data are used to establish the baseline behaviour pattern of each fish, relating to daily rhythm, feeding and so on. A computer then processes the data and compares present data with immediate past data. When this has been established after several days, the effluent is introduced with the continuously flowing seawater to each tank, at a level which will not elicit a reaction from the fish, but which is fairly close to the threshold. Drastic deterioration in effluent quality would evoke a response in several or all fish. This information would be captured together with the time of the event and then, automatically, effluent dosing will be diverted to a sample bottle and then to waste for a period

of time, while seawater continues to flow, washing the effluent from the tank. After a suitable time lapse effluent dosing would resume, and if a further response was elicited, the above cycle would be repeated. As backup it is planned to position 24-hour samplers at the outlet of all major contributors to the pipeline such that, in the event of a significant drop in quality, samples could be recovered for analysis to pinpoint the source.

b) Short-term toxicity tests on integrated 24-hour samples will be conducted regularly, using either mussel, oyster or urchin sperm, ova and embryos, or the eggs of the marine fish *Dascyllus trimaculatus*, depending on availability.

c) Longer-term tests will be conducted on microcosms in the conventional proportional dilution dosers as presently used at NIWR, and in troughs where organisms will settle out from the incoming seawater to supplement those in the sediments placed in the troughs at the start of each experiment.

Concentrations of effluent in both b) and c) above, will be at or around the dilutions calculated to be achieved at the boil in calm water.

#### **RICHARDS BAY PIPELINE SURVEYS**

Researchers : A D Connell, T P McClurg, D J Livingstone,  
R C Stanton, M M Calder, A Lord, R R Sibbald  
J Whitehorn, J Delpont and N Paynter

Organization : NIWR

Duration : 1974 - 1984 Pre-discharge  
1985 - 1988 Post-discharge

Funding : SANCOR, NIWR

In June 1981 the NIWR was approached by the Department of Environment Affairs to undertake a programme of research suitable for the meaningful assessment of environmental impact of the proposed Richards Bay Pipeline. Currents, sediment studies, water chemistry, primary productivity and plankton studies had all been undertaken during the early 1970s at Richards Bay by the National Physical Research Laboratory (NPRL) and NIWR, and reported on. In addition NIWR had done some water and sediment chemistry and benthic macrofauna studies at various points along the coast. These were expanded into studies of bacteriology of water, water and sediment chemistry, benthic fauna (including beam trawling), fluoride and metals in fishes and selected invertebrates, neuston netting for fish eggs and larvae, and skin and liver lesions in two flat fishes commonly encountered in the beam trawls. On the beaches bacteriological samples, as well as meiofauna samples and sediment and interstitial waters for chemical analysis, were collected. The results of all these studies have been accumulated for comparison with the discharge samples which are currently being collected and processed. This collection of data will continue for the next three years.

Results to date suggest that effluent from the pipeline as presently designed adequately disperses. Triomf has, however, been operating at a low level. Highlights include the poor benthic fauna numbers and diversity recorded in the sediment samples collected around 1980 - 81, attributed to the excessive dumping of dredge spoil, and the subsequent improvement that has resulted from dumping being diverted away from the study area. Severe changes in sandy beach meiofauna were also attributable to dumping of dredge spoil on the beaches. An interesting feature of the neuston net samples of egg and fish larvae was the high number of anchovy eggs encountered during winter sampling cruises.

#### PESTICIDE STUDIES IN THE NATAL MARINE ENVIRONMENT

Researchers : B D Gardner, A C Butler and R R Sibbald  
 Organization : NIWR  
 Duration : 1975 - ongoing  
 Funding : SANCOR, NIWR, Shell SA, Durban Corporation

The Natal laboratory of NIWR has concentrated its efforts on the chlorinated hydrocarbons in the marine environment. The main reasons for this have been:

- a) These pesticides were causing concern at the time when the research began and judging by the recent reaction to dieldrin, still do.
- b) They appear to be the only group that is long lasting in the environment.
- c) With the electron capture detector we have the means of detecting extremely low concentrations.

The most persistent pesticides that we have been able to identify have been DDT (mainly DDE with some TDE), Dieldrin, PCB's and some Lindane. PCB's are a mixture of chlorinated biphenyls but the trace we have found in the environment most closely resembles Arochlor 1260 (i.e. 60 % chlorinated). We have therefore standardized on this compound mixture and report PCB's found relative to 1260.

In the environment we have measured pesticides in everything from water to mammals. The CHC's are almost totally insoluble in water and extremely soluble in organic solvents, thus in animals they tend to accumulate in the fatty tissue. They also tend to be accumulated up the food chain. Therefore, since mammals, especially sea mammals, have large layers of fat and are at the top of the food chain, they would be expected to have the highest concentrations.

The pathway through the food chain is not the only one. Pesticides are also rapidly adsorbed through the skin. In our laboratory we found that fish accumulated more than 100 times the concentration in the water in

less than 24 hours. In the environment we found that mullet often had far higher concentrations of pesticides than their fish predators. We suspect that this is partly because they swim very close to the surface, often moving through the surface micro layer. It is evident that most of the pesticide in the water is in this micro layer.

In our survey of the South African beaches and estuaries we found the levels in fish and crustacea to be low. No pesticides were found in water, and only at Kosi were any pesticides detected in sediments. However, we did find higher levels of pesticides near the major centres such as Durban, Port Elizabeth, East London and Richards Bay. At Kosi the elevated levels reflected the spraying of mosquitoes with DDT. A later survey of the area showed a dramatic decrease in pesticide levels, but that survey was made just after winter when possibly spraying was less active. It did show, however, that pesticides were not accumulating in the area. Other evidence of this was that the DDT found earlier had been mainly in the form of the parent product DDT rather than the more stable metabolite DDE which is usually found when DDT has been accumulating for some time. DDE is usually the main product found in birds and sea mammals.

Relatively high concentrations of pesticides have been found in sea mammals, sea birds and their eggs. Levels in birds' eggs and cats on Marion Island were far higher than levels in mullet from Natal estuaries. However, levels in birds' eggs from the South African coast were up to 10 times higher than levels in eggs from similar birds on Marion Island.

#### Future Direction

- a) Surface layer studies, especially in estuaries and rivers. These may help to find the path-way of pesticides in the environment.
- b) Repeat investigations of the major estuaries to check whether levels have decreased.
- c) Repeat investigations of birds' eggs, especially those from St Croix and islands around the Cape West Coast.
- d) Repeat surveys of seals in the Cape to compare levels with those found by John Henry about 15 years ago.

**BACTERIOLOGICAL SURVEYS MONITORING THE SEA AND BEACHES IN THE VICINITY OF DURBAN**

Researchers : D J Livingstone and M Calder  
Organization : NIWR  
Duration : 1964 - ongoing  
Funding : Durban Corporation and NIWR

**SUMMARY**

Prior to the construction of the submarine outfalls (in 1968/9) sewage was disposed of at Durban harbour mouth with outgoing tides, and there were approximately 100 'stormwater' drains (some illegal), 33 of which were contaminated with sewage.

A system of evaluating seawater quality evolved from the work using *Escherichia coli* I, parasite ova, staphylococci, salmonellas (including *Salmonella typhi*), and salinity. The bacteriological background was established, using this system, against which future changes resulting from development could be measured.

The coastline sampled stretches from the Mgeni to Isipingo. The surveys have proved valuable in assessing changes in outfall and the sludge experiment, in pinpointing contaminative foci, and - depending on future developments (e.g. changes on shore, sludge dumping by barge, a third submarine outfall, etc.) - should prove to be of equal value in the future. The findings are also proving useful in assessing changes in coliform methodology.

Durban's tourist industry is worth approximately R 600 million p.a. with a multiplier factor of three; and tourists, of whom approximately 10 % are from overseas, number 1,25 million annually. The City is therefore understandably concerned about maintaining health standards on its beaches.

**SEA DISPOSAL OF SEWAGE : ENVIRONMENTAL SURVEYS IN THE DURBAN OUTFALLS REGION (THE SLUDGE EXPERIMENT)**

Researchers : D J Livingstone, M M Calder, D D Airey, A D Connell, E A Lord, T P McClurg, R R Sibbald, R C Stanton, K S Russell, W A M Botes, F C Els, M L Grundlingh and G Toms

Organization : NIWR, NRIO

Duration : 1980 - 1988, possibly longer

Funding : Durban Corporation and NIWR

**SUMMARY**

Five stations of the existing grid of sea stations around the diffuser section of each outfall, 11 Bluff beach sampling stations, and one station in between were selected for regular and intensive examination, along with the effluents from the respective Works. Disciplines involved were bacteriology, virology, benthic macrofauna, toxic metals, chemistry, chlorinated hydrocarbons, effluent toxicity, ocean currents in the vicinity of the outfalls, and computer modelling. During the sludge-discharge period of the experiment, sludge mixed with settled sewage was pumped from the Central Works for 12 months, while the Southern Works outfall - acting as a control - discharged only settled sewage. During the second 12 months of the programme, the roles of the two pipelines were reversed.

The experiment indicated that no pollution of the beaches, and no deleterious effects on the quality of the seawater or on the marine life resulted from the modified discharges.

Back-up investigations (apart from the ocean-current and modelling work) are continuing, while the chlorinated hydrocarbon testing programme has been extended to provide more detail on the distribution of dieldrin in mussels and fishes on Durban beaches and in the harbour.

**POLLUTION SURVEYS**

Researchers : T P McClurg and all NIWR marine staff

Organization : National Institute for Water Research

Duration : Long-term

Funding : Contracts with industry/NIWR

Two of the main discharges into the sea off Natal, notably the Durban and Richards Bay pipelines, are the subject of detailed studies. However, a number of other discharges have a potential impact on the Natal marine environment and have been an on-going concern of the NIWR, some of them for over 20 years. These include Mondi Board Mills (Felixton), AECI (Umbogintwini), S A Tioxide (Umbogintwini), SAICCOR (Umkomaas) and Smithchem (Sezela).

The nature and extent of NIWR involvement are dictated largely by requirements of the Department of Water Affairs, who regulate marine discharges through the issue of permits. Issue or renewal of a permit may require a survey, which the NIWR may undertake on contract. The surveys are generally concerned with environmental impact assessment and usually entail toxicity studies, chemical analysis of the effluent and receiving waters, and faunal surveys to detect community changes. The national marine pollution database (at NRIO, Stellenbosch) provides data for comparison and assessment, while data generated by these surveys serve to expand and update the database.

Surveys of this nature are considered to be an important practical implementation of the marine pollution expertise which exists at the NIWR in Durban. However, this type of survey usually has an element of urgency and requires a streamlined approach. This, together with possible contractual confidentiality, can result in the generation of data which may serve a practical purpose yet be unpublishable. This is not a healthy state of affairs in a scientific environment where progress is being increasingly judged on the basis of publications.

It is envisaged that these pollution surveys will continue for as long as there are questions to be answered on environmental impact. However, the need to augment the surveys to render them publishable must be addressed.

#### STUDIES ON SPECIFIC TOXIC METALS IN POLLUTED AREAS ON THE NATAL COAST

Researchers : T P McClurg, R C Stanton, E A Lord and D A Lord  
 Organization : NIWR, University of Port Elizabeth  
 Duration : To 1988  
 Funding : SANCOR, NIWR

Surveys of the east coast between 1974 and 1984 revealed that, with a few specific exceptions, the sea off Natal is relatively unpolluted by toxic metals. It was decided that future effort should be directed at gaining a broader understanding of the few instances where metals might pose a threat to the marine environment. Of immediate concern was the presence of elevated mercury concentrations in the nearshore zone at Umbogintwini and its accumulation by mussels. Stricter measures by AECI have reduced the quantity of mercury reaching the sea and its accumulation by *Perma perna* now appears to be within acceptable limits.

Two aspects of toxic metal pollution are currently receiving attention:

1. Metals in Durban Bay. Analysis of sediments from Durban Harbour showed very high concentrations of certain elements. The question arose as to whether these elements are bound relatively inertly to the substrate or whether they are biologically available and, therefore, potentially damaging to biota. To obtain a measure of bio-availability the soft tissues from a sample of oysters (*Pyenodonta*), taken from Durban Bay, were analysed for toxic metals. The results were compared with



those for oysters taken in the open sea (Aliwal Shoal and Landers Reef). Only lead and chromium showed no significant differences. Mercury, zinc, iron and manganese were significantly higher in the harbour oysters, whilst copper, cadmium, cobalt and nickel were significantly higher in the open sea oysters. Further work, entailing a transplant of oysters from the open sea to Durban Bay will attempt to resolve this curious finding.

2. Copper in the offshore environment at Richards Bay. Ore processing by Triomf at Richards Bay results in a copper-rich effluent which is being discharged to sea in combination with paper mill effluent and sewage. It was projected that the final concentration of copper reaching the sea could exceed the recommended maximum of  $5 \text{ ug l}^{-1}$  by an order of magnitude. At the same time it was recognised that the presence of particulate organics might reduce the toxicity of the copper by binding it into relatively inert complexes. A study is being made of the fate and effects of copper emanating from the Richards Bay outfall. Initial emphasis is on measuring concentrations of copper in the sea off Richards Bay and in determining in what form the copper exists (dissolved/particulate, labile/chemically stable). Thereafter the study will concentrate on assessing its biological impact through laboratory toxicity experiments and a field bio-accumulation study.

#### OIL POLLUTION INVESTIGATIONS ON THE NATAL COAST

Researchers : R R Sibbald, A C Butler and B D Gardner  
 Organization : National Institute for Water Research  
 Duration : 1982 - 1985  
 Funding : SANCOR, Shell S A, NIWR

#### SURFACE MICROLAYER

Levels of petroleum hydrocarbons in the ocean surface microlayer off Richards Bay were investigated. Of six surface microlayer samples, five showed the presence of petroleum hydrocarbons and two of these appeared to comprise the same oil. All petroleum found appeared to be marine fuel distillate, while the presence of measurable levels of n-alkanes suggested that the oil had not been present for a sufficient length of time to effect marked biodegradation. The apparent absence of crude oil in the samples was an indication that tanker ballast discharges and washings exerted no influence in the region at the time of sampling.

A notable feature of the results was that they were often orders of magnitude higher than values noted in the literature. This fact is probably due to the sampling technique we employed.

## SATURATED AND POLYCYCLIC AROMATIC HYDROCARBONS IN MUSSELS

A method for the isolation and GC determination of saturated hydrocarbons and PAH's was developed by A C Butler. Spiked mussel samples were processed and recovery percentages ranging from 78 % to 111 % for the saturated hydrocarbons were obtained, while the PAH's yielded recoveries ranging from 28 % to 84 %. A set of mussel samples from stations along the Bluff showed increasing levels southward towards the Umlaas and Reunion Canals, although characteristics of the extracts suggested that at these two canals the oil was from two different sources.

## FLUORIDE DISCHARGE INTO MANGROVE AREAS - PROBABLE CONSEQUENCES

Researchers : P Berjak, D J Mycock and C A Frankland  
 Organization : University of Natal, Durban  
 Duration : 1982 - 1983  
 Funding : FRD, Department of Agriculture and Water Supply

Some effects of dissolved fluoride on the establishment and growth of the two most common mangrove species of the Natal coast have been evaluated in view of the increasing offshore discharge of this potentially toxic pollutant.

Young plants of *Avicennia marina* (Forssk.) Vierh., were found to be tolerant to substrate fluoride levels as high as 50 p.p.m. because it can translocate and excrete the halogen. On the other hand, the growth of *Bruguiera gymnorhiza* (L.) Lam., which does not possess a salt-excretion mechanism, was severely retarded. This species accumulated far higher levels of fluoride than *A. marina*, resulting in gross cellular and sub-cellular abnormality.

Because of the different responses of *A. marina* and *B. gymnorhiza* to fluoride, a probable consequence of the discharge of this pollutant into a local mangrove area is the ultimate conversion of the swamp into a monospecific *A. marina* stand. It is unlikely that *Rhizophora mucronata*, a local species closely related to *B. gymnorhiza* and with a similar (non-excretory) salt-tolerance mechanism, is fluoride-tolerant. The change of a swamp into a mono-specific stand could have an effect on those components of the mangrove fauna largely dependent on rhizophoraceous leaf litter in general, or that of *B. gymnorhiza* in particular (eg. the grapsid, *Sesarma meinerti*), as well as on detritivores, thus bringing about changes and possibly a general reduction in species diversity.

Mangrove regions are noted for their high productivity, and are important as habitats for invertebrates and the juvenile forms of many marine fish. The accumulation of fluoride by plants, tolerant or otherwise, makes this ion more available to certain animals (e.g. amphipods, which are directly affected by dissolved fluoride) and would also have deleterious consequences for sensitive species at the lower levels of the food web. In addition, a concentration of the element through tolerant animal species could occur, to the detriment of sensitive predator species.

**RICHARDS BAY: OCEAN OUTFALL STUDY**

Researchers : J Zwamborn and G Toms  
Organization : NRIO  
Duration : Completed  
Funding : Engineering Consultants and CSIR

The contractors for the Richards Bay ocean outfall had suggested the use of flexible polypropilene pipelines based on the Scandinavian Design Practice (SDP). As the forces calculated according to the SDP differed from those reported by NRIO, the calculations as well as the seabed anchorage of the flexible pipeline were revised and a preliminary report prepared.

Following discussion of the report with the engineering consultants, a contract investigation was undertaken by NRIO and the consultants to determine the expected wave forces on and movements of the pipeline as laid. As part of this contract Prof I Larsen of the Royal Swedish Institute of Technology visited NRIO to install a program for calculating movements of the pipeline on the CSIR computer. The program was subsequently amended to allow direct calculation of pipeline displacement, using the Vocoidal Wave Theory. The amended program was used to determine anticipated movements and tensions along the pipeline under design conditions, using accepted coefficients of friction. The results are contained in a preliminary report.

At the request of the Department of Environment, comments were given on various changes in the nature and volume of the effluent, and there will be further consultation from time to time.

**ESTUARIES**

**RAPPORTEUR'S COMMENTS**

A E L Ramm

**MONITORING THE CONDITION OF NATAL'S ESTUARIES**

A E L Ramm, E C Cerff and T D Harrison

**CONTROL OF *Phragmites* GROWTH IN THE SIYAYA LAGOON BY MECHANICAL VS. CHEMICAL METHODS**

A E L Ramm, E C Cerff and T D Harrison

**DEVELOPMENT OF A DEGRADATION INDEX FOR RANK ORDERING NATAL'S ESTUARIES**

A E L Ramm, E C Cerff and T D Harrison

**ECOSYSTEM CHANGE IN RELATION TO THE HYDROLOGICAL REGIME OF LAKE ST LUCIA**

R H Taylor and S McLean

## ESTUARIES

Rapporteur's Comments : A E L Ramm

### GENERAL

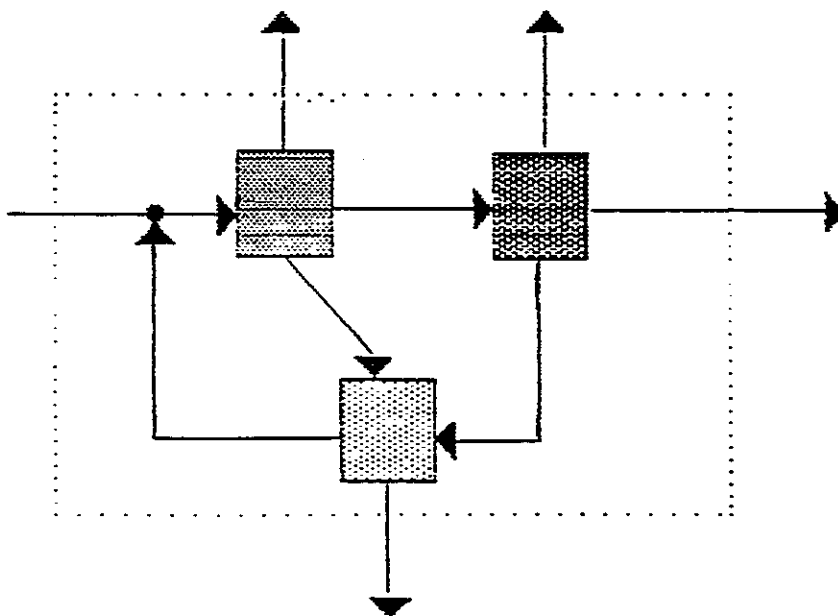
On the first day of the symposium 21 papers were presented on the subject of estuaries and mangroves. It should be noted that these only included papers of a biological nature which did not fit into the other categories, such as physical and geological studies.

### UNDERSTANDING SYSTEMS

Before examining the scope of studies which are currently being conducted, we might gain some perspective by looking hard at the fundamental questions we ask when studying any natural system.

A system can be defined as a *set of components* which are *interrelated* and *form a unit*.

A generalized system is illustrated below:



The boundaries of natural systems are often indistinct, and movement of energy and materials occurs across boundaries. This is why the boundary in the illustration is represented as a dotted line. While we recognize the artificiality of imposing boundaries on natural systems, it is a convenient way of defining the system's limits, a practical necessity for research studies.

Whenever we seek an understanding of natural systems we may ask three fundamental questions:

1. What is the current state of the system components?

This question usually involves measuring the components. Biomass of herbivores, standing stock of fish, stand density of vegetation, and concentration of total phosphorus are examples of such measurements.

2. How are the components interrelated?

Feeding behaviour, chemical reactions, and sediment transport processes are examples of component interactions.

3. How does the system change with time?

Natural systems of significance are never at a static steady state. Nutrient concentrations in coastal waters, fish populations, and the geology of river basins all change with time. A fundamental endeavour of science is to gain an understanding of system behaviour, often with a view to predicting the future states of a system.

The above three questions are as fundamental to an understanding of estuary systems in Natal as they are to any scientific inquiry. Let us keep them in mind as we summarize the current research.

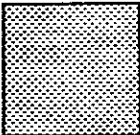
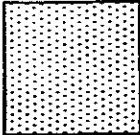

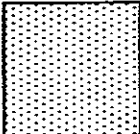

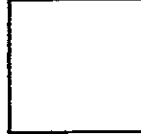
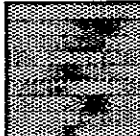

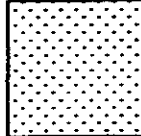
TABLE 1 - ORGANIZATION OF BIOLOGICAL STUDIES -ESTUARIES

		STRUCTURAL	FUNCTIONAL	TEMPORAL
LEVEL OF ORGANIZATION	INDIVIDUAL	taxonomy morphology anatomy	physiology behavior genetics	acclimatization
	POPULATION	demography biogeography habitat/niche	competition predator-prey social behavior	genetic drift speciation
	COMMUNITY	community structure	energy flow materials cycling	community succession

SUMMARY OF CURRENT RESEARCH

The scope of the 21 studies reporting on estuaries ranges from identification of algal epiphytes of mangroves to analyses of St Lucia ecosystem dynamics. Table 1 is an attempt to organize and categorize the studies reported on here.

TABLE 2 - COVERAGE OF CURRENT RESEARCH - ESTUARIES

	STRUCTURAL	FUNCTIONAL	TEMPORAL
INDIVIDUAL			
POPULATION			
COMMUNITY			

In this table biological studies are organized into three traditional levels: the individual, the population, and the community. These categories are represented as rows in the table. Biology has been further organized into studies of structure and studies of function. These are the first two columns in Table 1. In addition, a third column ("temporal") has been added, which represents studies which focus on changes in the structure and/or function of biological systems. Within each cell of the table are some examples of representative biological science.

I have attempted to classify the 21 studies on estuaries on the basis of this table by shading each cell relative to the number of current studies falling into its respective category. In some cases studies do not fall clearly into one cell, but are spread among cells. I have allowed for this by putting "fractions" into appropriate cells. This exercise is obviously subjective, but it does provide a broad overview of the character of current research. This is represented in Table 2.

The pattern which emerges from this summary indicates that current research is reasonably well represented by structural and functional studies at all three levels of organization. This does not necessarily imply that each area is well covered, but simply that all of the areas are covered. The pattern also indicates that virtually no studies are being conducted under the "temporal" category.

This conclusion can be rephrased in terms of our earlier discussion on natural systems and the fundamental questions of science. While we are conducting research to determine the current state of estuaries (question 1), and the interactions among the components of these systems (question 2), we are not conducting research to determine how these systems behave over time (question 3). This is an important observation.

Many of the practical concerns regarding Natal's estuaries involve long-term changes in these systems. It is generally accepted that many of Natal's estuaries have degraded significantly in the past 50 years. It is also generally assumed that human influences are largely responsible for this degradation. Yet we know very little about the 'normal' ageing processes (succession) of our estuaries, and are doing virtually no research to develop such an understanding. It is vitally important for management purposes to distinguish between naturally occurring changes and human influences.

It is also worth noting that there is little interaction between estuarine researchers. Many of the participants in this symposium admitted they were unaware of the scope of research being conducted. This is especially true where the researchers are from different disciplines.

#### CONCLUSION/GAPS

- The scope of research on Natal's estuaries and mangroves is broad and covers structural and functional aspects at the individual, population and community levels of organization
- There is virtually no research being conducted which focuses on an understanding of long-term patterns of change and the mechanisms responsible for producing change in Natal's systems.
- There is little interaction between the various investigators. This isolation is especially acute among different scientific disciplines
- Sediment-water interactions are poorly understood, are important, and research in this area must involve the participation and cooperation of physical and biological disciplines.



## MONITORING THE CONDITION OF NATAL'S ESTUARIES

Researchers : A E L Ramm, E C Cerff and T D Harrison  
Organization : Estuary and Coastal Processes Division, NIWR, CSIR  
Duration : 1984 - 1989  
Funding : NTRPC, NIWR

### OBJECTIVES

To develop suitable methods of monitoring Natal's estuaries and to characterize changes now and in the future.

### BACKGROUND

Monitoring Natal's estuaries was first conducted on an extensive basis by G Begg in the period 1978 - 1981. Begg's studies were conducted exclusively with a specially designed one-meter beam trawl. This gear was a logical choice for his work, considering the constraints of his project. The biological results of the surveys were analysed using an ordination procedure (DECORANA). From this analysis, Begg developed a classification system of Natal estuaries based on community composition.

### RESEARCH APPROACH

Biological surveys of the Natal estuarine systems were begun routinely in February 1985. By estuarine systems we refer here to all systems classified by G Begg (1984) as estuaries, lagoons, and rivermouths. In an effort to sample the systems more efficiently, we have adopted the use of a variety of gear, as well as the one-meter beam trawl. In this manner comparability to the previous Begg surveys could be achieved, without compromising a representative, efficient survey programme. A sampling-gear comparison study has been initiated in order to evaluate the comparability of our methods with previous methods. A survey schedule for the estuaries has been established, with allowance for repeating selected systems as necessary. To date, 48 systems have been sampled, resulting in a total of 201 discrete collections. A computerized data-base and associated application software has been developed for storing, sorting, summarizing, analysing and comparing collection data. A library of over 1 000 reference articles and books, as well as maps and aerial photographs of the Natal coast and portions of the Transkei coast, has been developed. A set of colour stereo aerial photographs at a scale of 1:5 000 was obtained in July 1985, and is being incorporated into the library. All library materials are being entered into the computer database to facilitate access.

### FINAL PRODUCTS

As the programme progresses, changes in the estuaries since Begg's surveys should be measurable, although the causes of change may be obscure. This is due to the fact that the previous surveys were conducted during a period which was climatically much drier than at present. We will be able to begin to address these questions when sufficient data from the surveys are available, which should be within approximately one year.

**CONTROL OF *Phragmites* GROWTH IN THE SIYAYA LAGOON BY MECHANICAL VS. CHEMICAL METHODS**

Researchers : A E L Ramm, E C Cerff and T D Harrison  
Organization : Estuary and Coastal Processes Division, NIWR, CSIR  
Duration : 1986 - 1987  
Funding : NTRPC, NIWR

**OBJECTIVES**

To investigate means of controlling encroachment of *Phragmites* in Natal estuaries, and the potential environmental effects of possible control measures.

**BACKGROUND**

Earlier this year, following a survey of the national and international literature, we determined that 'Roundup' (Monsanto Corporation's formulation of the isopropylamine salt of glyphosate) would be a promising herbicide for *Phragmites*. Roundup is a non-selective systematic herbicide which is increasingly being used for control of perennial weeds in vegetable crops, orchards, in industrial areas, and in conifer plantations and reforestation areas. It has been shown to exhibit relatively low toxicity to a variety of aquatic plants and animals. It is biodegraded rapidly in the environment, does not appear to form toxic breakdown products, and has already been shown in one study to be effective at low dosages for *Phragmites* control in marshlands.

**RESEARCH APPROACH**

Our preliminary concept is to establish small blocks within the *Phragmites* beds in the Siyaya estuary. Controls and treatments (both mechanical and chemical) will be allocated among the blocks to measure the relative effectiveness of treatment, cost, and environmental impact of each treatment. Two forms of mechanical treatment are proposed. In the first case, all *Phragmites* will be removed within each block by cutting below the water surface. In the second case, all plant material, including as much root and rhizome mass as possible, will be removed. Chemical treatment will consist of application of Roundup via aerial spraying to the stems and leaves at a rate of 1 kg/acre. This amount has been shown to be effective in previous trials. Every effort will be made to minimize carry-over of herbicide to the water surface. It should be noted that in field experiments conducted in Canadian ponds, no significant toxicity to *Daphnia magna* populations was observed at direct application rates of over 100 kg/acre. Effectiveness of treatment will be measured by stand density and regrowth rates in all blocks. Glyphosate residual concentrations will be monitored in the water column in all blocks treated with herbicide, and in adjacent blocks. Although not a direct measure of toxicity, this will provide an estimate of potential toxicity. Dissolved oxygen concentrations will be measured within the water column in all blocks. This will provide a general indication of the physiological stress on the aquatic fauna associated with the *Phragmites*, as related to treatments.

## FINAL PRODUCTS

The above approach will provide valuable information on which to base an assessment of the relative effectiveness and general impact of *Phragmites* removal. We consider this the minimum level of effort for a first attempt at addressing the question of *Phragmites* control in Natal estuaries. While many questions will remain unanswered, we feel that this constitutes a level of effort which is reasonable given the manpower and time available.

We would fully expect that the results of this cooperative effort will suggest further studies of a more comprehensive and detailed nature. However, we believe it is premature to propose such studies until the above information can be obtained, analysed, and interpreted.

## DEVELOPMENT OF A DEGRADATION INDEX FOR RANK ORDERING NATAL'S ESTUARIES

Researchers : A E L Ramm, E C Cerff and T D Harrison  
Organization : Estuary and Coastal Processes Division, NIWR, CSIR  
Duration : ongoing  
Funding : NTRPC, NIWR

## OBJECTIVES

To develop and apply a numerical method of measuring community degradation which can be used for assessing and managing Natal's estuaries.

## BACKGROUND

An index method has been developed which condenses biological community data into a form which can be readily understood and used by the water resource planner. The concept and mathematical expression of this community degradation index (CDI) is new. A major advantage of the CDI methodology is that no subjective decisions need be made regarding the sensitivity of a particular species or biological assemblage to a pollutant or mix of pollutants. The CDI has been applied to fish community data collected from the Cuyahoga River, Ohio (USA). The close agreement between community degradation as expressed by the index and field observations of the river, provides strong justification for the use of the CDI as a measure of habitat degradation.

## RESEARCH APPROACH

We are presently attempting to build upon the above index method. If successful, this effort will result in a ranking of the degree of degradation of Natal estuaries on a scale of 0 to 10. Discussions have been held with biologists from UN, the University of Port Elizabeth, and with staff of NRIO. Although still in a very preliminary stage, the results of our efforts to date appear encouraging. It is felt that such an index would provide a more objective input to estuary ranking than has previously been the case. It would also serve as an input to necessary decisions regarding future development along the Natal Coast.

## FINAL PRODUCTS

It is possible that the coupling of this concept, the use of *Phragmites* (reeds) cover values for estuarine monitoring, and certain aspects of river hydrologic theory, may lead to a measure of "Remaining Life" for coastal rivers. We have discussed these possibilities with Sediment Dynamics Division personnel at NRIO and have prepared a joint statement of our preliminary ideas for NTRPC.

## ECOSYSTEM CHANGE IN RELATION TO THE HYDROLOGICAL REGIME OF LAKE ST LUCIA

Researchers : R H Taylor and S McLean  
 Organization : NPB  
 Duration : 1984 to 1989  
 Funding : NPB, SANCOR

## OBJECTIVES

To characterize biotic changes (temporal and spatial), which occur with changing salinity and water levels at an ecosystem level.

## BACKGROUND

St Lucia is the largest estuarine and coastal lake system in Southern Africa, and is one of South Africa's more important conservation assets. Its natural processes are being affected by changing land-use patterns, and it is therefore necessary to manage the system to alleviate some of the adverse influences. It has been recognized that it is essential to have a basic understanding of how the ecosystem functions in order to manage it effectively. Up until now, virtually all the research work that has been conducted in the area has been directed at specific aspects of the ecosystem. This project is being conducted to integrate the findings of previous research and monitoring projects in order to elucidate the changes which occur in the ecosystem functioning as hydrological conditions fluctuate.

## RESEARCH APPROACH

The main hypothesis being tested is that the structure of the food chains changes in response to changing salinity. To achieve this I have been accumulating as much historical data as possible (from other research workers and from the routine monitoring programmes). These data are being analysed to detect trends which can be related to changing water levels and salinity.

Where there are major gaps in data, the existing monitoring programme has been expanded to be able to fill these voids.

Detailed work will be carried out on the benthic fauna, as they are likely to be the main indicators of lake condition.

A conceptual model of ecosystem functioning, based on an understanding of ecosystem changes, is being developed. This model will be used to explain the effects of various management options.

#### FINAL PRODUCTS

1. Synthesis documents
  - 1.1 In the form of papers relating to each main component. These will be submitted for publication at regular intervals during the project.
  - 1.2 Conceptual model and final summing up documents. These will be published after completion of the project.
2. A monitoring programme will be designed, and implemented in phases, during the project.
3. Future research needs will be identified during this project and studies which will provide feed-back for this project will be implemented. Other future research will be planned for implementation at the end of this project.
4. Management implications emanating from this project will be submitted to the Natal Parks Board and will be incorporated into the management programme at its completion.

**AQUACULTURE**

RAPPORTEUR'S COMMENTS : J W D Turner

FISH AND COLLOID PRODUCTION IN EFFLUENT FERTILIZED PONDS  
J W D Turner, R R Sibald and J Hemens

**DOLPHINS AND TURTLES**

RAPPORTEUR'S COMMENTS : D A Melton

DOLPHIN RESEARCH  
D A Melton

NATAL CETACEAN DYNAMICS  
V M Peddemors

THE INFLUENCE OF TEMPERATURE ON THE SEX OF *Caretta caretta*  
J A Maxwell and G H Frank

TONGALAND SEA TURTLE RESEARCH PROGRAMME  
G R Hughes

**DATA CENTRE**  
N M Walters

## AQUACULTURE

Rapporteur's comments : J W D Turner

No marine aquaculture research on the Natal/KwaZulu coast is at present being undertaken. Future research should be guided by the following limitations:

1. As the Natal coastline is a 'high energy' area no 'open sea' ranching is feasible at this stage
2. Estuaries are sensitive areas, ecologically and socially, and their use for aquaculture is usually limited by predators which are difficult or impossible to control
3. Flat areas near seawater, e.g. Richards Bay Southern Sanctuary and St Lucia Estuary, are prone to severe flooding. Furthermore, St Lucia is a nature reserve
4. Suitable cheap food sources

As there are serious limitations to natural aquaculture sites on our coast, the alternative is to use seawater in controlled culture environments or to 'seed' natural systems with juveniles of over-exploited species.

Seawater must be transferred to the culture facilities. Due to relatively small tidal fluctuations, 'tidal pumps' are not thought to be feasible, making conventional pumping essential. To offset the cost of pumping, fairly high intensity aquaculture systems will have to be employed. These can be divided into two broad categories, i.e. 'fish' culture and 'algal' culture.

## FISH CULTURE

Marine prawns and possibly red tilapia are candidate species for intensive aquaculture. Extensive research has been done world wide, and the basic technology exists and can be modified to suit local conditions.

A number of fish species have been exploited. Research should be done on the breeding habits of these species and a 'seeding' programme instituted in an attempt to re-establish them.

## ALGAL CULTURE

South Africa imports large quantities of colloids annually. The major problem encountered, both locally and abroad, with the culture of macroalgae is contamination by unwanted epiphytes. Research to overcome this problem has been largely successful, but only with high energy inputs and therefore high costs. This area is certainly one that needs further attention as present supplies are becoming increasingly expensive.

**FISH AND COLLOID PRODUCTION IN EFFLUENT FERTILIZED PONDS**

Researchers : J W D Turner, R R Sibbald and J Hemens  
Organization : NIWR  
Duration : 1979 - 1983  
Funding : NTRPC, NIWR

Secondary chlorinated domestic sewage effluent was investigated as a fertilizer for the culture of selected algae and fish and prawn species in sea water ponds.

**ALGAL CULTURE**

The intention to culture red algae (*Gelidium amansii*, *Hypnea specifera* and *H. rosea*) for the production of colloids was thwarted by excessive epiphytic contamination, especially by *Enteromorpha* spp. As this problem could not be easily and practically overcome, the research was discontinued.

**FISH PRODUCTION**

Mullet (*Mugil cephalus* and *Liza macrolepis*) and tilapia (*Oreochromis mossambicus*, *Sarotherodon aureus* x *S. niloticus* hybrids and Red tilapia) were cultured at + 25 ppt sea water. While mullet were not suited, projected tilapia yields of 3,9 to 10 t ha<sup>-1</sup> 220 day<sup>-1</sup> were obtained.

**PRAWN CULTURE**

*Penaeus monodon* and *P. indicus* were investigated. Neither species performed satisfactorily purely on *in situ* primary production. However, with the addition of chopped tilapia protein supplements (produced in similar ponds) a projected yield of 1,05 t *P. monodon* was obtained.

**HEALTH ASPECTS**

Effluent, pond water, sea water and fish and prawn flesh samples were analysed for bacterial and viral quality and for heavy metal and chlorinated hydrocarbon pesticide accumulation. Both fish and prawn were found to be suitable for human consumption.



**DOLPHIN RESEARCH**

Rapporteur's comments : D A Melton

We now know to a large extent what species can be expected to occur off the Natal coast. Recent research (Ross, Cockcroft and Melton, 1985) will provide better distribution and abundance data for some species, and should lead to recommendations concerning appropriate methodology and frequency for monitoring dolphins.

Likewise the work of G Ross and V Cockcroft is providing much information on the basic biology of the more common species from strandings and particularly shark net mortalities. This work should also progress into a lower level monitoring phase, with safeguards that rarer species are not neglected.

The main new thrust at present is integrated field work from sea, shore and air. Much of this research will be a routine development based on studies elsewhere, and will involve the following: movements (individually recognizable animals and telemetry); group structure and dynamics; aspects of population dynamics; aspects of behaviour; and habitat utilization.

Areas which will be problematic or of particular interest are as follows:

1. Quantification of the habitat and particularly food resources to allow meaningful area utilization analysis will be difficult. Assistance/integration with researchers working on fish, bottom conditions and pollution will be necessary.
2. Suitable telemetry systems need to be developed, although it may be decided that this field of research is not a priority at present.
3. It will be important for feeding and density data to be translated into terms that allow the importance of dolphins as top predators to be evaluated.
4. Although some postgraduate studies are planned, it seems likely that most work is better suited to routine monitoring by a marine mammalogist working full time on the coast. The creation/filling of this post should be a priority.
5. Experimentation by NSB and collaborators with techniques to alleviate mortalities of dolphins in shark nets should be continued and developed.

**DOLPHIN RESEARCH**

Researchers : D A Melton and others (see below)  
 Organization : Zoology Department, UN, PMB  
 Duration : 1984  
 Funding : Various (see below)

**RECENT/ONGOING PROJECTS**

The following is a list of projects for which I am supervisor and/or co-researcher:

1. Population estimates of inshore dolphins off S E Africa using aerial census techniques. G Ross, D A Melton, V Cockcroft, 1985. Funding: SANCOR. Data are still being analysed from this first detailed extensive survey.
2. Studies on the biology of three inshore dolphins from strandings and shark net catches. V Cockcroft (Ph.D. study) 1983 - ongoing. Funding: full time employee Port Elizabeth Museum and University Research Fund.
3. Factors affecting the numbers, distribution and shark net mortality of three inshore dolphin species off the Natal South Coast. W Taylor (B.Sc. Hons project) 1985. Funding: UN.
4. Area utilization and group dynamics of dolphins off the Natal north coast. H Richards (B.Sc. Hons project) 1985. Funding: UN.
5. Ecology and conservation of bottlenose dolphins off the Natal coast. H Richards (M.Sc.) 1986 - ongoing. Funding: private sponsorship, applications to University Research Fund and Endangered Wildlife Trust (EWT).

Until projects 3 and 4 started in 1985 virtually no field research had been undertaken on dolphins off the Natal Coast. Our group's aim is to rectify this situation using boat, land and aerial based observations. Emphasis in 1986 will be on project 5, with an additional study of hump-back dolphins starting if funding is obtained.

For bottlenose dolphins, distribution, density, group dynamics, habitat utilization and aspects of behaviour will be investigated. The work is an extension of project 4 and attention will be paid to the influence of man on dolphins in the coastal zone.

**NATAL CETACEAN DYNAMICS**

Researcher : V M Peddemors  
Organization : UN  
Duration : 1985 - 1988  
Funding : CSIR, EWT

The past year has seen the development of the Natal Dolphin and Whale Watch, an organization utilizing the layman to tentatively identify and report any cetaceans found along the Natal coastline. The "watchers" receive identification training in the form of either personal discussions or with pamphlets of whales and dolphins likely to be found along this coast. Data sheets plus any photographs are then returned by the "watchers". In conjunction with this, Greystone Enterprises have kindly assisted by donating helicopter time between Durban and Richards Bay on a regular basis. The John Rolffe Rescue Services' helicopter has been assisting to some extent with sighting data for the South Coast. It is hoped to gradually gain insight into dolphin school distribution and movements with a view to formulating a conservation strategy. Whale sightings will be used to determine frequency of occurrence along the Natal coast and, with photographic records, it is hoped to identify individual whales to determine their return cycle and possible calving rates.

In June this year a new project will commence, concentrating on determining the population size, distribution and group dynamics of the humpbacked dolphin, *Sousa plumbea*. This species has been listed as endangered and, as a result of its close association with the extreme inshore part of the marine environment, is being negatively effected due to a variety of man-induced activities. This project will produce ecological data necessary to assess the conservation status of this species. Emphasis will be on a comparative approach between areas with varying human disturbance.

# WHALE SIGHTING FORM

NAME ..... TELEPHONE .....

ADDRESS .....

PLACE WHALES WERE SIGHTED .....

NUMBER OF WHALES SIGHTED .....

ACCURATE OR ESTIMATE .....

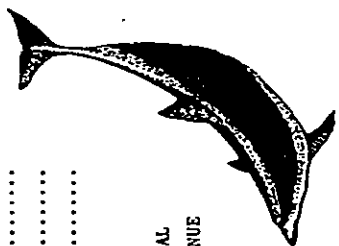
DISTANCE FROM SHORE OR POSITION AT SEA .....

DATE ..... TIME ..... WEATHER .....

POSSIBLE IDENTIFICATION (SIZE, COLOUR, HEIGHT AND SHAPE OF BLOW etc.) .....

OTHER INFORMATION (BEHAVIOUR, SWIMMING FORMATION, SPEED, DIRECTION, etc.) .....

- 1a NAME..... b ADDRESS.....
- 2 DATE.....
- 3 TIME.....h.....
- 4 LOCALITY.....
- 5 SIGHTING METHOD SHORE .. BOAT .. DIVING .. SURFING ..  
AERIAL .. OTHER .. (.....)
- 6 PREVAILING WEATHER CONDITIONS:  
a WIND DIRECTION: S.W.  N.E.  ONSHORE  OFFSHORE   
b WIND SPEED (knots): 0-5  5-10  10-15  15-20  >20   
c CLOUD PRESENCE: HEAVY  INTERMITTANT  LIGHT  NONE
- 7 WATER CONDITIONS:  
a TEMPERATURE: .....C  
b TURBIDITY (VIZ.): .....m  
c DEPTH: .....m  
d SURFACE: FLAT  SLIGHT CHOP  FEW WHITE CAPS  HEAVY   
BEAUFORT SCALE
- 8 DOLPHIN SPECIES: BOTTLENOSED  HUMPBACKED  COMMON   
SPINNER  OTHER .....
- 9 SCHOOL SIZE: SINGLE  5  5-10  10-20  20-30   
> 30   
MORE ACCURATE ESTIMATE .....
- 10 NUMBER OF CALVES: ESTIMATE .....
- ACCURATE .....
- UNKNOWN .....
- 11 DIRECTION OF TRAVEL: SOUTH  NORTH  OFFSHORE   
TOWARDS SHORE
- 12 DISTANCE FROM SHORELINE: .....m
- 13 BEHAVIOUR PATTERN: <sup>1</sup> PORPOISING AWAY FROM CRAFT   
SLOW SWIM  FEEDING  PLAYING   
OTHER .....
- 14 IDENTIFIABLE ANIMALS AND THEIR CHARACTERISTICS: .....
- 15 OTHER ANIMALS IN VICINITY: .....
- 16 COMMENTS .....
- 17 DIAGRAM: (please use other side if required)

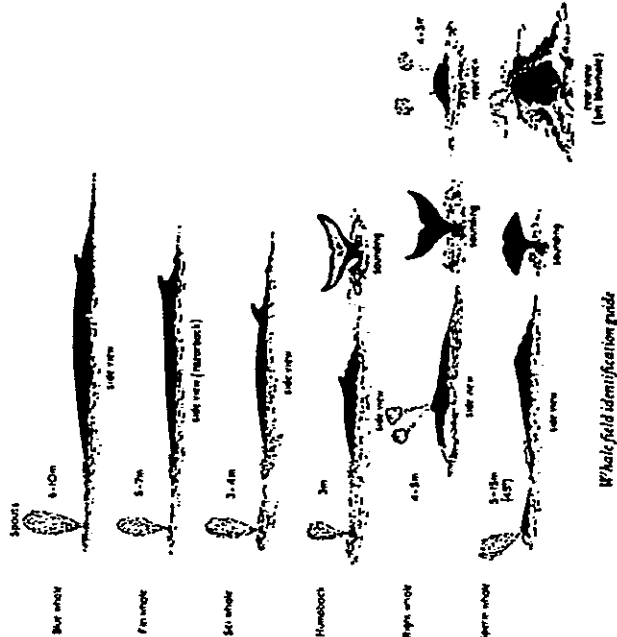


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Dept. Biological Sciences



Whale field identification guide

(see numbers)

**THE INFLUENCE OF TEMPERATURE ON THE SEX OF *Caretta caretta***

Researchers : J A Maxwell and G H Frank  
 Organization : UDW  
 Duration : 1983 - 1986  
 Funding : S A Wildlife Society, UDW

Recently it has been shown that sexual differentiation in many chelonians and crocodylians is temperature dependent. This has tremendous implication for marine turtle conservation, especially since current measures involve the translocation of eggs from natural nesting sites to protected nurseries elsewhere.

A field study was undertaken to establish the natural sex ratio. This indicated that males only were produced at the beginning of the season (cooler) and females only produced at the end of the season (warmer).

Current research is investigating the pivotal temperature under laboratory conditions by determining the sex ratios of hatchlings incubated at different constant temperatures between 27 °C and 33 °C. Sexual dimorphism of hatchlings is not apparent and sectioning of the gonads for microscopic examination is necessary. Indeed the use of differential staining techniques is required.

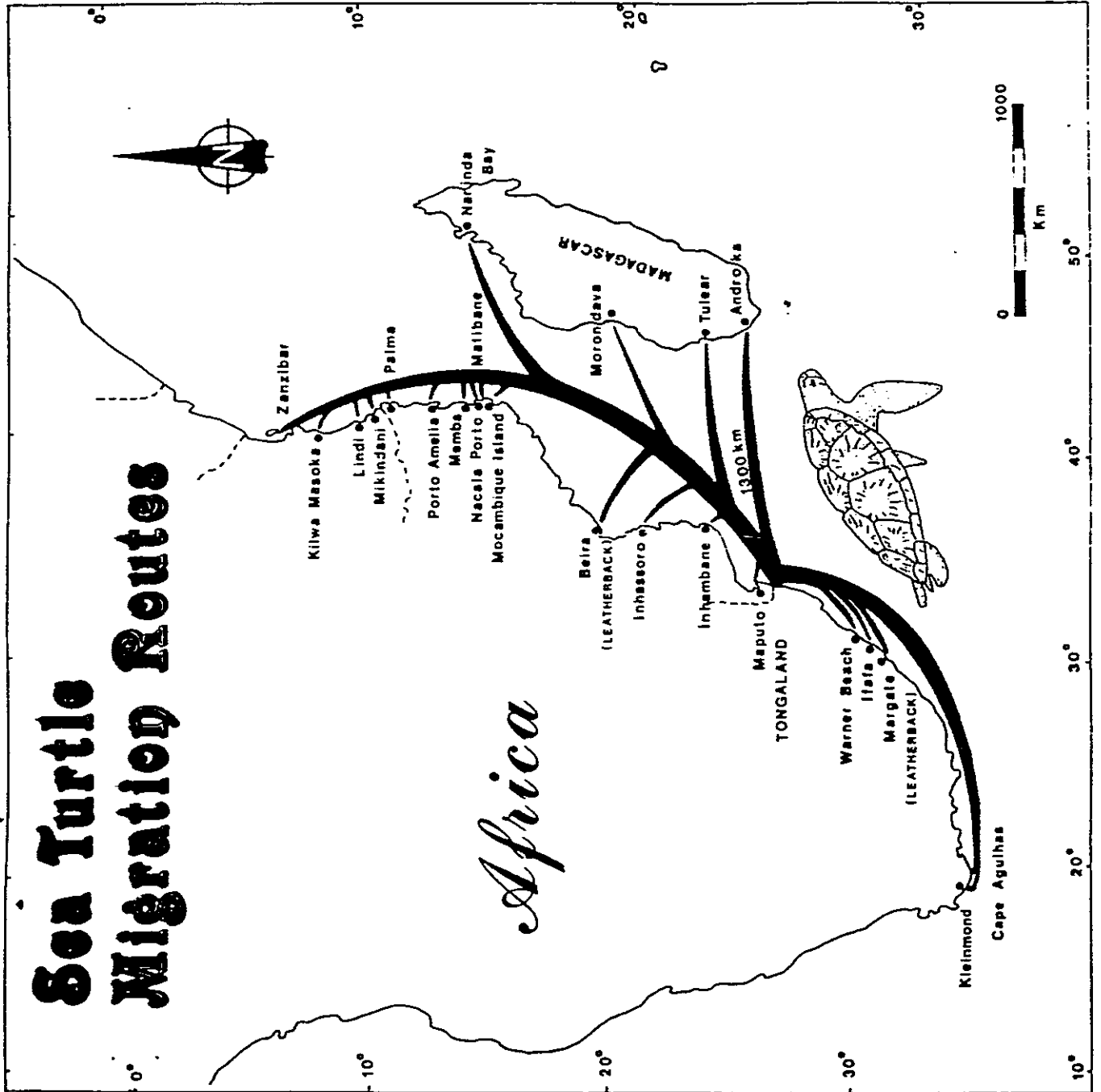
Simultaneously, staging of the embryos at the different temperatures is being carried out in conjunction with both light and electron microscopy (both SEM and TEM).

To understand the mode of action of temperature, it is necessary to pinpoint the sensitive stages (embryonic) for sexual differentiation of the gonads. To specify the critical periods in loggerhead turtles, temperature shifts during incubation are being made.

**TONGALAND SEA TURTLE RESEARCH PROGRAMME**

Researchers : G R Hughes and Staff of Natal Parks Board  
 Organization : NPB  
 Duration : Ongoing  
 Funding : NPB

This sea turtle research programme started in 1963 and during the first decade emphasis was placed on taxonomy and distribution of the two species nesting on the beaches of Natal. The main research tool was the monel metal tag and the movements and subsequent recovery of marked animals provided extensive information on long distance migrations (see fig. 1) re-migrations and inter-nesting intervals, egg production,



reproductive lifetimes etc., of the loggerhead turtle *Caretta caretta* and the leatherback turtle *Demochelys coriacea*.

Since 1969 research has continued in Tongaland but on a low key monitoring level. The metal tag (now Titanium) is still the main tool of operation and continues to provide a steady flow of information on reproductive lifetimes (up to 16 years for loggerheads; 14 years for leatherbacks), inter-nesting intervals, homing ability, etc., (Tables 1 and 2).

The marking of hatchling loggerheads (143 254 to date) to obtain data on dispersal, growth rates and ability to return to Natal beaches has been in progress since 1970 and continues this year. Marked hatchlings have been collected right down the South African Coast and from the Atlantic side of the Cape Coast.

Finally in Tongaland an egg translocation project to establish a new nesting nucleus, south of Sodwana Bay in the St Lucia Marine Reserve, has been carried out for the past four years. This was started in response to a suggestion that Kosi Bay will be developed as a harbour. The mouth of such a harbour would be in the heart of the loggerhead breeding grounds. To date 79 555 eggs have been translocated with a best hatching success of 74 % being obtained. Tests with a perforated plastic "basket" which were very promising in 1984/85 are continuing with an improved mesh this season. (Eggs are collected, placed in the "basket", translocated and re-buried with the "basket" in order to minimize handling or disturbance of eggs).

Turtle research has also moved out of Natal and studies initiated in Madagascar and the surrounding islands. These studies continue under the auspices of the French Government. All turtle tag records are however held in Pietermaritzburg.

Additional work has been carried out on body temperatures and developmental biology (temperature dependent sex-determination etc.) by the Universities of Natal, Durban-Westville and Port Elizabeth.





TABLE 2  
A SUMMARY OF LEATHERBACK RENIGRATIONS TO TONGALAND, 1963 - 1984

SEASON	No	Sex	1yr	2yr	3yr	4yr	5yr	6yr	7yr	8yr	9yr	10yr	11yr	12yr	Collapsed	%	Re-migrations
1963/64	18	1♂	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1964/65	13	12	92.3	1	7.7	-	-	-	-	-	-	-	-	-	-	-	-
1965/66	27	25	92.6	-	2	7.7	-	-	-	-	-	-	-	-	-	-	7.7%
1966/67	5	3	60.0	-	1	20.0	1	20.0	-	-	-	-	-	-	-	-	7.7%
1967/68	18	18	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-	40.0%
1968/69	19	14	73.7	-	-	4	21.0	1	5.3	-	-	-	-	-	-	-	-
1969/70	28	17	60.7	-	3	10.7	-	2	7.1	1	3.6	-	-	-	-	-	26.3%
1970/71	17	12	70.6	-	3	17.7	-	-	-	-	-	-	-	-	-	-	17.9
1971/72	39	33	84.6	-	3	7.7	-	-	-	-	-	-	-	-	-	-	39.3%
1972/73	21	17	81.0	-	1	4.7	-	-	-	-	-	-	-	-	-	-	11.8
1973/74	54	46	85.2	-	4	7.4	2	3.7	-	-	-	-	-	-	-	-	29.4%
1974/75	63	55	87.2	-	3	4.8	1	1.6	2	3.2	-	-	-	-	-	-	7.7
1975/76	65	46	70.8	-	13	20.0	2	3.0	-	-	-	-	-	-	-	-	14.8%
1976/77	58	33	56.8	1	1.7	11	19.0	8	13.8	-	-	-	-	-	-	-	1.9
1977/78	70	34	48.6	-	12	17.1	23	32.9	-	-	-	-	-	-	-	-	3.2
1978/79	63	35	55.6	-	9	14.3	16	25.4	-	-	-	-	-	-	-	-	12.6%
1979/80	79	45	57.0	-	13	16.5	11	13.9	3	3.8	-	-	-	-	-	-	29.2%
1980/81	83	46	55.4	-	18	21.7	10	12.1	1	1.2	1	1.2	-	-	-	-	4.6
1981/82	65	31	47.7	-	17	26.2	4	6.2	3	4.6	2	3.1	2	3.1	-	-	8.6
1982/83	65	38	58.5	-	17	26.2	8	12.3	1	1.5	-	-	-	-	-	-	43.1%
1983/84	78	40	51.2	-	16	20.5	6	7.7	3	3.9	1	1.3	2	2.6	1	1.3	1.4
1984/85	72	45	62.5	-	10	13.9	8	11.1	3	4.2	1	1.4	1	1.4	2	2.8	1.4
1984/85	93	66	71.0	-	10	10.8	8	8.4	3	3.2	1	1.1	1	1.1	2	2.2	1.1

\* Very dubious data because of difficulty of recognition.

**DATA CENTRE**

Researcher : N Walters  
Organization : NRIO, CSIR  
Duration :  
Funding : CSIR

The South African Data Centre for Oceanography (SADCO) has a considerable collection of data relating to the coastal zone and estuaries of Natal as well as data on the Indian Ocean. These data are made available on request to researchers concerned with environmental quality, marine resources and oceanographic studies in general. Those who are linked to the CSIR computer network can obtain data directly from the SADCO data base. Various utility programmes have been developed to facilitate access to data, and these can be used for preparing a wide variety of data products (histograms, contours etc.) without knowledge of programming on the part of the user.

**MANAGEMENT NEEDS**

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**DEPARTMENT OF WATER AFFAIRS**

G J Grobbelaar

The discharge of water into the sea is controlled under the Water Act, and a permit must be obtained from the Department of Water Affairs for this purpose. Frequently, when such permits are issued, the conflicting interests of developers and conservationists result in confrontation.

Background is therefore needed in each instance to assess the possible impact of the introduction of potential pollutants on specific habitats or communities. If this information is not available, research, funded on a contractual basis, has to be undertaken as soon as possible in order to provide it, thus allowing assessment of the effects of discharge to formulate the best solution in the circumstances.

Considerable information on our marine communities and marine toxicology is accumulating. Expertise in the design of marine discharge systems has increased considerably in the last decade.

**SEA FISHERIES RESEARCH INSTITUTE**

D Pollock

Amongst other priorities, the following were identified by research scientists from the SFRI:

1. The effects of removal of top predators, especially large predatory fish, sharks and mammals, on lower trophic levels in the Natal coastal ecosystem.
2. Studies of prawn and fish stocks of the Tugela Bank.
3. Feasibility studies for penaeid prawn aquaculture in Natal estuaries with particular reference to St Lucia estuary.

**NATAL PARKS BOARD**

M M Brokensha

I have listened with great interest to the proceedings of the last two days, but not one speaker has identified the real problem - people. We do not need to understand the biological processes to see the end product. Geological processes go on but we have to manage people now!

A few years ago the NPB decided to register all projects being undertaken in areas under its control. I was surprised to see how many there were, and I am even more surprised to see how many marine orientated research projects there are in Natal!

As a manager and not a scientist I must say that I am somewhat disappointed that not more of these projects are management orientated rather than academic projects, because again, we need to manage people.

I must make it quite clear that I am not opposed to academic projects and accept their value. From a management point of view the management orientated project must obviously be of far more use. T de Freitas and the staff of ORI gave an indication of the escalation in effort on the Natal coast - not merely from an angling point of view but also in respect of the harvesting of the various bait organisms. This is where the management needs of Natal, in my opinion, lie.

The intensity of development on the Natal coast means that we have human population pressures. They are escalating and that is where our problems originate.

As I see it there is an urgent need for sociological research - call it recreation science if you will. We need to know about:

1. The use of vehicles on beaches and the use of the beaches themselves.
2. Population structures in heavily exploited areas.
3. Catch per unit effort in respect of exploited angling species.
4. The population structures, growth rates and mortalities of bait organisms.
5. Establish realistic bag limites.
6. Establish realistic closed seasons.
7. More information about the ecological impact of shark nets.

The Natal Parks Board utilizes a system of management planning which makes use of whatever research information is available, but it is important that this information is correctly interpreted. In a nutshell there is a need to make more use of the information that is already available.

I recognize the need for all these things, but I also understand the need to find the money to fund them and the impossibility of carrying out the research if it is not forthcoming. I recognize the need to provide the means of collecting the data, such as the number of people utilizing the resource - and if this means a "general fishing licence" to provide the funds and the information - so be it.

Exercises, like this workshop, provide a great deal of information to the enlightened but it also highlights the need for more management orientated research. Quickly escalating populations and a dramatic increase in the use of the resource highlight the urgency of the problem. R van der Elst indicated that 30-40 % of the shad which migrate up the Natal coast are caught - I find that frightening!

In conclusion, I would like to say that somebody has got to make decisions - that somebody is the manager and he has to make sound decisions, based on sound scientific research. It is important therefore for somebody to do that research, based on management needs and management of people will be an essential requirement.

## NATAL TOWN AND REGIONAL PLANNING COMMISSION

A M Little

### INTRODUCTION

The main thrust of my contribution is the need for "ecological planning". The essential factor is the need to establish the basis for reconciling human demands and environmental resources in such a way that both man and his environment may survive. The Town and Regional Planning Commission, being a co-ordinating body, wrestles with this type of problem daily.

Much has been said about the coastal and marine environment at this workshop - the need to understand them and their processes of genesis and growth, their limitation and conservation. By contrast, then, I will outline a few of the human processes which will have to be taken into account in our planning.

### CRITICAL ISSUES

#### Population of Natal/KwaZulu

	1970-2010 (in 1000's)				
	Whites	Coloureds	Indians	Blacks	Total
1970	443	68	524	3 275	4 310
1980	566	94	672	4 766	6 098
1990	631	111	798	6 175	7 715
2000	692	128	906	7 858	9 583
2010	748	138	987	9 726	11 599

Note that the population is expected to almost double by 2010; that the White group is a minority, and that nearly half the Black population will be under 15 years of age.

#### Urbanization

Nearly 90 % of the White, Indian and Coloured groups live in urban areas now, but only 35 % by the year 2000. The housing needs might exceed 30 000 units per year in Natal/KwaZulu. Continued legal and illegal influx of people from neighbouring territories is likely to increase this figure.



### Geographical Location

There has been a large movement of people to the coastal strip in Natal. In the Durban-centred complex the population density rises to 1 000 per km<sup>2</sup>, while along the coastal strip the average exceeds 300 per km<sup>2</sup> - and is growing.

The reasons are not difficult to appreciate. The rural inland areas have reached agricultural carrying capacity; the coastal areas are highly productive bio-climatically; employment opportunities (i.e. coal, mines, etc.) are reducing inland while most growth points are located at the coast (i.e. Richards Bay, Isithebe, Tongaat/Compensation, Durban, Umkomaas, Port Shepstone/Marburg).

### Employment

Without wishing to pile on the agony, I can just mention that 75 000 jobs need to be created each year from now to 2000. This is more than the nation could provide in 1980. The majority of the population will not be qualified to seek employment in Western World types of commerce and industry for some years, so that it will have to be involved in "agricultural" and "informal" sector activities. The population will be relatively "poor" on average.

The effect of these major strategic forces on the coastal environment, I leave for your consideration.

### RESEARCH

In my view, we need to broaden the horizons of our research efforts from an examination of coastal processes to an examination of the effects of intensive human habitation on the coast line. We need not only to model the natural processes, even approximately so as to be able to answer the question of "How will we manage the resources of the coastal strip if (and when) we have hundreds and thousands of people occupying it?" We need also to examine the means of conserving our resources within the social, economic and political environment we will have by the turn of the century.

### TIMING

One of the most difficult tasks facing a planning body is to be neither behind the times nor so far ahead of public opinion that the proposals are considered academic.

M Louise Haskins puts it this way :

"Frustrated are the fruits of action forced by  
impulse premature;  
But voyages accomplished, deeds achieved  
and plans fulfilled  
Belong to actions held in check till time of  
rightful birth."

**PROBLEMS, NEEDS AND PRIORITIES**

**PROBLEMS, NEEDS AND PRIORITIES**

In all, 85 projects, involving 70 participants from 15 different organizations in Natal and KwaZulu, were reported on at the symposium.

**PROBLEMS WERE IDENTIFIED AS FOLLOWS:**

- Both management and the general public are insufficiently aware of coastal needs, which therefore need to be made known on a broad front. The same applies to coastal research.
- There is insufficient integration between coastal research and socio-political reality.
- There is a lack of funds for important research.
- There is a shortage of research workers, particularly in the disciplines of Geology, Physics, Chemistry and Coastal Engineering.
- More attention needs to be given to publication in refereed journals.

**NEEDS WERE IDENTIFIED AS FOLLOWS:**

- Tentative management policies should be formulated and applied on the best available information and should be constantly re-evaluated.
- Water quality criteria need to be enforced in Natal.
- The use of a sophisticated research vessel is needed for research in fish and prawn stocks on the Tugela Bank and for other purposes.
- Bag limits and closed seasons for fish need constant re-evaluation.
- Researchers, planners and managers should meet regularly by means of a mini symposium such as the present one to improve information exchange and co-ordination.
- Research should include, whenever possible, sociological aspects.
- Scientists should be prepared to assist resource managers by drawing on general experience.

**RESEARCH PRIORITIES WERE IDENTIFIED AS:**

- Sediment-water interactions, including the role of dunes and estuaries and the erosional effect of man-made structures on beaches.
- The effects of vehicles on beaches.

- The sociological effects of increasing numbers of people utilizing beaches.
- The ecological consequences of shark nets.
- The population structure, growth rates, recruitment and mortality, as well as utilization patterns by man, of exploited intertidal organisms.
- The determination of the distribution of spawning ground and fish larvae to establish the origin of fish stocks in Natal. The same for crustaceans and other exploited invertebrates.
- The nature of the sardine run and associated predator migration.
- Evaluation of fishery enhancement techniques such as artificial reefs, fish aggregating devices and artificial re-seeding programmes.
- Alternative resources which would reduce pressure on currently over-exploited linefish stocks in Natal.
- Catch-per-unit effort of exploited angling fish.
- The effect of the removal of top predators (including dolphins, seals and seabirds) on the reef fish community.
- The fish and prawn stocks of the Tugela Bank region.
- Metal pollution from dredge spoil at Richards Bay, and specifically copper pollution from industrial effluent.
- The occurrence of dieldrin in Natal marine fauna.
- Improved assessment techniques for pipeline discharges.
- Monitoring of the quality of effluent discharged from the Richards Bay pipelines.
- Primary productivity, especially as it relates to important zoological studies.
- Microbial decomposition of algal detritus.
- The feasibility of fish, algal and prawn aquaculture.
- The effects of sand movement on the biota of hard substrata.

It was generally agreed that urgent management problems exist and that the emphasis of research should be conservation and management related.

## RECENT TITLES IN THIS SERIES

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